ISSN 1880-6988

THE JOURNAL OF ECONOMETRIC STUDY OF NORTHEAST ASIA (JESNA)

Vol. 8 No. 1 March 2012

Contents

Economic Research Institute for Northeast Asia

THE JOURNAL OF ECONOMETRIC STUDY OF NORTHEAST ASIA
(JESNA)

THE JOURNAL OF ECONOMETRIC STUDY OF NORTHEAST ASIA is interested primarily in publishing articles on econometric analysis of the Northeast Asian region(s), or related regions, including various types of modeling, econometric studies, and the development of a body of data, such as for national accounts, input-output tables, flow-of-funds accounts, and various indices of prices and quantities, etc.

The journal is published in English in principle twice a year.

Economic Research Institute for Northeast Asia (ERINA)
Address: 13th Floor, Bandaijima Building, Bandaijima 5-1, Chuo-ku,
Niigata City, 950-0078, Japan
Tel: +81-25-290-5545
Fax: +81-25-249-7550
E-mail: webmaster@erina.or.jp

The Journal of Econometric Study of Northeast Asia

Vol. 8 No. 1 March 2012

Contents

The Internal and External Effect of Demand on the Japanese Economy with a Special Focus on its Transportation System using an International and Interregional Input-Output System

Tsubasa Shibata* and Hiroyuki Kosaka†

Abstract

The purpose of this paper is to analyze the internal and external effect of the development of high-speed transportation (shinkansen, expressways and air routes) on Japan's regional economies.

In order to assess the effect of high-speed transportation, we developed the benefit index of transportation by applying the concept of the gravity model, and incorporated this index into a Nine Interregional Input-Output Model which is composed of nine regions and eight sectors. The model is based on tables from 1965 to 2000, in constant prices, and determines the sectoral output and sectoral price simultaneously.

Using this system we prepared the following scenarios. 1) We conducted a scenario simulation without the development of high-speed transportation. We then compared the regional economy in the absence or presence of the development of a high-speed transportation system. 2) In addition we simulated China's demand impact on private consumption and total output.

As a result, we could uncover the mechanisms behind the problems associated with the economic disparities among regions: i.e., centralization (concentration of people and goods) and decentralization occurred, respectively, in the core and local regions. In addition, the analysis also found a positive relationship between the rise in China's demand and Japan's regional economic growth.

Keywords: international input-output model, Japanese economy, transportation

1. Introduction

After World War II, Japan experienced a period of reconstruction followed by high economic growth, and Japan became the country with the second largest GDP in the world in 1967. We can point out that establishing a better, high-speed transportation system was one of the crucial factors for the high economic growth. Since the Tokyo Olympics were held in 1964, and also the Osaka Expo in 1970, the high-speed transportation system has been rapidly developed (shinkansen lines, expressways and air routes). The high-speed railway "Tokaido Shinkansen" started in 1973, and has been the main transportation route linking the Japanese metropolitan regions of Tokyo, Nagoya and Osaka. The line transported 43.78 million passengers in 1965, and subsequently 55.25 million passengers, increasing 26% on the previous year, between Osaka and Tokyo. Moreover, the Japanese economy grew at a rapid pace of over 10% per annum during the 1960s.

When we look at regional economies in detail, however, not all regions have necessarily experienced high economic growth to an equal degree, and some regions have experienced serious recession. In the 1970s, people and goods were concentrated in large economic regions such as Tokyo or Osaka, and other regions with small-scale economies declined.

* Research Associate of SFC Institute, Keio University, 5322 Endo, Fujisawa, Kanagawa, 252-8520, Japan

† Faculty of Policy Management, Keio University, 5322 Endo, Fujisawa, Kanagawa, 252-8520, Japan

In the 1980s, the situation became more serious. The infrastructure of transportation was highly developed and the cost time-wise for travel was shortened between Tokyo and Osaka, which enabled people to go back and forth between the two in a day. Therefore, the head offices of the financial institutions or large companies in Osaka were transferred to Tokyo, and people and goods were moved to the Kanto region, which became the cause of excessive centralization in Tokyo.

Thus, in order to grasp the economic effects of transportation from a logical stand point, we need to examine historically the impact of the high-speed transport infrastructure developments in the period of high economic growth by use of a model.

The rest of this paper is organized as follows: Section 2 explains the framework of our model; Section 3 shows the data for the input-output table and the transportation index; Section 4 shows the model structure; Section 5 presents the results of the scenario analysis; and Section 6 presents the conclusions.

2. The Characterizing Approach

We would like to explain our approach in the following three sub-sections.

2.1 Interregional Input-Output Modeling

We prepare the Interregional Input-Output Model as the basic framework. This model determines sectoral output and sectoral price simultaneously. There are three features.

First is the Interregional Input-Output Data.[1] These are very useful and powerful data. They include Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyushu, and Okinawa. In addition, these data cover eight sectors. They enable us to analyze the economic spillover effect on Japanese regional economies in detail. Table 1 presents the regional classification. Table 2 shows the sectoral classification.

Second, we build the Interregional Input-Output model in constant price terms. We use the interregional input-output tables for 1965, 1970, 1975, 1980, 1985, 1990, 1995, and 2000.[2] These original IO data are evaluated in current prices. In order to analyze the

Table 1 Classification of Regions[3]

Region	Prefecture
Hokkaido	Hokkaido
Tohoku	Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima
Kanto	Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Niigata, Yamanashi, Nagano, Shizuoka
Chubu	Toyama, Ishikawa, Gifu, Aichi, Mie
Kinki	Fukui, Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama
Chugoku	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi
Shikoku	Kagawa, Kochi, Ehime, Tokushima
Kyushu	Miyazaki, Nagasaki, Saga, Fukuoka, Kagoshima, Oita, Kumamoto
Okinawa	Okinawa

[1] Compiled by the Ministry of Economy, Trade and Industry of Japan.
[2] Made by Sonoe Arai and Masayuki Ogata at the Ministry of Economy, Trade and Industry of Japan.
[3] Details are given in the paper.

Table 2 Classification of Sectors

No.	Sector
1	Agriculture
2	Mining
3	Manufacture of metal products
4	Manufacture of machinery
5	Miscellaneous manufacturing industries
6	Construction
7	Wholesale and retail trades, and transportation trade and transportation
8	Services

real economies, it is necessary to use the IO table in constant prices. Hence, we deflated these input-output tables by using some sectoral prices that are taken from the System of National Accounts (SNA), where the base year is 1990.

Third, we employ the input-output model based on the demand-oriented model, which can analyze the impact of transportation development through the demand side of the economy, such as intermediate demand or private consumption. Therefore, this model enables us to ascertain the change in the industrial structure or the regional economic disparities.

2.2 Making the Benefit Index of Transportation

In order to measure the effect of high-speed transportation, we develop an index of transportation evaluation by applying the concept of the gravity model. The gravity model is explained as representing the interaction I^{hk} between the hth and the kth region, in which P^h is the population of the hth region, and d^{hk} is the physical distance between the two. [J.Q. Stewart, 1948]

$$I^{hk} = G\frac{P^h P^k}{(d^{hk})^2} \tag{2.1}$$

Although d^{hk} is the physical distance in the above model, our index of transportation extends d^{hk} in the economic sense. Subsequently, the economic distance index D^{hk} is defined below:

$$\begin{aligned} D^{hk} &= \text{time required to travel from } h \text{ to } k + \text{transportation fare to travel from } h \text{ to } k \\ &= \text{opportunity labor cost } + \text{ transportation fare to travel from } h \text{ to } k \end{aligned} \tag{2.2}$$

The travel time in (2.2) is converted to the opportunity labor cost in monetary terms; the travel time (one hour) is replaced by the wage rate per hour. Hereafter D^{hk} is labeled $D^{hk}(t)$ to show the time t explicitly. In order to produce the benefits of transportation over time historically, we formulate the benefit index of transportation $T^{hk}(t)$ in the following:

$$T^{hk}(t) = \frac{1/D^{hk}(t)}{1/D^{hk}(1965)} \tag{2.3}$$

The benefit transportation index in (2.3) is designed to exhibit the difference of cost between the current period and the initial one. Yet the proportion of expenses of opportunity labor cost plus transportation fare depends on the income level historically, namely, the historical income should be subtracted. Therefore, we have to modify (2.3) to (2.4) with the current income being subtracted. Thus the formula is as below:

$$T^{hk}(t) = \frac{\dfrac{1}{\left\{\dfrac{wage(t)}{wage(1965)}\right\}^{1}\!/D^{hk}(t)}}{\dfrac{1}{\left\{\dfrac{wage(1965)}{wage(1965)}\right\}^{1}\!/D^{hk}(1965)}} \tag{2.4}$$

The index, (2.4), now makes clear the performance of transportation in the current year compared to the initial year of 1965. If the performance of the current year improved upon that for 1965, the index may show more than unity. Otherwise, the index will be less than unity. The index for individual transportation is made in different ways; railways, roads, and air routes. The formulation is detailed in Section 3.2.

2.3 Incorporating these Indices into the Input-Output System

The transportation indices are incorporated into the IO model. The transportation indices are intended to enter the IO model by three routes, where transportation contributes to: a) the conveyance of intermediate goods from one region to another; b) the regional private consumption by the potential model augmented by D_{ij}; and finally c) the stimulation of labor transfer. Thus, this model system can analyze the influence which the transportations affect on the individual economic factors and the whole Japanese economy.

3. The Method of Computing the Benefit Index for Transportation: Railways, Roads and Air Routes

3.1 Regional Classification

First we specify the details for the regions. We decompose the total Japanese economy into nine regional economies corresponding to the regional classification of the input-output tables. We also select the representative or core city for each region. Thus we select: Sapporo in Hokkaido; Sendai in Tohoku; Tokyo in Kanto; Nagoya in Chubu; Osaka in Kinki; Hiroshima in Chugoku; Matsuyama (Takamatsu) in Shikoku; Fukuoka [=Hakata] in Kyushu; and Naha in Okinawa. Based on these cities, we measure the traveling times and fares for people moving or traveling between regions.

3.2 The Benefit Index for Railways

We explain the indices of transportation evaluation focusing first on railways. The degree of transportation benefit is formulated as:

Figure 1 The Nine Regions and their Representative Points/Cities

$$T_{trn}^{hk}(t) = \frac{\dfrac{1}{\left\{\dfrac{mwage(t)}{mwage(1965)}\right\}(timecost\_newtrn(t) + fare\_newtrn(t))}}{\dfrac{1}{\left\{\dfrac{mwage(1965)}{mwage(1965)}\right\}(timecost\_oldtrn(1965) + fare\_oldtrn(1965))}} \quad (3.1)$$

T_{trn}^{hk}	:	The benefit index of transportation moving from region h to k by using the new type of train (shinkansen)
$mwage$	:	Monthly nominal wage
$timecost$	:	Time constant (converted into monetary terms) required to travel from region h to k
$fare$	:	The fare to travel from region h to k
$newtrn$	:	Using high-speed railways (shinkansen)
$oldtrn$	:	Using old railways
t	:	Time, from 1965 to 2000

In the sample period, each year's performance is compared with the old railway transportation of 1965. If the performance improved upon the level in 1965 (for example, by technological progress, or by more efficient operation in terms of time), the index will be above unity. Otherwise, the index will be less than unity. Table 3 shows the details of the travel routes between the representative cities.

Table 3 High-Speed Railways and Old Railway Lines

Section	Old Railway	Shinkansen Railway
Sapporo ⇔ Sendai	Hakodate Line, Tohoku Line	Hakodate Line, Tohoku Shinkansen
Sendai ⇔ Tokyo	Tohoku Line	Tohoku Shinkansen
Tokyo ⇔ Nagoya	Tokaido Line	Tokaido Shinkansen
Nagoya ⇔ Osaka	Tokaido Line	Tokaido Shinkansen
Osaka ⇔ Hiroshima	Sanyo Line	Sanyo Shinkansen
Mainland ⇔ Matsuyama	Sanyo Line	Sanyo Shinkansen
Hiroshima ⇔ Hakata	Sanyo Line	Sanyo Shinkansen

Table 4 Old Roads and Expressways

Section	Old Road	Expressway
Sendai ⇔ Tokyo	Route 4	Tohoku Expressway
Tokyo ⇔ Nagoya	Route 1	Tomei Expressway
Nagoya ⇔ Osaka	Route 2	Meishin Expressway
Osaka ⇔ Hiroshima	Route 2	Sanyo Expressway
Honshu ⇔ Matsuyama	Route 2	Honshu-Shikoku Bridge Expressway
Hiroshima ⇔ Fukuoka	Route 2, Route 3	Sanyo Expressway, Chugoku Expressway, Kyushu Expressway

3.3 The Benefit Index for Roads

We explain the index of transportation evaluation which focuses on highways. The degree of transportation convenience with respect to highways is written as:

$$T_{high}^{hk}(t) = \frac{\dfrac{1}{\left\{\dfrac{mwage(t)}{mwage(1965)}\right\}(timecost\_highway(t) + fare\_highway(t))}}{\dfrac{1}{\left\{\dfrac{mwage(1965)}{mwage(1965)}\right\}(timecost\_road(1965) + fare\_road(1965))}} \quad (3.2)$$

T_{high}^{hk} : The benefit index of transportation moving from region h to k using highways

$highway$: Using expressways

$road$: Using old roads

t : Time, from 1965 to 2000

There are 36 observations from 1965 to 2000 for each variable. Table 4 shows the details of the travel methods between the points or cities.

3.4 The Benefit Index for Air Routes

Air routes have a special feature in that there are no routes which correspond to ordinary

Table 5 Airports

Representative City	Airport
Sapporo	New Chitose Airport
Sendai	Sendai Airport
Tokyo	Haneda Airport
Osaka	Itami Airport
Hiroshima	Hiroshima Airport
Matsuyama	Matsuyama Airport
Hakata	Fukuoka Airport
Okinawa	Naha Airport

roads or train services. The improvement of air routes must be evaluated by the number of direct flights between regions. In our investigations, their number was smallest in 1993. Thus we set the year 1993 as the base year. The degree of transportation convenience with respect to air transportation is written as:

$$T_{air}^{hk}(t) = \frac{\dfrac{1}{\left\{\dfrac{mwage(t)}{mwage(1993)}\right\}(timecost\_air(t) + fare\_air(t))}}{\dfrac{1}{\left\{\dfrac{mwage(1993)}{mwage(1993)}\right\}(timecost\_air(1993) + fare\_air(1993))}} \tag{3.3}$$

T_{air}^{hk} : The benefit index of transportation moving from region *h* to *k* by using air routes

air : Using air routes

t : Time, from 1965 to 2000

Table 5 shows the details for the travel methods between points or cities.

3.5 Making the Benefit Index allowing Substitutability among the Three Forms of Transportation

As (3.1), (3.2), and (3.3) show, individual transportation is evaluated independently, ignoring substitutability among forms of transportation. Thus the index signifies that, if expressways are improved in terms of the travel-time required or of cost, the index for expressways would rise and the indices for other transportations (high-speed railways and air routes) would remain unchanged. Yet the index cannot reflect the real world sufficiently: that is people would make a choice from among the three kinds of transportation. If the benefit for expressways rises, the performance of railways and air routes should deteriorate correspondingly. In order to include people's choices from among the three kinds of transportation, we reformulate the benefit indices for transportation allowing substitution among the three, in the following:

$$TT_{trn}^{hk}(t) = \left(\frac{T_{trn}^{hk}(t)T_{trn}^{hk}(t)T_{trn}^{hk}(t)}{T_{trn}^{hk}(t)T_{high}^{hk}(t)T_{air}^{hk}(t)}\right)^{\frac{1}{27}}, \tag{3.4}$$

$$TT_{high}^{hk}(t) = \left(\frac{T_{high}^{hk}(t)T_{high}^{hk}(t)T_{high}^{hk}(t)}{T_{trn}^{hk}(t)T_{high}^{hk}(t)T_{air}^{hk}(t)}\right)^{\frac{1}{27}} \tag{3.5}$$

and

$$TT_{air}^{hk}(t) = \left(\frac{T_{air}^{hk}(t)T_{air}^{hk}(t)T_{air}^{hk}(t)}{T_{trn}^{hk}(t)T_{high}^{hk}(t)T_{air}^{hk}(t)}\right)^{\frac{1}{27}} \tag{3.6}$$

where TT_{trn}^{hk}, TT_{high}^{hk}, and TT_{air}^{hk} are the substitutability indices for high-speed railways, expressways, and air routes, respectively. It is worth noting that if one of the three transportation indices rises, the others should decline.

4. The Modeling of the Interregional Input-Output System for Nine Regions

We consider an interregional input-output table with *r* regions and *n* sectors. The fundamental structure of the model is based on the Chenery-Moses interregional input-output model. Regarding the model for transportation, not modeled in the current paper is a process resulting from transportation-the construction of plants, which in turn leads to production-mainly because of the unavailability of time-series data for investment or capital stock by individual region. Instead we assume that a firm's headquarters are already located in the same region, and that it may have plants in other regions.

Input Coefficients

The input coefficients express the input required for a unit of production under existing production technologies and represent a certain production technological standard. They are also called technical coefficients. Generally, in the Chenery (1953)-Moses (1955) input-output model, the source region is unknown and the input coefficients are the same among the source regions. In addition, we also assume that there is no difference between the levels of technology among regions. Based on these assumptions, we formulate the input coefficient as follows:

$$axr_{ij} = \frac{\sum_{k=1}^{r}\sum_{h=1}^{r} xvr_{kj}^{hk}}{XXR_j} \tag{4.1}$$

where axr_{ij} is the amount of input *i* required to produce a unit of output *j*, xvr_{ij}^{hk} is the intermediate input of region *h*'s commodity *i* in sector *j* of region *k*, and XXR_j is the output in sector *j*. Using (4.1), the input coefficient matrix for country *k* can be written as:

$$A = \begin{bmatrix} axr_{11} & \cdots & axr_{1n} \\ \vdots & \ddots & \vdots \\ axr_{n1} & \cdots & axr_{nn} \end{bmatrix} (n \times n) \tag{4.2}$$

Transaction Coefficients of Intermediate Goods

The transaction coefficient of intermediate goods is defined as:

$$mvr_i^{hk} = \frac{\sum_{j=1}^{n} xvr_{ij}^{hk}}{\sum_{j=1}^{n} xvr_{ij}^{k}} \tag{4.3}$$

where mxr_i^{hk} is the ratio of country h's commodity i to the total intermediate input in region k. Then we endogenize it to explain the impacts of transportation development on the trade between regions as:

$$mvr_i^{hk} = \alpha_i^k \left(T_{high}^{hk}\right)^{\beta_{i,high}^{hk}} \tag{4.4}$$

where T_{high}^{hk} is the index for expressways in moving between regions h and k. In the domestic distribution network roads have the largest share for transportation networks. Thus, only the expressway index is incorporated in this formulation.

Private Consumption

Private consumption is quite essential among final demand components. Thus, we endogenize the consumption affected by transportation as follows:

$$\begin{aligned}\log\left(CPR_i^{hk}\right) = \alpha_i + \beta_i \log\left(\frac{WAGE^k}{P_c}\right) + \gamma_{i,trn}^{hk} \log\left(\frac{\sum_{l\in S} TT_{trn}^{lk}\, WAGE^l}{P_c}\right) \\ + \gamma_{i,high}^{hk} \log\left(\frac{\sum_{l\in S} TT_{high}^{lk}\, WAGE^l}{P_c}\right) + \gamma_{i,air}^{hk} \log\left(\frac{\sum_{l\in S} TT_{air}^{lk}\, WAGE^l}{P_c}\right) \\ + \delta_i \log\left(\frac{P_i}{P_c}\right)\end{aligned} \tag{4.5}$$

where CPR_i^{hk} is region k's private consumption of commodity i coming from region h, $WAGE^k$ is the wages in current prices of region k, P_i is the price in sector i, P_c is the consumer price index at the macro-level, and TT_{trn}^{lk}, TT_{high}^{lk}, and TT_{air}^{lk} are indices explaining the substitutability across the forms of transportation. CPR_i^{hk} is determined by the neighboring regions' wages, such as $\sum_{l\in S} TT_{trn}^{lk}\, WAGE^l$, $\sum_{l\in S} TT_{air}^{lk}\, WAGE^l$ and $\sum_{l\in S} TT_{high}^{lk}\, WAGE^l$. The definition of neighboring regions is presented in Table 6.

Determining Intermediate Goods

The trade coefficient in (4.3) can be expressed as:

$$xvr_{ij}^{hk} = mxr_i^{hk} XXR_{ij}^k \tag{4.6}$$

Table 6 The Definition of Neighboring Regions

Region	Definition of l in (4.5)		
	Railways	Roads	Air Routes
Hokkaido	Tohoku	—	Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyushu, Okinawa
Tohoku	Hokkaido, Kanto	—	Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyushu, Okinawa
Kanto	Tohoku, Chubu	Tohoku, Chubu	Hokkaido, Tohoku, Shikoku, Kyushu, Okinawa
Chubu	Kanto, Kinki	Kanto, Kinki	Hokkaido, Tohoku, Shikoku, Kyushu, Okinawa
Kinki	Chubu, Chugoku	Chugoku, Chubu	Hokkaido, Tohoku, Okinawa
Chugoku	Kinki, Shikoku, Kyushu	Kinki, Shikoku, Kyushu	Hokkaido, Tohoku, Okinawa
Shikoku	Kinki, Chugoku, Kyushu	Kinki, Chugoku, Kyushu	Hokkaido, Tohoku, Kanto, Okinawa
Kyushu	Chugoku	Chugoku	Hokkaido, Tohoku, Kanto, Okinawa
Okinawa	—	—	All regions except Okinawa

From this formulation, we can regard the trade coefficient as the share distribution for output. Furthermore, the input coefficient in (4.1) can be also represented as:

$$XXR_{ij}^{k} = axr_{ij}XXR_{j}^{k} \tag{4.7}$$

Sectoral Output

From the identity with respect to demand, the output in sector i of region h is written as:

$$\sum_{k=1}^{r}\sum_{j=1}^{n} xvr_{ij}^{hk} + F_i^h = XXR_i^h \tag{4.8}$$

Equation (4.8) can be rewritten by using (4.6) and (4.7) as:

$$\sum_{k=1}^{r}\sum_{j=1}^{n} mxr_i^{hk} axr_{ij}XXR_j^k + F_i^h = XXR_i^h \tag{4.9}$$

Sectoral Price

Sectoral price is determined by the unit material cost and the unit labor cost as:

$$p_j = \alpha_j + \beta_j\left(\frac{\sum_k wage_j^k}{\sum_k XXR_j^k}\right) + \gamma_j\left(\frac{\sum_k\sum_i\sum_h xv_{ij}^{hk}}{\sum_k XXR_j^k}\right) \tag{4.10}$$

Employment: Sectors and Regions

Labor demand is explained as:

$$L_j^k = \alpha^k\left(XXR_j^k\right)^{\beta}\left(\sum_{l\in S} TT_{trn}^{lk}\sum_{l\in S} TT_{high}^{lk}\sum_{l\in S} TT_{air}^{lk}\right)^{\gamma_{trn,\ high,\ air}^{k}} \tag{4.11}$$

where L_j^k is employment in sector *j* of region *k*. As in equation (4.11), L_j^k is determined by the neighboring regions' accessibility. The process whereby transportation from the supply side affects labor demand is as follows. Transportation firstly affects the interregional location of firms, and secondly output in turn affects labor and intermediate demand. Although the output in the labor demand equation already incorporates the effect of transportation, we hazard the attachment of transportation benefit terms within the labor demand equation, with the exception of output, in order to express the movement of the labor supply, which is affected by transportation via different routes. In the estimation of the above equation, we use the probabilities of the use of the three transportation systems. In order to identify the correct sign for the explanatory variables and the plausibility of the fitted equation, we use Akaike's information criterion.

Wage Rate: Sectors and Regions

The wage rate is formulated as:

$$wage\_rate_j^k = \alpha_j^k\left(\frac{XXR_j^k}{L_j^k}\right)^{\beta_j^k} \tag{4.12}$$

where $wage\_rate_j^k$ is the wage rate in sector *j* of region *k*. It is assumed that the wage rate

Table 7.1 RMSE of Prices

Panel A:RMSE of Price

Economy	Sector1	Sector2	Sector3	Sector4	Sector5	Sector6	Sector7	Sector8
	0.056	0.304	0.025	0.027	0.031	0.023	0.033	0.024

Table 7.2 RMSE of Output

Panel B:RMSE of Output

Economy	Sector1	Sector2	Sector3	Sector4	Sector5	Sector6	Sector7	Sector8
Hokkaido	0.040	0.103	0.083	0.031	0.069	0.011	0.058	0.028
Tohoku	0.075	0.206	0.127	0.087	0.093	0.014	0.073	0.045
Kanto	0.061	0.263	0.046	0.021	0.032	0.008	0.032	0.030
Chubu	0.126	0.301	0.066	0.056	0.079	0.011	0.097	0.035
Kinki	0.113	0.574	0.060	0.042	0.081	0.015	0.058	0.036
Chugoku	0.069	0.541	0.106	0.047	0.056	0.017	0.124	0.033
Shikoku	0.063	0.270	0.088	0.038	0.060	0.020	0.063	0.022
Kyushu	0.078	0.168	0.100	0.062	0.053	0.011	0.056	0.020
Okinawa	0.051	2.449	0.132	0.061	0.081	0.016	0.024	0.030

can be explained by labor productivity. Figure 2 (see Section 5) demonstrates the relation among variables. The dependent variable of equation (4.12) is nominal. Explaining the equation for the variable of price determination (4.10) is the nominal total wage.

Final Test

The details of the estimated results are omitted (See T. Shibata and H. Kosaka, 2009). To finish, we show the results of the final test for the whole system. Tables 7.1 and 7.2 show the root mean square errors (RMSEs) of the final test for the prices in eight sectors, and those of the production for eight sectors of the nine respective regions.

5. Scenario Analysis

We prepared two kinds of scenario simulations. The first handles the domestic economy to analyze internal effects. The second handles the relationship between China and Japan to examine the external effects. This latter scenario is divided into two cases. The first case assumes that China's private consumption rises. The second case supposes that China's total output increases. We uncover the impact of these assumptions on Japan's regional economy. The details are below.

5.1 Scenario Analysis of Internal Effects

5.1.1 Baseline

We simulate the baseline scenario which reflects the real economy from 1965 up to 2000. Although some of variables should be improved, the calculated values in the final test adequately trace the actual values. Thus we were able to accept the interregional IO model.

5.1.2 Scenario

This deals with no transportation development since 1965. It implies the benefit of transportation indices (BITs) were fixed at unity for all transportation modes (railways, roads, and air routes). We then compare this scenario with the baseline scenario where all indices are set at the actual values from 1965 to 2000.

5.1.3 Results

a) The Effect on the Sectoral Output in Total: The demand side

The simulation results are as follows. Table 8 shows the percentage deviations of the total output from the baseline.

Regarding Japanese economic growth with no transportation development, output declines evenly. From 1965 to 2000, the scenario with no development in transportation shows that output declines evenly down to -3%. Next we want to compare the impacts on metropolitan core areas with those on the non-metropolitan peripheral areas. Our analysis implies that non-metropolitan peripheral areas with no transportation development would have suffered a more negative impact compared to metropolitan core areas, which would have lead to greater income disparity. It is expected that the Japanese economy would have worsened without any high-speed transportations.

b) The Impact on Labor Mobility: Supply side

Next we want to compare the impact on labor mobility as a result of transportation development. Tables 9.1 and 9.2 show the regional share of employment. Table 9.1 shows the regions with large-scale economies and Table 9.2 shows the regions with small-scale

Table 8 Percentage Deviation of Output from the Baseline (%)

	Total Output	Output / Metropolitan Area (Core)	Output / Non-Metropolitan Area (Periphery)
1965	0.00	0.00	0.00
1970	-1.28	-0.91	-2.06
1975	-1.72	-1.31	-2.51
1980	-2.37	-1.77	-3.57
1985	-2.93	-2.69	-3.44
1990	-2.98	-2.63	-3.78
1995	-3.29	-3.05	-3.83
2000	-3.34	-3.03	-4.06

Table 9.1 The Annual Mean of Labor Share in Metropolitan Areas (Core) (descending order) (%)

Kanto		Kinki		Chubu	
Baseline	41.915	Baseline	17.051	Baseline	11.842
Scenario	41.889	Scenario	17.032	Scenario	11.800

Table 9.2 The Annual Mean of Labor Share in Non-Metropolitan Areas (Periphery) (descending order) (%)

Kyushu		Chugoku		Tohoku		Shikoku	
Baseline	11.206	Baseline	7.603	Baseline	6.661	Baseline	3.722
Scenario	11.213	Scenario	7.658	Scenario	6.662	Scenario	3.745

economies. We found some interesting trends in these tables.

The labor share of metropolitan core areas increases, whereas that of non-metropolitan peripheral areas declines as the result of the no-high-speed-transportation scenario. This outcome implies that the development of the transportation system provides an incentive for labor to move from rural areas to urban areas. This implies that labor mobility from the non-metropolitan to the metropolitan regions might not occur without high-speed transportation. Note that, as Okinawa appeared only from 1975, and sector 1 in Hokkaido has muted estimation results, both regions are omitted from the tables.

c) Impact on the Regional and Sectoral Economy

Next we want to compare the change in regional specialization and sectoral concentration resulting from transportation development. The Balassa index is used as the means to analyze this question, and measures the industrial concentration of each region.

$$BI_i^r = \frac{\frac{XXR_i^r}{\sum_i^n XXR_i^r}}{\frac{\sum_i^R XXR_i^r}{\sum_r^R \sum_i^n XXR_i^r}} \tag{5.1}$$

The Balassa index (5.1) measures the sectoral share of the ith industry for the entire *r*th region over the sectoral share of the *i*th industry for all the regions.

Here, we calculate Balassa indices for the baseline and scenario cases, using these formulae:

<u>Baseline case</u>

$$BI\_Baseline_i^r = \frac{\frac{XXR\_Baseline_i^r}{\sum_i^n XXR\_Baseline_i^r}}{\frac{\sum_i^R XXR\_Baseline_i^r}{\sum_r^R \sum_i^n XXR\_Baseline_i^r}} \tag{5.2}$$

<u>Scenario case</u>

$$BI\_Scenario_i^r = \frac{\frac{XXR\_Scenario_i^r}{\sum_i^n XXR\_Scenario_i}}{\frac{\sum_i^R XXR\_Scenario_i^r}{\sum_r^R \sum_i^n XXR_i^r}} \tag{5.3}$$

Then we compare the Balassa index for each industry in the baseline case with that in the scenario case:

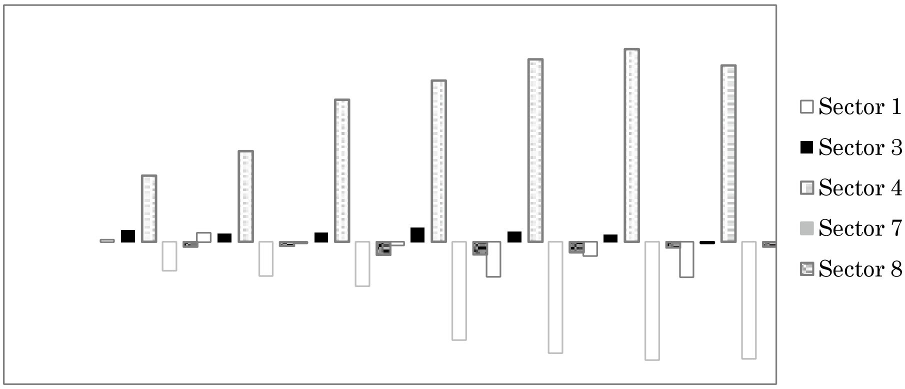
$$\begin{aligned} &BI\_Baseline_i^r - BI\_Scenario_i^r > 0 \quad &\text{Positive effect on industry} \\ &BI\_Baseline_i^r - BI\_Scenario_i^r = 0 \quad &\text{No effect} \\ &BI\_Baseline_i^r - BI\_Scenario_i^r < 0 \quad &\text{Negative effect on industry} \end{aligned} \tag{5.4}$$

If the index in the baseline case is greater than that in the scenario case, it implies that transportation development has a positive impact on industrial concentration in the region. On the other hand, if the index in the baseline case is lower than that of the scenario case, it implies that transportation development has a negative impact on industrial concentration in the region. The results are shown in Figure 2. We can see some interesting trends in this figure.

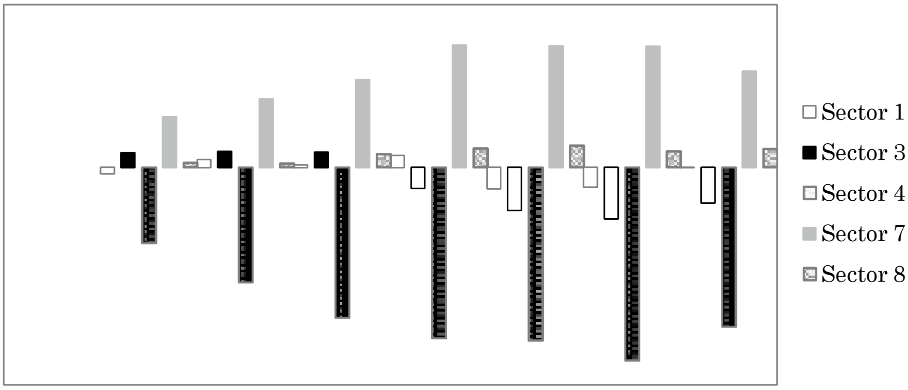
There was a negative value for the fourth sector (the machinery manufacturing sector) in Kanto. It implies that the machinery sector tended to deconcentrate as the transportation system developed. In fact, the machinery sector was believed to have shifted toward the Tohoku region. As we can see, there were positive values for this sector in the

Figure 2 Balassa Indices

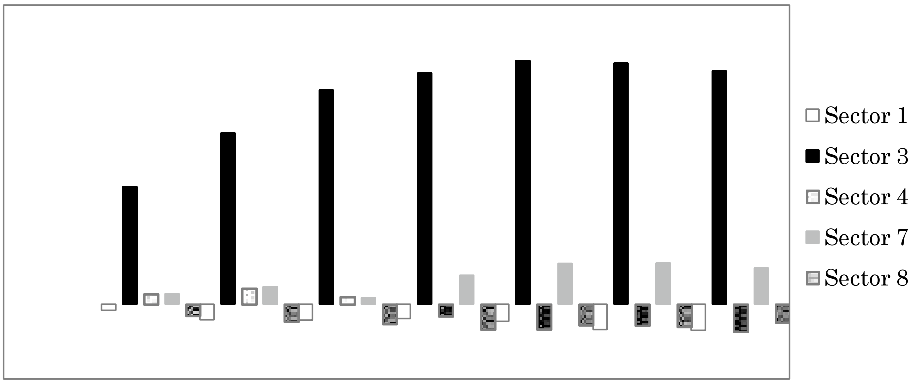
Tohoku



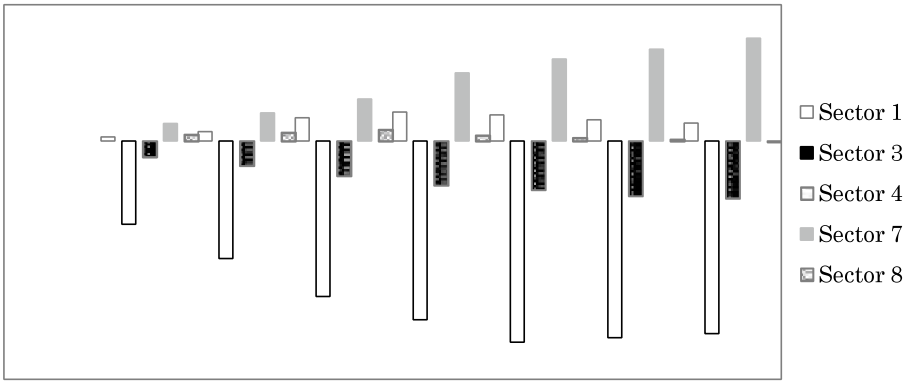
Kanto



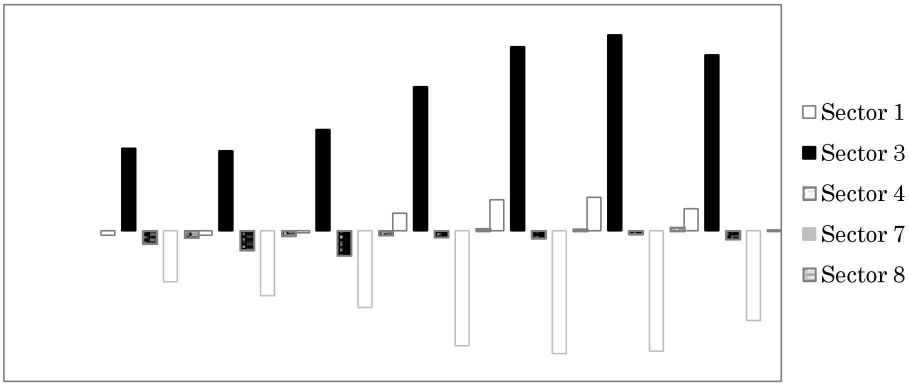
Chubu


Sector 1
Sector 3
Sector 4
Sector 7
Sector 8

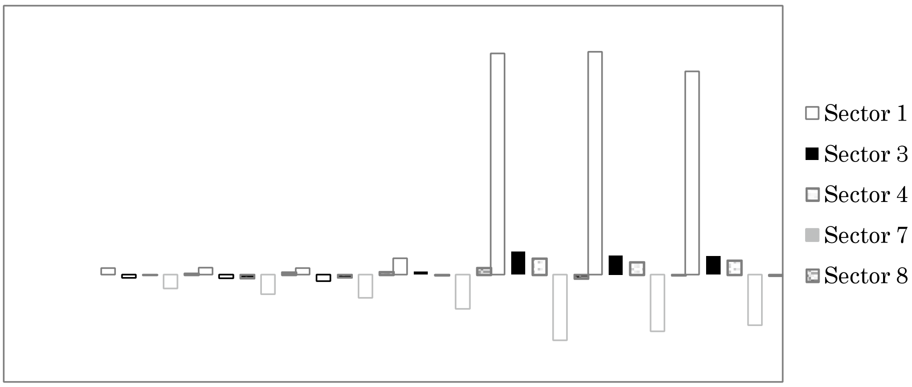
Kinki


Sector 1
Sector 3
Sector 4
Sector 7
Sector 8

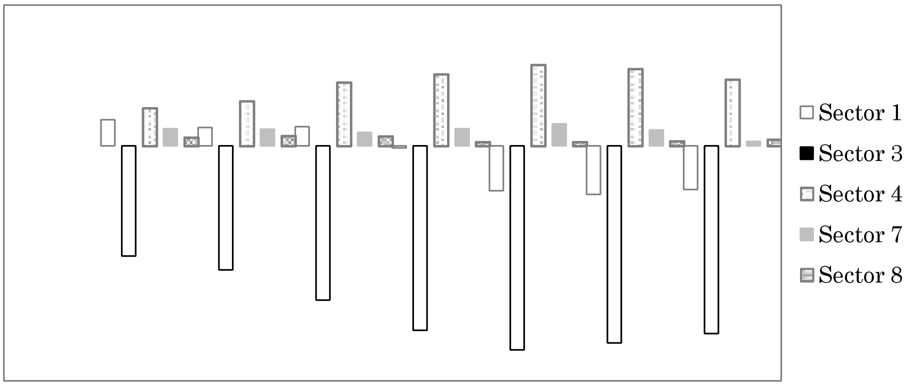
Chugoku



Shikoku



Kyushu



Tohoku region. There were negative values for the seventh sector in the Tohoku region (wholesale and retail, and transportation). It suggests that the seventh sector tended to deconcentrate and shift toward the Tokyo metropolitan area. It seems that concentration and deconcentration play complementary roles for each region. Next, there were negative values in the Kinki region in the third sector (metal products manufacturing). This means that this sector tended to deconcentrate and shift toward the Chugoku and Chubu regions. In contrast, the seventh sector deconcentrated in the Chugoku and Shikoku regions and shifted toward the Kinki region. Finally, the third sector tended to deconcentrate in Kyushu and shift toward the Chugoku region.

5.2 Scenario Analysis of External Effects

In order to examine the relationship between China's rise in demand and Japan's regional economic growth, we endogenize the export variables within the Nine Interregional Input-Output Model and explain them by using data for China from the Asian International Input-Output tables. The details are below. In the international IO system, as well as the interregional system, fixed investment is thought of as exogenous because of the decision-making at a high level beyond that of profit-loss accounting or cost accounting, and because of data unavailability.

5.2.1 Baseline

Case 1: The Rise in China's Private Consumption

In this case, we endogenized EXR_4^k in our model. This is *k*'s exports of the commodities from the fourth sector. This is explained as follows:

$$\log EXR_4^k = \upsilon_4^k + \omega_4 \log CPR_3^{JPN,CHN} \tag{5.5}$$

$CPR_3^{JPN,CHN}$ is the data from the Asian International Input-Output tables[4] and is China's private consumption of commodities produced by manufacturing industries (the fourth

[4] Original

sector) in Japan. We add this equation into and solve our model. Here, there are two things to pay particular note to: sectors and samples. Concerning sector classification, the third sector in $CPR_3^{JPN,CHN}$ corresponds to the fourth sector in the Nine Interregional Input-Output Model. As for samples, since the Asian IO has only four time-points from 1985 to 2000, we simulated samples within that range. This is thus the Case 1 baseline scenario, which reflects the real economy from 1985 up to 2000.

Case 2: The Rise in China's Total Output

In this case, we also endogenized EXR_4^k in our model. This is *k*'s exports of the commodities from the fourth sector. This is explained as follows:

$$\log EXR_4^k = \varphi_4^k + \psi_4^k \log XXR_3^{JPN,CHN} \tag{5.6}$$

$XXR_3^{JPN,CHN}$ is the data from the Asian International Input-Output tables[5] and is China's total output produced by manufacturing industries (the fourth sector) in Japan. We add this equation into and solve our model. This is thus the Case 2 baseline scenario, which reflects the real economy from 1985 up to 2000.

5.2.2 Scenarios

Case 1: The Rise in China's Private Consumption

In this case we made the simulation assuming $CPR_3^{JPN,CHN}$ rose by 10% from 1985 to 2000. We computed this model.

Case 2: The Rise in China's Total Output

In this case we made the simulation, assuming $XXR_3^{JPN,CHN}$ increased by 10% from 1985 to 2000. We computed this model.

5.2.3 Results

Table 10.1 presents the results from Case 1 and shows the percentage deviation of the total output level from the baseline by area. Table 10.2 shows the results from Case 2.

Table 10.1 Case 1: Percentage Deviation of Private Consumption from the Baseline (Unit: %)

	HOKKAIDO	TOHOKU	KANTO	CHUBU	KINKI	CHUGOKU	SHIKOKU	KYUSHU	OKINAWA
1985	0.04	0.23	0.19	0.42	0.25	0.18	0.23	0.26	0.03
1990	0.03	0.23	0.17	0.38	0.23	0.16	0.21	0.30	0.02
1995	0.04	0.30	0.20	0.45	0.28	0.20	0.27	0.49	0.02
2000	0.05	0.35	0.21	0.50	0.31	0.19	0.29	0.66	0.04

Table 10.2 Case 2: Percentage Deviation of Total Output from the Baseline (Unit: %)

	HOKKAIDO	TOHOKU	KANTO	CHUBU	KINKI	CHUGOKU	SHIKOKU	KYUSHU	OKINAWA
1985	0.04	0.13	0.18	0.27	0.17	0.18	0.13	0.11	0.02
1990	0.02	0.08	0.10	0.17	0.10	0.11	0.08	0.07	0.01
1995	0.02	0.09	0.12	0.19	0.11	0.12	0.09	0.07	0.01
2000	0.02	0.09	0.11	0.19	0.11	0.09	0.08	0.07	0.01

[4] Original

In Case 1, a rise in China's private consumption creates the largest impact in Kyushu. Next behind it there is a 0.4% positive impact in Chubu. Meanwhile, in Case 2 there is a large impact on the metropolitan areas (Kanto, Chubu, and Kinki). China's increase in demand has a great influence on regional economies in Japan. Considering the results from Section 5.1, we can point out that China's rise in demand may contribute to industrial concentration.

6. Conclusions

Our study constructed an interregional input-output model for the Japanese economy covering nine regions in constant-price terms, which determined the sectoral outputs and sectoral prices simultaneously. Then we developed the indices of transportation evaluation which focused on the balance between the time-cost and the monetary-cost of high-speed transportation. Finally, incorporating this index into the interregional input-output model, in this paper we analyzed the effects of the development of transport infrastructure.

Several findings were obtained by our scenario simulations. Firstly, we were able to verify that the development of transportation positively contributed to the economic growth of Japan as a whole. However, we also found that it had negative effects on some regions. Thus the contribution from the development of transportation differs by region. Secondly, we showed that the development of transportation gave rise to problems which are observed in contemporary Japan, such as concentration in Kanto (particularly in Tokyo) and the hollowing-out of regions of smaller economic scale than Kanto. Thirdly, we were able to ascertain that the rise in China's demand had a far greater influence on the economy of Japan.

Overall, this paper was able to achieve its aims; however, several improvements would be required. First, although we developed the index of transportation in time-cost and monetary-cost terms, the index can be improved by including other factors that show the state of transportations, such as the number of lines or flights. Second, our model could explain the impacts of the development of transportation on the demand side of the economy in Japan; however, the effects of the economic growth induced by transportation development on further transportation development are neglected in the model. That is, our model could only get a handle on one side of the interaction between the development of transportation and economic growth. To solve these problems, it is imperative to endogenize these indices within the model. Third, a more precise description of the regional economies is also required.

References

Chenery, H.B., 1956, "Interregional and International Input-Output Analysis" in T. Barna (ed.) *The Structural Interdependence of the Economy*, New York, John Wiley and Sons, Inc.

Chenery, H.B., and P.G. Clark, 1959, *Interindustry Economics*, New York, John Wiley & Sons, Inc.

Clark, C., 1966, "Industrial Location and Economic Potential", *Lloyds Bank Review*, 82, pp. 1-17.

Harris, C.D, 1954, "The Market as a Factor in the Localization of Industry in the United States", *Annals of the Association of American Geographers*, 44(4), pp. 315-348.

Isard, W., 1951, "Interregional and Regional Input-Output Analysis: A Model of a Space Economy", *The Review of Economics and Statistics*, Vol. 33, pp. 318-328.

Kosaka, H., 1994, *Model Analysis on the Global System*, Yuhikaku, Tokyo. [in Japanese]

Moses, L., 1955, "The Stability of Interregional Trading Patterns and Input-Output Analysis", *American Economic Review*, 45(5), pp. 803-26.

Ohtake, F., 2005, *Inequality in Japan: Illusion of the divided society and its future*, Nihon Keizai Shinbunsha. [in Japanese]

Rich, D.C., 1980, *Potential Model In Human Geography*, Geo Abstracts.

Sasaki, K., and S. Kunihisa, 2007, *Genealogy of Interregional Econometric Analysis in Japan*, Tohoku University Press. [in Japanese]

Shibata, T., and H. Kosaka, 2009, *Analyzing Effect of Transportation Infrastructure on Japanese Interregional Input-Output System*, SFC Discussion Paper DP2009-006, Keio University. [in Japanese]

Stewart, J.Q., 1948, "Demographic Gravitation: Evidence and applications", *Sociometry*, Vol. 11, pp. 31-58.

Tschangho, J.K, H. Ham and D.E. Boyce, 2002, "Economic Impacts of Transportation Network Changes: Implementation of a Combined Transportation Network and Input-Output Model", *Papers in Regional Science*, 81(2), pp. 223-246.

Highway report, Ministry of Land, Infrastructure and Transport edition.

JTB timetables, 1965 to 2000, JTB press.

Freight Census Data, Ministry of Land, Infrastructure and Transport.

Road schedule, 1965 to 2000, Ministry of Land, Infrastructure and Transport edition.

Input-Output-Based Economic Impact Evaluation System for Small City Development: A Case Study on Saemangeum's Flux City Design*

Bo Meng,[1] Nobuhiro Okamoto,[2] and Yoshiharu Tsukamoto[3]

Abstract

This paper aims to develop an interregional input-output model for evaluating the macro-economic impacts of the ROK's Saemangeum Flux City Development Plan. The main features of our model are summarized as follows: (1) the consumption expenditure of households is regarded as an endogenous variable; (2) the technological change in production is determined by the change in the industrial location quotient caused by the investment activities of firms; and (3) a strong interdisciplinary feedback function between city design and economic analysis is explicitly considered in the economic impact evaluation system.

Keywords: input-output, city design, economic impact

1. Introduction

From a Google map it is easy to find the longest tide embankment (33 km) in the world located on the ROK's central west coast-the Saemangeum region of Jeollabuk-do province. This embankment was completed in 2006, after about 15 years of twists and turns due to some environment-related issues. It is the main construction of the Saemangeum Reclamation Project originally proposed by the ROK's Ministry of Agriculture and Forestry (MAF) in 1991, for the purpose of farmland creation and water resource development. During its construction, various plans for the development of Saemangeum have been proposed by different agencies. For example: *Plans for Developing Saemangeum as an International Free Economic Zone* (1994), and *Comprehensive Development of Saemangeum* (1998) by Jeollabuk-do province; the *Rural Community and Agriculture Corporation General Plan* (1998), and *Ocean City Proposal* (2003) by Professor Kim Seokcheol; *Environmental Bodies' Saemangeum New Plan* (2003) by the Resident Meeting for Saemangeum led by Professor Oh Changwhan; and *Business City Plan* (2007) by the Organization Committee of Distribution Exhibition of Jeollabuk-do (see Jeollabuk-do and UDIK, 2008).

To reflect the various development ideas, the government instructed related research institutes to propose a new Saemangeum land-use development plan in 2006. By adjusting various ideas, the new plan has become more practical, but still focuses on developing

* We are grateful to Mr. Chao Qu, graduate student, Graduate School of Information Science, Tohoku University, for his contribution to this paper. Thanks to the Department of Architecture and Building Engineering, Tokyo Institute of Technology, and the local government of Jeollabuk-do province, ROK, for making this work possible. We also thank Ms. Ai Nakayama and Ms. Sahori Koyanagi, students of Daito Bunka University, for their help in the collection of literature.

[1] Research Fellow, Institute of Developing Economies (JETRO) and OECD

[2] Associate Professor, Department of Asian Area Studies, Graduate School of Daito Bunka University

[3] Graduate of School of Science and Engineering, Associate Professor, Department of Architecture and Building Environment, Tokyo Institute of Technology

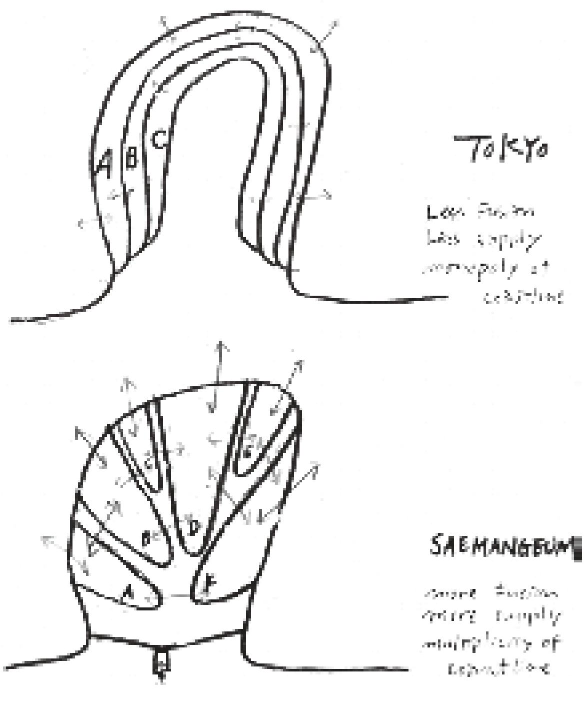
farmland, reflecting the former plans of MAF and environmental bodies. Considering the locational importance of Saemangeum as a newly rising center of the Yellow Sea Rim, it seems that more constructive proposals are expected, which can significantly reflect the changing domestic and foreign situation that Saemangeum is facing.

Later, the current ROK president (Lee Myung-bak) proposed three basic directions (the Dubai of Northeast Asia, a center of specialized economy, and new development sites based on a canal and inland harbor) and seven projects (an international free economic zone, plans for metropolitan cities, a Yellow Sea rim marine tourist resort, a complex for the Honam Canal and inland harbor, a specialized economic zone, a healthy town, and the Honam high-speed railway-east-west highway network) for Saemangeum. Thus the Saemangeum development is to become more accelerated.

Against this background, the Jeollabuk-do government organized an international competition for ideas in order to find a design plan based on a realizable and innovative development concept meeting the people's sincere desires. As one of the competition participants, the design team of Tokyo Institute of Technology led by Professor Tsukamoto provided a design plan with the name of "Saemangeum Flux City Design" (SFCD).

The SFCD started from an original consideration of Saemangeum's special reclamation pattern. As shown in Figure 1, the reclamation in Tokyo Bay adopts a kind of gradual pattern, which makes the reclaimed area far away from the original coastline. As a result, the residents around Tokyo Bay can only enjoy relatively less coastline, and the city design also tends to become very monotonous. In comparison with Tokyo Bay, the 33-kilometer-long Saemangeum dike not only creates a large area of farmland, but also makes it possible

Figure 1 The Different Reclamation Patterns between Tokyo Bay and Saemangeum



to shape a more resident-friendly and nature-oriented coastline. This provides the basic idea for designing a city with a multiple "flux" concept, namely, the flux of human beings, goods and services, money, knowledge and information.

Based on this concept, a daring and complex development program was provided by our design team. As shown in Figure 2, the program takes advantage of Saemangeum's special geographical location, economic potential and industrial tradition with significant consideration of the schedule of public investment, the existing land-use pattern, and various other policy restrictions. In addition, for balancing the positive qualities of a single-mass and archipelago-style reclamation from the viewpoint of architecture, an active revolving line is employed to design a one-line coast for the city design of Saemangeum (see Figure 3). This design not only breaks down the reclaimed areas into more manageable, flexible and scalable dimensions, but also adds a symbolic value to Saemangeum. For detailed information about the SFCD, one can refer to Arqfuture (2009) and Tsukamoto (2008a, 2008b).

The purpose of this paper is to develop an interdisciplinary interface between architecture, civil engineering and economics to evaluate the macro-economic impacts of the SFCD on the ROK's regional economy. The paper proceeds as follows: Section 2 introduces the analysis framework used for the impact evaluation of the SFCD; Section 3 shows the models in detail; Section 4 gives a brief explanation of the available data used; Section 5 applies the model shown in Section 3 to the evaluation of the SFCD and discusses the simulation results in detail; and the concluding remarks are given in Section 6.

Figure 2 The Development Concept and Program for the SFCD

Figure 3 The One-Line Coast of the Saemangeum City Design

2. Analysis Framework

For the impact analysis of city development the following three economic models are probably the most utilized tools globally. They are macro-econometric models: the Computable General Equilibrium (CGE) model; and the Input-Output (IO) model. In order to evaluate the economic impacts of the SFCD, which model would be the most appropriate?

Macro-econometric models have traditionally been considered to be one of the major tools for the analysis of national or regional development plans. However, it is generally difficult to obtain sufficient statistical data to estimate model parameters that cover relatively smaller regions. Since the GDP share of Jeollabuk-do to the whole of the ROK was just approximately 3% in 2007, the GDP share of Saemangeum to the whole of the ROK will be yet smaller because it is still in the process of development at present. This is particularly true when such small economies are studied; reliable regional statistics are difficult to obtain. In addition, the macro-econometric models cannot give a detailed analysis of the inter-industry relationships.

CGE models are a class of empirical economic models used to simulate economy-wide reactions to changes in policy, technology or other external factors. They are based on the Keynesian set of macro-balancing equations arranged within a Social Accounting Matrix (SAM). In this sense, they can be considered a descendant of Leontief's IO model. This kind of model is basically made up of a non-linear simultaneous equation system for solving the equilibrium system. A number of exogenous parameters should be quantified in advance. However, when a small regional economy is the analytical target, it will be quite difficult to calibrate all the required parameters. If the parameter used is composed of arbitrary elements, the analysis results will lose reliability.

IO models should be useful due to their smaller data requirements; many regression equations in their macro-econometric counterparts can be replaced by linear equilibrium conditions based on micro-economic theory. According to Leontief, "Input-output analysis is a practical extension of the classical theory of general interdependence which views the whole economy of a region, a country and even of the entire world as a single system and sets out to describe and to interpret its operation in terms of directly observable basic structural relationships" (Leontief, 1987). In addition, compared to the availability of SAM data required by CGE models, the IO data is easier to obtain; the parameters required by an IO model can be easily calibrated under the officially published IO table. Considering the purpose of the analysis and data availability, an IO model should be the first choice for our analysis.

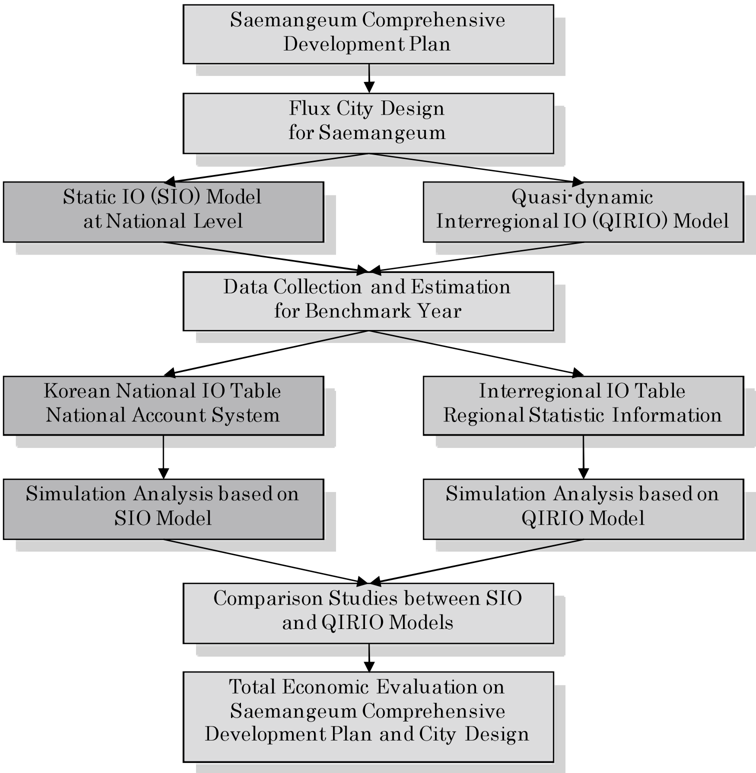
The pioneering theoretical work in the field of IO analysis can be traced through Leontief (1947), Isard (1951), Moses (1955), Polenske (1968), and Round (1978), the early extensions can be found in Miller and Blair (1985), and Sasaki (1989), and for recent developments one can refer to Michael and Dietzenbacher (2001), and Miller and Blair (2009), etc.

For the estimation of Saemangeum's economic impacts, we developed two kinds of IO models. One is a Static Closed IO (SCIO) model based on the ROK national IO table. The merits of this model can be summarized as follows: (1) it is easy to use; (2) it does not require any special supplementary data; and (3) it can give very brief and compact analysis on the impact of development plans at the national level. The demerit of the model is that the aspects of time and space are ignored. Therefore this model cannot reflect the dynamic and spatial technological changes explicitly. For overcoming this problem, we developed a Quasi-dynamic Interregional IO (QIRIO) model, in which the technological change (input coefficients of the IO table) is determined by the change in the industrial location quotient (LQ) induced by a firm's new investment activities. In comparison with the widely used open IO model, both models used for the Saemangeum project are closed models, in which the consumption expenditure of households is regarded as an endogenous variable. This means that the impact of investment via residents' income can be estimated endogenously in our models.

The whole analysis framework can be summarized as follows (see Figure 4):

i. Based on the government's development direction, the city design (SFCD) will be done by our design team.
ii. The two kinds of IO models described above will be constructed respectively for the impact estimation of the SFCD.
iii. Under the model requirements, the related data for economic analysis will be collected and estimated (for the detailed information on data one can refer to Tsukamoto (2008b)).
iv. Two kinds of IO tables will be compiled. One is the ROK national IO table for the SCIO model. The other one is the Jeollabuk-do and the rest of Korea interregional IO table for the QIRIO model. Both tables are based on the officially published data for the year 2000.
v. The simulation analyses will be done for each model.

Figure 4 Analysis Framework



vi. Based on the simulation results and the comparison study between the two models, the total impacts of the SFCD will be evaluated.

Since the QIRIO model used is specially designed for the SFCD, we need to give a detailed introduction to its analysis framework, which is shown in Figure 5:

i. At the beginning point of the Saemangeum development, the local government is planning to provide the fundamental social infrastructure, which can be achieved by the initial public investment. The economic impact of such initial investment will be measured by the benchmark interregional IO table.

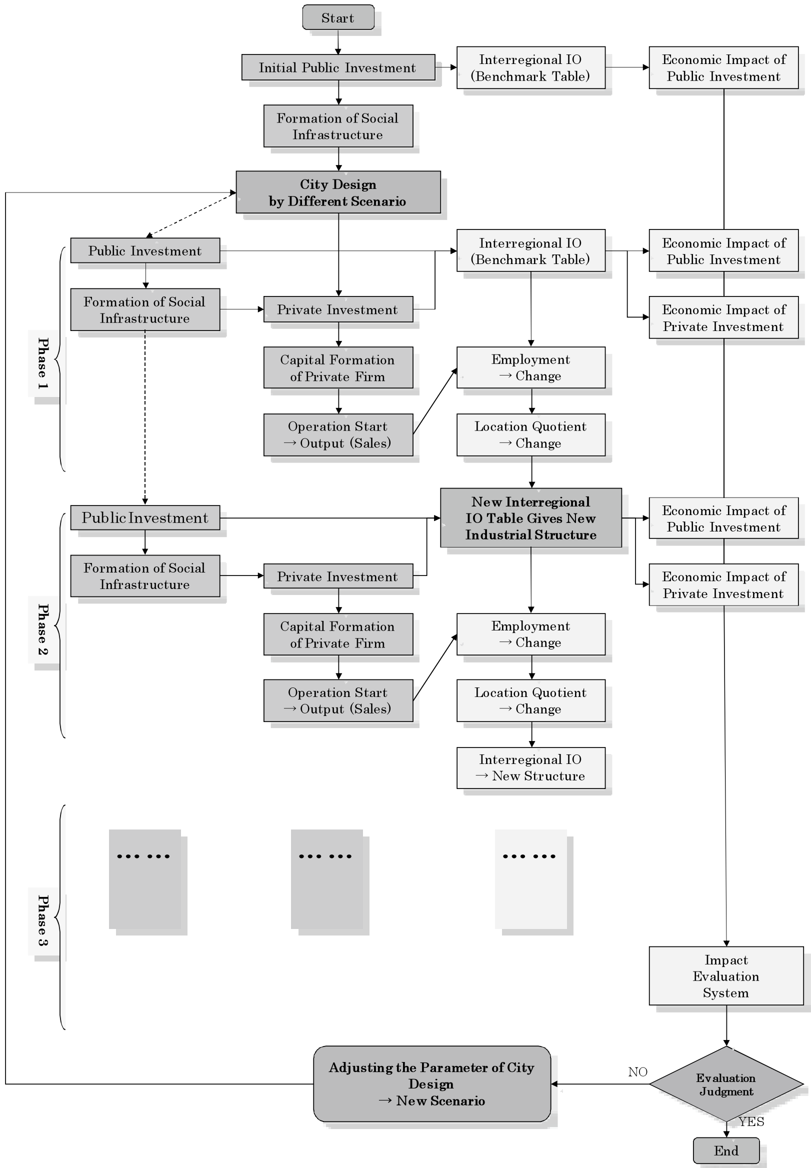
ii. According to government development directions and the completed initial public investment, the city design in different scenarios has been done by our design team. Although the city designs mainly focus on the private sector, the related public sectors are also carefully considered within the whole design.

iii. We separate the whole development period into four phases, each phase covering several years.

iv. At the beginning of Phase 1 the related public investment will be carried out. The economic impact of such investment can be measured by the benchmark interregional IO table.

v. The public investment in Phase 1 will form the related social infrastructure. This

Figure 5 Analysis Framework of the QIRIO Model



infrastructure becomes an important incentive for the private sector to invest in Saemangeum.

vi. The possibility of private investment under the existing and the planned social infrastructure is investigated and discussed, and then the spatial location, the economic scale and the industrial type of the expected private sector are designed. The expected private investment will be used as input data for the economic impact analysis.

vii. The private investment will form the industrial capital stock and then provide the production capacity for the private sector.

viii. Based on the amount of expected private investment, the expected sales can be estimated. Using the employment coefficients calculated from the benchmark interregional IO table, the expected employment will be obtained.

ix. Since the LQ used in our model is based on the relative scale of industrial employment, change in employment will cause a relative change in the LQ.

x. The input coefficients of the IO table are determined by the LQ in our model, and therefore the change in LQ induces the change in input coefficients. Then the new interregional IO table for the next phase can be estimated in terms of the new input coefficients. Such a new table reflects the new spatial production network and industrial structure.

xi. From Phase 2, the impacts of new investment will be evaluated by the updated interregional IO table.

xii. The economic impacts estimated in each phase will be summarized and adjusted under our Impact Evaluation System.

xiii. If the total economic impacts can satisfy our expected results, the evaluation procedure will be finished. Otherwise, we will change the parameter of city design to estimate the impacts of a new design by the same methodology.

The main merits of the above model can be summarized as follows:

i. The impacts of public investment and private investment are estimated separately.

ii. Since the interregional IO table is updated phase by phase, the quasi-dynamic change of industrial structure can be considered explicitly.

iii. According to the simulation results, the city design is adjusted. In this sense, the model provides an interdisciplinary feedback function between city design and economic analysis.

iv. At the end of the procedure, a relatively significant and effective city design can be obtained under the given Saemangeum development directions by government and various budget and resources restrictions.

3. Model

3.1 Static Closed IO Model

The classic Leontief open IO model can be given as follows:

$$X = (I - A)^{-1} \cdot Y \tag{1}$$

where X, A, $(I\text{-}A)^{-1}$ and Y are respectively: the n-sector column vector of gross outputs; the $n \times n$ matrix of input coefficients; the Leontief inverse; and the column vector of final demands.

If the IO table is available, the A matrix can be calculated. Using equation (1), the impact of newly increased exogenous final demand (household expenditure, government expenditure, investment, and exports) on output can be easily measured, namely:

$$\Delta X = (I - A)^{-1} \cdot \Delta Y \qquad (2)$$

In addition, from the IO table, the value added ratio v_i for sector i can be calculated too, and then the impact of final demand on gross value added (GDP) can be measured by the following equation:

$$\Delta GDP = V \cdot (I - A)^{-1} \cdot \Delta Y \qquad (3)$$

where V is the diagonal matrix constructed by v_i.

Furthermore, if supplementary data on employment by sector are available, the impact of final demand on employment can also be estimated with the following equation:

$$\Delta E = L \cdot (I - A)^{-1} \cdot \Delta Y, \qquad (4)$$

where E represents the employment vector, and L represents the diagonal matrix constructed by the employment input ratio l_i.

In the above open model, the household expenditure is regarded as an exogenous variable. However, this "exogenous" categorization is something of a strain on basic economic theory. For grasping the impact of exogenous investment on households' income, one could move the household sector from the final demand column and place it inside the intermediate input table, that is, make it one of the endogenous sectors. This is known as closing the model with respect to households. Such a closed IO model can be written as having the following forms:

$$\acute{X} = (I - \acute{A})^{-1} \cdot \acute{Y} \qquad (5)$$

or

$$\begin{pmatrix} X \\ Xn+1 \end{pmatrix} = \begin{pmatrix} I-A & -C \\ -V & -1 \end{pmatrix}^{-1} \cdot \begin{pmatrix} Y^* \\ Y^*_{n+1} \end{pmatrix} \qquad (5')$$

where $\acute{X}$, $\acute{A}$ and $\acute{Y}$ are respectively the $(n+1) \times 1$ vector of outputs, the $(n+1) \times (n+1)$ matrix of input coefficients, and the $(n+1) \times 1$ vector of final demands. C and V are respectively the household consumption expenditure coefficients (column vector) and income coefficients (row vector)[1]. Y^* is the $n \times 1$ vector of the remaining final demands for the output of the original n sectors.

Using the above equation, the development impacts on output, GDP and employment under the closed model can also be estimated in a similar way, as shown in equations (2), (3) and (4).

---

[1] The total value of household consumption expenditure is used as the CT to estimate its income coefficients according to the industrial wage structure of the IO table. This makes it possible to balance household total consumption expenditure and its disposable income within the IO framework during the target period (normally one year). In this sense, the activity of a household is just to spend a part of its disposal income under the fixed expenditure rates given by the IO table. At the same time, in the absence of survey information, we assume that there are not any transactions for the intra-household sector.

3.2 Quasi-Dynamic Interregional IO Model

Since the Saemangeum development project will not only affect Saemangeum itself but also influences Jeollabuk-do and the rest of the ROK, from a policymaker's or city designer's viewpoint, the national-level IO model is insufficient because it cannot describe the regional disparities that a policy or development plan can bring. This is especially true in countries, like the ROK, which have many provinces. Therefore, the interregional IO model is more preferable for the purpose of our analysis.

For the application of an interregional IO model, the interregional IO table should be given in advance. The widely used methods for the construction of an interregional IO table consist of: 1) survey-based methods, 2) non-survey methods, and 3) hybrid-approach-based methods, which can be regarded as the combination of the former two methods, and sometimes they are also called partial-survey- or semi-survey-based methods. It is highly ideal to conduct a detailed survey on regional purchases and sales by sector or commodity. However, in reality, it is impossible to conduct such a survey frequently, since this kind of survey needs a great amount of time, funding and manpower. Therefore, to make detailed regional economic analysis possible, a non-survey based method, not dependent on a survey, has been developed in the United States, Japan, and Australia, etc. Although the accuracy and reliability of non-survey methods has been widely discussed, in many cases it is the first choice for the regional economist because of the unavailability of data. In addition, it is also very convenient in terms of saving time and money under budget constraints.

Among the non-survey methods used for constructing regional and interregional IO models, the most widely used method is the quotient approach. In the existing literature, a number of variations of the quotient approach have been developed and discussed, which include the Simple Location Quotient, Purchase-only Location Quotient, Cross Industry Quotient, Supply-Demand Approach, Regional Purchase Coefficient, and Fabrication Effect Approach, etc. (see Miller and Blair, 1985). According to empirical work in the United States, in general the Simple Location Quotient method is the best one among the various location quotient techniques (see Schaffer and Chu,1969; Morrison and Smith,1974; Sawyer and Miller,1983; and Miller and Blair, 1985).

For the impact analysis of the Saemangeum project, the following interregional IO model based on the Location Quotient (LQ) method is introduced. Here, assuming that we have only two regions, *R* and *S*, in the nation, we let a_{ij}^{RR} and a_{ij}^{SS} denote the regional input coefficients for regions *R* and *S*, respectively, and t_i^R and t_i^S the self-sufficiency ratio within the region for R and S, and then the tentative regional input coefficient in each region can be given from the national input coefficient (a_{ij}^N) as follows:

$$a_{ij}^{RR} = t_i^R \cdot a_{ij}^N \quad a_{ij}^{SS} = t_i^S \cdot a_{ij}^N \tag{6}$$

Since we assume that there are only two regions in the nation, the interregional commodity input of each region will be shown in the following form:

$$a_{ij}^{SR} = (1 - t_i^R) \cdot a_{ij}^N \quad a_{ij}^{SR} = (1 - t_i^S) \cdot a_{ij}^N \tag{7}$$

Then the tentative interregional input coefficient matrix of the interregional IO model can be given as follows:

$$A' = \begin{pmatrix} A^{RR} & A^{RS} \\ A^{SR} & A^{SS} \end{pmatrix} = \begin{pmatrix} T^{R} & (I-T^{S}) \\ (I-T^{R}) & T^{S} \end{pmatrix} \cdot \begin{pmatrix} A^{N} & 0 \\ 0 & A^{N} \end{pmatrix} \tag{7'}$$

where T is the interregional transaction diagonal matrix constructed by $t_i^R, (k=R \text{ or } S)$. For estimating T, the following method is employed:

$$t_i^k = LQ_i^R, \text{ when } LQ_i^R < 1; \; t_i^k = 1, \text{ when } LQ_i^R \geq 1. \tag{8}$$

GDP, total output and employment data are normally used for calculating LQ. Based on the SFCD, the expected industrial sales are given, which can be used to estimate employment data by the benchmark IO table. Therefore, the employment data is used as the determinant factor in our model. The LQ used is defined as follows:

$$LQ_i^R = \frac{E_j^R / E^R}{E_j^N / E^{N}} \tag{9}$$

where E represents employment. LQ represents the percentage of the region's total active employment compared to that for the nation. It also provides us information on what industry the region has or does not have and the extent to which each industry is under- or over-represented in the region compared to the nation. Furthermore, LQ also represents the trade pattern of that region: if it is larger than or equal to unity, that industry is concentrated in that region compared to the national average and it is considered that the supply of that commodity meets the demand for the commodity within the region, and further, that sector exports the commodity outside the region. If LQ is less than unity, it is viewed as less concentrated in that region and less capable of satisfying the regional demand for its output, and as a result, the commodity is imported from outside region to meet the regional demand for the commodity. Thus, it is assumed that the national coefficient will apply to the region and the regional surplus produced will be exported to the rest of the nation when LQ is greater than 1. On the other hand, the national coefficient will be adjusted downward in the case of LQ less than 1, and the regional coefficients are estimated from the national coefficient by multiplying them by LQ. In other words, LQ denotes the self-coefficient ratio. If LQ is greater than 1, the commodity is produced by using fully domestic intermediate goods. In contrast, if LQ is less than 1, the intermediate goods are imported from another region for production.

Given LQ, we can estimate the interregional input coefficient matrix by adjusting the T matrix in each phase according to equation (7'). The quasi-dynamic determination process is given as follows:

$$T_P = f_1(LQ_p); \; LQ_p = f_2(E_{p-1}) \tag{10}$$

where p represents the phase, f_1 the function relationship between T_p and LQ_p, and f_2 the function relationship between LQ_p and E_{p-1}. Namely, the interregional transaction matrix in phase p is determined by the employment of phase p - 1.

Being similar to the SCIO model, we introduce the household activity into the above model. The closed QIRIO model can be given in the following forms:

$$\acute{X} = (I-A)^{-1} \cdot \acute{Y} \tag{11}$$

or

$$\begin{pmatrix} X^{R} \\ X^{R}_{n+1} \\ X^{S} \\ X^{S}_{n+1} \end{pmatrix} = \begin{pmatrix} 1-A^{RR} & -C^{RR} & -A^{RS} & -C^{RS} \\ -V^{R} & -1 & 0 & 0 \\ -A^{SR} & -C^{SR} & 1-A^{SS} & -C^{SS} \\ 0 & 0 & -V^{S} & -1 \end{pmatrix}^{-1} \cdot \begin{pmatrix} Y^{R*} \\ Y^{R*}_{n+1} \\ Y^{S*} \\ Y^{S*}_{n+1} \end{pmatrix} \tag{11'}$$

3.3 Estimation Method for New Industry Impacts in the IO model

An aerospace industry is proposed for within the SFCD. This industry will be set up *newly* in the target region and the impact will be calculated by our IO model. The input-output model can also provide a framework to assess the economic impact associated with the introduction of a new industry into an economy.

In our model, the final demand approach introduced by Isard and Kuenne (1953) will be used for the new industry impact analysis. At the moment the IO table for the ROK does not have a sector for the aerospace industry. Therefore we have to estimate the IO data for this industry. In practice, we get it from the IO table of other regions or countries (in our case, the United States) and we estimate what and how much the aerospace industry inputs into and from other industries. Assuming that we can estimate the total sales or output for this industry, then we can calculate the new demand on the existing sector in the region by multiplying the input coefficient of the aerospace industry by the estimated total sales as follows:

$$\Delta Y_{iN} = a_{iN} \cdot X_{N}, \tag{12}$$

where ΔY_{iN} is the new demand for commodity i induced by the movement in of the new sector N, a_{iN} is the input coefficient of the new industry's production, and X_N is the estimated total output after the new industry starts production. Then the impact induced by the introduction of the new industry into the region can be estimated with the following model:

$$\Delta X = (I-A)^{-1} \cdot \Delta Y \tag{13}$$

3.4 International IO Link Model

The impact of the Saemangeum development on other countries is also one concern from the international viewpoint. For estimating such impacts, we use the following international-national IO link model.

$$\Delta M = M(I-A)^{-1} \cdot \Delta Y_{SFCD}, \tag{14}$$

where ΔM is the import demand induced by the Saemangeum development, M the dialog matrix of import ratio, A the input coefficients in the national IO table, and ΔY_{SFCD} the investment for the Saemangeum development. In accordance with the above equation, the imports induced by the Saemangeum development can be obtained, which will be used as input data in the following international IO model:

$$\Delta X_{AIO} = (I-A_{AIO})^{-1} \cdot \Delta M', \tag{15}$$

where ΔX_{AIO} is the newly increased outputs in other countries induced by the Saemangeum development via the ROK's imports ($\Delta M'$). A_{AIO} is the input coefficients of the Asian International IO (AIO) table (see IDE-JETRO, 2003). It should be noted that $\Delta M'$ is the increased imports into the ROK by country (other countries' exports), which is obtained by splitting ΔM into the ten economies of the AIO table in terms of the ROK's import shares by origin.

4. Data Collection and Estimation

4.1 Basic Configuration of the Data

1) Sector classification

Considering the requirements of the SFCD, the model size and the data availability, a 40-sector classification is adopted in our models. These 40 sectors are completely consistent with the 76-sector classification used in the AIO table. The detailed description of sectors and the concordance codes are shown in Table 1.

Table 1 Sector Classification

KIO code	Description	AIO code
1	Grain	001, 002
2	Food crops	003
3	Non-food crops	004
4	Other agriculture and forestry, fisheries	005-007
5	Mining	008-011
6	Milled grain and flour	012
7	Fish and meat products	013, 014
8	Food products	015
9	Other food products	016, 017
10	Apparel products	018-023
11	Other light industry	024-028
12	Industrial chemicals	029, 030
13	Chemical fertilizer and pesticides	031
14	Drugs and medicine	032
15	Other chemicals	033-037
16	Non-metal products	038-040
17	Metal products	041-043
18	Machinery	044-048
19	TV, audio and communication equipment	049
20	Electronic computing equipment	050
21	Semiconductors and integrated circuits	051
22	Other electronic products	052-054
23	Motor vehicles	055
24	Other transport equipment	056-058
25	Other manufactured goods	059-060
26	Electricity and gas	061
27	Water supply	062
28	Building construction	063
29	Other construction	064
30	Wholesale and retail trade	065
31	Transportation	066
32	Telephone and telecommunication	067
33	Finance and insurance	068
34	Real estate	069
35	Education and research	070
36	Medical and health services	071
37	Restaurants	072
38	Hotels	073
39	Other services	074
40	Public administration and unclassified	075-076

2) Spatial dimensions

In line with the model requirements and the data availability, the following three dimensions are used in our analysis: (a) the national level: the whole ROK economy; (b) the domestic regional level: Jeollabuk-do and the rest of the ROK; and (c) the international level: the Asia-Pacific region covered in the AIO table.

3) Development periods

According to the SFCD created by our design team, we separate Saemangeum's development period into the following four phases: Phase 1 (2008-2012); Phase 2 (2013-2015); Phase 3 (2016-2020); and Phase 4 (2021-2030).

4) Currency unit and time discount rate

For simplicity of international comparison, the US dollar is used as the common currency unit in our analysis. The exchange rates among different national currencies are the monthly average values in June 2008 based on the IFS (International Financial Statistics service of the International Monetary Fund) data. In addition, since the Saemangeum development project will last to 2030, the future economic impacts are estimated at the present value. For simplicity, the time discount rate used is based on the average interest rate published by the Bank of Korea. The detailed information is shown below:

1 US dollar = 1029.27 ROK won
1 Japanese yen = 9.63 ROK won
The yearly time discount rate = 5.5%

4.2 Data Requirements

1) ROK national IO table

The 2000 AIO table is available to us, which includes an ROK component. Therefore, aggregating the original 76 sectors of the AIO table into 40 sectors, we are able to obtain an ROK national IO table. This table is used as the benchmark data for the SCIO model.

2) Interregional IO table for Jeollabuk-do and the rest of the ROK

The IO table for Jeollabuk-do and the rest of the ROK is estimated by the so-called non-survey-based methodology (for a detailed introduction of the non-survey-based methodology, one can refer to the previous section). The main control totals (CTs) used for the estimation are the data from the ROK national IO table and the officially published statistical data (output, final demand, and GDP, etc.) of Jeollabuk-do. This table is used as the benchmark data for the QIRIO model. The layout of the interregional table is shown in Figure 6.

3) Asian International IO (AIO) Table

The AIO table is compiled by the Institute of Developing Economies (IDE). This table covers ten economies (the ROK, China, Taiwan, the Philippines, Malaysia, Singapore, Thailand, Indonesia, Japan and the United States) and 76 sectors. For detailed information, one can refer to IDE's Statistical Data Series (see IDE-JETRO, 2003). The 2000 AIO table is used as the benchmark data for the international IO link model.

4) Investment in social infrastructure and industrial investment

The investment in social infrastructure is mainly estimated from the governmental officially published development plan, and the industrial investment is based on the Facility List (see Tsukamoto, 2008b) estimated by our design team. The investment is considered as an exogenous variable and is used as the input data for the economic impact analysis. The related information is summarized in Tables 2 and 3.

The expected industrial investment is mainly estimated by our design team. Based on the existing literature (see Erenburg,1993, Monadjemi, 1996), we use the average investment inducement coefficient to fix the total private investment expected. Then the detailed programs of the SFCD are designed within the total private investment scale. In addition, for detailed estimation, the scale of land use, the limitations of the population capacity, the feasibility of spatial design and other related information are also used as constraint conditions.

Figure 6 Layout of Jeollabuk-do-Rest of ROK Input-Output Table

			Intermediate Demand (A)		Final Demand (F)		Exports		
			Jeollabuk-do	Rest of ROK	Jeollabuk-do	Rest of ROK	Exports to RoW	Discrepancy	Total Outputs
		Code	(AJ)	(AK)	(FJ)	(FK)	(LW)	(QX)	(XX)
	Jeollabuk-do	(AJ)	A^{JJ}	A^{JK}	F^{JJ}	F^{JK}	L^{JW}	Q^{J}	X^{J}
	Rest of ROK	(AK)	A^{KJ}	A^{KK}	F^{KJ}	F^{KK}	L^{KW}	Q^{K}	X^{K}
Freight and Insurance		(BF)	BA^{J}	BA^{K}	BF^{J}	BF^{K}			
Imports from RoW		(CW)	A^{WJ}	A^{WK}	F^{WJ}	F^{WK}			
Duties & Import Taxes		(DT)	DA^{J}	DA^{K}	DF^{J}	DF^{K}			
Value Added		(VV)	V^{J}	V^{K}					
Total Inputs		(XX)	X^{J}	X^{K}					

Table 2 The Investment in Social Infrastructure

(million US$)

	Phase 1	Phase 2	Phase 3	Phase 4	Total
Coast reclamation and seawall	1,265	1,442	171	151	3,029
Roads	0	2,646	1,824	1,824	6,293
Lifelines	0	2,514	1,732	1,732	5,978
Railways	0	1,410	0	0	1,410
Bridges	0	60	0	0	60
Green belts	0	603	602	602	1,807
Total	1,265	8,674	4,329	4,309	18,577

Table 3 Expected Industrial Investment based on the SFCD

(million US$)

	Sector	Total	Phase 1	Phase 2	Phase 3	Phase 4
1	Grain	0	0	0	0	0
2	Food crops	0	0	0	0	0
3	Non-food crops	976	0	976	0	0
4	Other agriculture and forestry, fisheries	0	0	0	0	0
5	Mining	0	0	0	0	0
6	Milled grain and flour	125	0	0	125	0
7	Fish and meat products	99	0	0	99	0
8	Food products	936	0	0	936	0
9	Other food products	201	0	0	201	0
10	Apparel products	0	0	0	0	0
11	Other light industry	0	0	0	0	0
12	Industrial chemicals	0	0	0	0	0
13	Chemical fertilizer and pesticides	0	0	0	0	0
14	Drugs and medicine	1,270	0	0	1,270	0
15	Other chemicals	50	0	0	50	0
16	Non-metal products	0	0	0	0	0
17	Metal products	0	0	0	0	0
18	Machinery	1,174	0	0	1,113	60
19	TV, audio and communication equipment	102	0	0	102	0
20	Electronic computing equipment	0	0	0	0	0
21	Semiconductors and integrated circuits	0	0	0	0	0
22	Other electronic products	0	0	0	0	0
23	Motor vehicles	1,939	0	1,939	0	0
24	Other transport equipment	300	0	58	0	241
25	Other manufactured goods	181	0	181	0	0
26	Electricity and gas	0	0	0	0	0
27	Water supply	0	0	0	0	0
28	Building construction	0	0	0	0	0
29	Other construction	0	0	0	0	0
30	Wholesale and retail trade	2,687	124	2,538	25	0
31	Transportation	9,476	0	9,476	0	0
32	Telephone and telecommunication	0	0	0	0	0
33	Finance and insurance	25	0	0	25	0
34	Real estate	17,328	0	7,050	5,850	4,429
35	Education and research	3,556	0	769	1,770	1,017
36	Medical and health services	333	0	161	25	148
37	Restaurants	524	524	0	0	0
38	Hotels	4,916	3,859	558	196	303
39	Other services	9,416	4,362	1,074	3,299	681
40	Public administration and unclassified	6,605	0	265	23	6,316
	Total	62,219	8,868	25,047	15,110	13,195

5) The input and sales structure of the aerospace industry

The aerospace industry is one of the key sectors in the SFCD. For estimating the economic impact of this new industry, the information on its input and sales structure should be given in advance. However, such information for the ROK is not available to us. Since the United States has such an industry, its input and sales structure can be used as alternative information. The detailed information is estimated from the US 1997 IO table, in which two aerospace-related industries are identified separately, namely, guided missile and space vehicle manufacturing (UIO354) and propulsion units and parts for space vehicles and guided missiles (UIO355).

6) The expenditure structure of foreign tourism

The impact of foreign tourism on Saemangeum is also a major concern for the local government. For estimating such an impact, information on the expenditure structure of foreign tourism is required. Since it is difficult to obtain the relevant data from the ROK statistics at present, the Japanese expenditure structure in foreign countries is used as proxy data. Tourism from China also has great potential; however, the existing statistical data is very rough, so for simplicity, we assume that Chinese tourists have a similar overseas expenditure preference to the Japanese.

5. Simulation Analysis

5.1 Simulation Analysis based on the Static Closed IO Model

In this section, we would like to simulate the size of impacts by using a static IO model. The total economic impacts of the Saemangeum project evaluated by the SCIO model are shown in Table 4. The total impact on GDP is US$87,833 million, which is roughly 9.05% of ROK GDP for 2007 (US$970 billion). The yearly average contribution of total investment to ROK GDP is US$3,819 million, which is roughly 0.39% of ROK GDP. The total impact on employment shows that the Saemangeum project will give rise to 4,159,621 job opportunities during the project period. This also means that there will be newly increased employment of 180,853 persons every year. In addition, Table 4 also shows that the "Private/Public" ratio for employment is greater than the ratios for GDP and other items. This means that the public investment in Saemangeum is GDP-oriented, and the private investment is employment creation-oriented.

Figure 7 shows the detailed impacts on GDP for 40 sectors. Since the investment in Saemangeum during the development period is mainly used in the construction industry, it is easy to understand that the sectors of "Building construction" and "Other construction"

Table 4 Total Economic Impacts under the SCIO Model

(million US$)

	Total impacts for the whole development period (2008-2030)			
	Investment	Output	GDP (Income)	Employment (persons)
Public	18,577	65,758	21,272	889,688
Private	62,219	213,598	66,562	3,269,934
Total (Public + Private)	80,796	279,356	87,833	4,159,621
Private / Public (rate)	3.35	3.25	3.13	3.68
	Yearly average impacts			
	Investment	Output	GDP (Income)	Employment (persons)
Public	808	2,859	925	38,682
Private	2,705	9,287	2,894	142,171
Total (Public + Private)	3,513	12,146	3,819	180,853

Figure 7 Impacts of Total Investment on Sectoral GDP

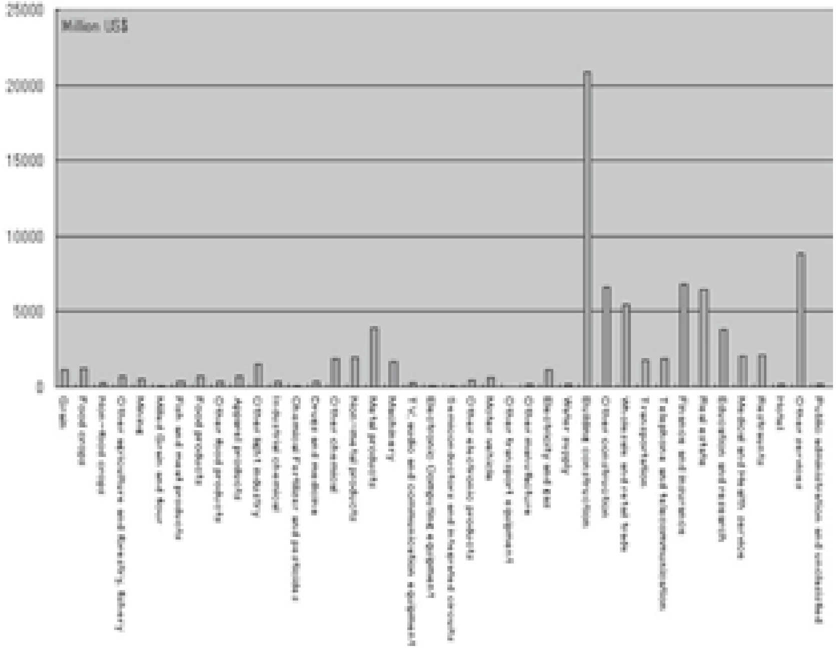
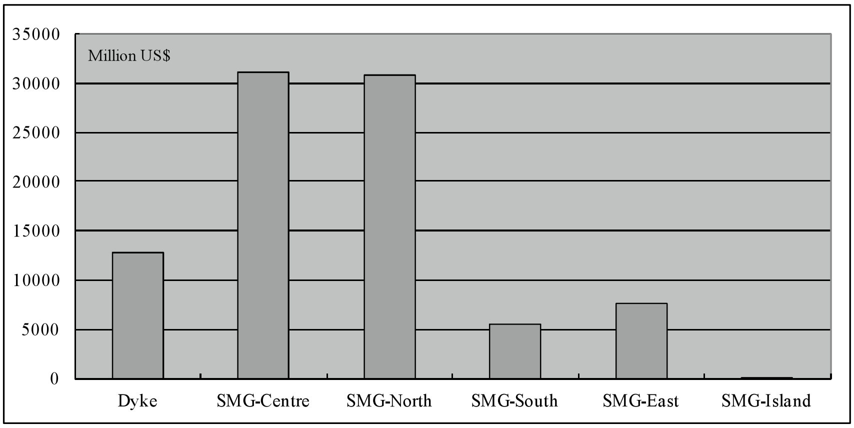


Figure 8 Impacts of Private Investment on GDP by Area



will sustain large impacts. The construction investment will cause new intermediate demand for goods and services, and subsequently the new GDP of other related sectors will be induced by way of inter-industry production networks. Therefore, we can also see from Figure 7 that “Other services”, “Finance and insurance”, “Real estate”, and “Wholesale and retail trade” show relatively strong GDP impacts, followed by “Metal products”, “Machinery” and “Other Chemical”. For detailed results of the impacts on output, GDP and employment, one can refer to Table A1 (Appendix).

Figure 8 shows the impacts of private investment on GDP by area. The center and north of Saemangeum clearly enjoy relatively greater benefit than the east and south. This is mainly due to the differences in industrial location and investment scale.

5.2 Simulation Analysis based on the Quasi-Dynamic Interregional IO Model

5.2.1 Evaluation of the SFCD

Supposing that investment in each phase is performed as in Table 3, employment consequently changes in each phase. The variation in employment changes LQ. Then the new LQ is used to construct a new interregional IO table for each phase. Table 5 shows the multipliers taken out from the Leontief inverse matrix of the interregional IO model. Since the household sector is used as an endogenous variable in our model, the income multiplier and industry multiplier can be calculated in one model at the same time. AJ and AK represent Jeollabuk-do and the rest of the ROK, respectively.

Looking first at the results from the income multiplier, at present for the SFCD the income multiplier for Jeollabuk-do only increases without having any influence on the rest of the ROK in Phase 1. The income multiplier in the Jeollabuk-do area rises to 1.464 in Phase 2, and the spillover effect (interregional impact) on the rest of the ROK is also at the largest, at 0.314. For the rest of the ROK, in Phase 3 and Phase 4 the multiplier inside the region rises to 1.736 and the spillover effect on Jeollabuk-do increases to 0.055, and it is the largest figure among the phases. Here we look at the industry multiplier. In Phase 1, the multiplier for Jeollabuk-do goes up from 2.136 to 2.152. It reaches 2.168, its highest point, in Phase 2. Although it then decreases in Phase 3 and Phase 4, the multiplier for the rest of the ROK meanwhile reaches 2.910, its highest point, in Phase 3. Moreover, the spillover effect on Jeollabuk-do also rises to 0.157. The following summarizes the above results:

Phase 1: The effect of development appears only in Jeollabuk-do.
Phase 2: Industry output and income impacts are the greatest in Jeollabuk-do.
Phase 3: The effect of development spreads to the rest of the ROK. Industry output and income impacts are greatest in the rest of the ROK. The connection between Jeollabuk-do and the rest of the ROK becomes close.
Phase 4: The connection between Jeollabuk-do and the rest of the ROK is still close.

Table 5 Income and Industry Multipliers in the QIRIO Model

		Income multiplier		Industry multiplier	
Initial		AJ	AK	AJ	AK
	AJ	1.453	0.029	2.136	0.081
	AK	0.299	1.725	0.821	2.882
Phase 1	AJ	1.462	0.029	2.152	0.080
	AK	0.302	1.725	0.829	2.883
Phase 2	AJ	1.464	0.029	2.168	0.081
	AK	0.314	1.727	0.860	2.885
Phase 3	AJ	1.461	0.055	2.156	0.157
	AK	0.312	1.736	0.853	2.910
Phase 4	AJ	1.460	0.055	2.153	0.157
	AK	0.312	1.736	0.852	2.910

5.2.2 Impact of investment in social infrastructure and private industry

Table 6 shows the total impacts evaluated by the QIRIO model. The total impacts on output, GDP and employment are, respectively, US$193,294 million, US$59,231 million, and 2,820,035 persons, all lower than the impacts under the SCIO model (see Table 4). Since the aspects of time and space are ignored in the SCIO model this means that the average production technology of the ROK is adopted for Jeollabuk-do in the SCIO model. However, the real industrial structure and technology of Jeollabuk-do is far from the ROK's national level, and as a result the impacts will be overestimated in the SCIO model. Therefore, it can be concluded that the QIRIO model is a more rational and reliable method for economic impact analysis.

The detailed impact by investment in both social infrastructure and private industry is shown in Table 7. The total output in industrial sector and income in the household sector

Table 6 Total Economic Impacts estimated by the QIRIO Model

(million US$)

	Total impacts for the whole development period (2008 - 2030)			
	Investment	Output	GDP (Income)	Employment (persons)
Public	18,577	46,070	14,288	673,750
Private	62,219	147,224	44,943	2,146,285
Total (Public + Private)	80,796	193,294	59,231	2,820,035
Private / Public (rate)	3.35	3.17	3.15	3.19
	Yearly average impacts			
	Investment	Output	GDP (Income)	Employment (persons)
Public	808	2,003	621,021	29,294
Private	2,705	6,401	1,954	93,317
Total (Public + Private)	3,513	8,404	2,575	122,610

Table 7 The Economic Impacts estimated by the QIRIO Model

(million US$)

Economic impacts of social infrastructure-related investment													
		Total output				Value added				Employment (persons)			
		Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
Jeollabuk-do	Industry	1,769	12,442	6,192	6,069	560	3,975	1,964	1,927	28,460	202,085	101,400	99,597
	Household	1,009	7,051	3,499	3,456								
Rest of ROK	Industry	1,308	9,101	4,628	4,561	392	2,729	1,381	1,361	16,168	112,628	57,106	56,306
	Household	392	2,729	1,381	1,361								
Total		4,477	31,323	15,701	15,447	952	6,703	3,345	3,289	44,627	314,713	158,506	155,903

Economic impacts of industrial investment													
		Total output				Value added				Employment (persons)			
		Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
Jeollabuk-do	Industry	11,353	32,736	19,649	16,964	3,538	10,298	6,149	5,313	184,417	536,601	325,935	281,768
	Household	6,416	18,425	11,051	9,594								
Rest of ROK	Industry	9,342	26,676	16,332	14,173	2,761	7,893	4,814	4,178	114,845	328,231	200,467	174,021
	Household	2,761	2,761	2,761	2,761								
Total		29,871	85,729	51,847	44,909	6,299	18,191	10,963	9,491	299,262	864,832	526,402	455,788

in Jeollabuk-do, induced by the investment for social infrastructure, are respectively, in million US$: 1,769 and 1,009 in Phase 1; 12,442 and 7,051 in Phase 2; 6,192 and 3,499 in Phase 3; and 6,069 and 3,456 in Phase 4. The biggest impact will appear in Phase 2. With regard to job creation in Jeollabuk-do, 28,460 jobs will be generated in Phase 1; 202,085 in Phase 2; 101,400 in Phase 3; and 99,597 in Phase 4.

The total output in industrial sector and income in household sector in Jeollabuk-do, induced by the investment of private industry, are respectively, in million US$: 11,353 and 6,416 in Phase 1; 32,736 and 18,425 in Phase 2; 19,649 and 11,051 in Phase 3; and 16,964 and 9,594 in Phase 4. The biggest impact will appear in Phase 2, in the same way as for social infrastructure. With regard to job creation in Jeollabuk-do, 184,417 jobs will be generated in Phase 1; 536,601 in Phase 2; 325,935 in Phase 3; and 281,768 in Phase 4. The impacts in Jeollabuk-do stimulate the total output, income, GDP and employment of the rest of the ROK. This means that the development of Saemangeum induces not only the growth of the Jeollabuk-do economy, but also that of the economy of the entire country.

5.2.3 The economic impacts of the movement in of the aerospace industry

As a special feature of the Saemangeum development, the aerospace industry is a big attraction. We also measured the influence of the aerospace industry on Saemangeum. The results are shown in Table 8.

A portion of the factories in the aerospace industry will begin operation in Phase 2. The estimated sales are respectively, in million US$: 524 (Phase 2); 383 (Phase 3); and 531

Table 8 The Economic Impacts of the Aerospace Industry

(million US$)

		Impact on Output			
		Phase 1	Phase 2	Phase 3	Phase 4
Jeollabuk-do	Industry	0	862	625	868
	Household				
Rest of ROK	Industry	0	486	352	489
	Household				
Total		0	2,001	1,453	2,018

		Impact on GDP			
		Phase 1	Phase 2	Phase 3	Phase 4
Jeollabuk-do	Industry	0	267	194	269
	Household				
Rest of ROK	Industry	0	147	107	148
	Household				
Total		0	414	300	417

		Impact on Employment			
		Phase 1	Phase 2	Phase 3	Phase 4
Jeollabuk-do	Industry	0	13,936	10,114	14,038
	Household	0	507	369	512
Rest of ROK	Industry	0	6,033	4,379	6,083
	Household	0	147	107	148
Total		0	19,969	14,493	20,121

Table 9 The Economic Impacts of Tourism

(million US$)

	Impact on Output			
	Phase 1	Phase 2	Phase 3	Phase 4
Jeollabuk-do	9,023	10,130	15,230	19,172
Rest of ROK	1,231	1,382	2,088	2,643
Total	10,254	11,512	17,317	21,815
	Impact on GDP			
	Phase 1	Phase 2	Phase 3	Phase 4
Jeollabuk-do	2,976	3,348	4,981	6,353
Rest of ROK	352	396	595	755
Total	3,328	3,744	5,576	7,108
	Impact on Employment (persons)			
	Phase 1	Phase 2	Phase 3	Phase 4
Jeollabuk-do	228,407	256,552	383,155	490,252
Rest of ROK	12,553	14,107	21,215	26,923
Total	240,960	270,658	404,370	517,175

(Phase 4). Intermediate materials are needed for the operations of the aerospace industry. Intermediate-materials purchases serve as a generator of final demand. The total output of Jeollabuk-do for meeting final demand is, in million US$: 852 (Phase 2); 625 (Phase 3); and 858 (Phase 4). On the other hand, the income generated for the residents of Jeollabuk-do is, in million US$: 507 (Phase 2); 369 (Phase 3); and 512 (Phase 4). GDP of US$194-289 million dollars has also resulted from the activity of the industry, and the figures are by no means small.

Looking at employment, the aerospace industry also contributes to the economy of Jeollabuk-do in employment expansion. The job creation effect is 13,936 (Phase 2), 10,114 (Phase 3), and 14,038 (Phase 4) new jobs. So, 10,000 or more job opportunities are created by the aerospace industry in each phase.

5.2.4 The economic impacts of tourism

In our city design, the tourism industry is one of the most important programs. In order to analyze its impact via the expenditure of foreign (especially Chinese) travellers, we use the ROK's interregional open IO model excluding the household sector because the consumption expenditure of foreign guests is regarded as the final demand. The impact of tourism by phase is shown in Table 9.

The expected number of visitors in our design is 11.8 million people for Phase 1, 13.2 million for Phase 2, 19.7 million for Phase 3 and 25.2 million for Phase 4. Assuming that visitors spend US$500 (from the figure in Las Vegas), the GDP in Jeollabuk-do will increase by US$2,976 million in Phase 1, US$3,348 million in Phase 2, US$4,981 million in Phase 3 and US$6,353 million in Phase 4. Compared with US$23,873 million, the GDP of Jeollabuk-do in 2005, the tourism industry will increase GDP by approximately 3.6% per year. As for job creation, there will be 228,000 jobs in Phase 1, 257,000 in Phase 2, 383,000 in Phase 3 and 490,000 in Phase 4. Considering the fact that there were 2,280,000 persons employed in Jeollabuk-do in 2005, the tourism industry increases the number of jobs by the same percentage as GDP. If part of this economic benefit becomes income for local government in Jeollabuk-do, it will contribute to the Saemangeum development as treasury funds.

5.3 Impacts of the Saemangeum Development on Other Countries

The induced imports by origin and sector are shown in Table 10. The Saemangeum development will increase imports US$18,027 million, which are mainly from China (US$9,190 million), Japan (US$3,677 million) and the United States (US$3,109 million), followed by Indonesia, Singapore, Taiwan, Malaysia, Thailand and the Philippines. The major goods imported from China are: "Metal products", "Other chemical", "Apparel products", "Industrial chemical" and "Other light industrial goods"; the major goods shipped from Japan are: "Other chemical", "Metal products", "Machinery", "Other electronic products" and "Motor vehicles"; imports from the United States are similar to

Table 10 Induced Imports by Origin and Sector

(million US$)

Sector	China	Indonesia	Japan	Korea (ROK)	Malaysia	Taiwan	Philippines	Singapore	Thailand	USA	Total
1	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	15.1
2	3.0	1.0	0.2	0.0	0.5	0.0	3.3	0.0	0.3	15.3	23.5
3	1.1	0.8	0.2	0.0	0.1	0.1	0.0	0.0	0.4	2.6	5.3
4	13.4	1.6	8.2	0.0	5.8	1.5	0.1	0.2	0.3	18.5	49.6
5	7.6	1.4	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.1	9.6
6	0.8	21.4	0.1	0.0	0.0	0.0	1.4	0.1	11.4	7.6	42.7
7	20.0	0.6	2.1	0.0	0.1	0.7	0.4	0.2	3.4	61.9	89.4
8	99.2	13.8	24.0	0.0	28.4	6.3	11.4	4.4	25.3	127.1	339.9
9	1.2	0.1	14.6	0.0	0.6	0.1	0.2	1.4	0.0	8.3	26.4
10	459.2	21.9	35.3	0.0	2.3	28.4	0.6	0.3	8.0	22.8	578.7
11	135.8	114.8	72.8	0.0	49.5	5.2	0.8	5.0	18.9	240.3	643.1
12	344.5	9.8	266.3	0.0	5.5	14.1	1.4	10.0	7.3	160.6	819.3
13	2.5	5.1	9.5	0.0	3.0	0.3	0.2	0.0	0.0	44.6	65.2
14	9.9	0.8	29.6	0.0	0.2	1.3	0.0	7.1	0.4	28.6	77.9
15	3,178.8	268.0	1,040.5	0.0	108.8	83.5	18.6	218.7	81.1	901.3	5,899.3
16	65.6	15.8	182.5	0.0	3.9	8.0	0.7	4.7	9.1	96.5	386.8
17	3,732.0	26.4	957.3	0.0	25.1	54.6	3.4	39.7	7.0	299.4	5,144.9
18	194.3	2.4	331.0	0.0	7.7	16.2	0.3	13.1	7.6	191.2	763.8
19	111.0	3.5	13.1	0.0	25.1	42.5	5.3	8.2	7.6	351.8	567.9
20	70.4	2.1	49.9	0.0	53.4	38.8	11.1	77.7	30.5	72.6	406.5
21	52.8	0.0	26.1	0.0	8.5	9.8	5.1	6.3	2.1	41.0	151.9
22	59.1	0.2	255.5	0.0	40.2	60.8	1.5	6.8	4.8	41.3	470.1
23	8.9	0.2	127.8	0.0	0.0	0.5	0.1	0.1	1.1	53.9	192.6
24	0.6	0.0	0.6	0.0	0.0	0.2	0.0	0.2	0.0	11.5	13.1
25	19.7	0.4	35.9	0.0	0.5	3.2	1.3	2.0	0.9	53.6	117.4
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	334.8	10.2	140.1	0.0	6.8	15.5	10.9	9.0	6.1	152.5	685.9
31	254.0	12.8	53.5	0.0	4.5	5.6	7.8	1.5	3.4	98.5	441.6
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	9,190.2	534.9	3,676.6	0.0	380.9	397.1	85.8	416.6	236.9	3,108.5	18,027.5

Table 11 The Spillover Effects on Other Countries

(million US$)

Sector	China	Indonesia	Japan	Korea (ROK)	Malaysia	Taiwan	Philippines	Singapore	Thailand	USA	Total
1	162.8	18.3	3.8	0.4	0.6	0.2	1.2	0.0	9.0	23.0	219.2
2	83.7	7.6	4.6	0.3	6.3	0.2	6.8	0.0	6.5	30.1	146.2
3	76.6	16.5	1.8	0.1	8.2	0.6	0.2	0.1	8.6	20.7	133.4
4	261.7	21.3	20.6	0.9	23.8	3.6	0.7	0.2	3.9	88.9	425.6
5	1,548.3	158.9	20.9	1.7	53.6	5.5	1.7	0.2	11.6	263.0	2,065.3
6	38.1	24.0	4.5	0.4	0.6	0.3	2.2	0.1	14.5	10.5	95.2
7	57.2	2.7	10.2	0.7	0.6	1.3	0.7	0.3	4.8	80.0	158.5
8	166.7	25.2	42.4	1.2	60.4	10.0	14.8	5.3	29.1	164.6	519.7
9	50.6	0.5	27.1	0.4	1.1	0.1	0.3	1.9	0.3	9.6	91.9
10	1,200.6	34.9	87.5	27.4	4.7	66.0	1.1	0.9	14.9	50.8	1,488.9
11	431.6	148.9	249.4	12.1	65.7	20.9	1.8	8.9	26.8	414.4	1,380.5
12	1,092.7	42.7	775.4	110.0	23.4	99.8	2.9	25.3	22.9	438.4	2,633.5
13	89.0	6.7	16.5	0.5	4.7	1.0	0.4	0.0	0.4	64.9	184.1
14	31.6	1.3	34.2	0.2	0.3	1.7	0.1	7.3	0.5	34.9	112.0
15	5,159.1	291.0	1,443.5	73.4	153.4	153.7	26.4	271.6	107.1	1,186.5	8,865.7
16	247.2	16.9	247.9	4.3	6.9	15.8	1.1	5.7	11.0	130.2	687.0
17	6,032.8	38.0	1,808.5	85.7	45.7	156.0	5.9	51.6	15.3	599.6	8,839.2
18	714.1	9.1	548.6	16.3	12.3	35.1	0.6	20.2	12.8	295.0	1,664.2
19	198.9	4.3	36.3	5.6	29.9	50.2	5.6	17.2	8.7	386.9	743.5
20	111.0	4.1	81.0	3.8	66.8	61.9	12.7	122.8	46.2	94.2	604.7
21	156.8	0.6	96.2	33.8	37.4	37.9	18.9	31.4	9.1	124.5	546.6
22	364.6	1.5	488.6	19.7	44.6	93.9	2.5	9.7	10.8	109.4	1,145.4
23	291.8	5.8	272.1	2.1	1.8	5.7	0.3	1.0	4.7	106.2	691.5
24	58.5	3.5	10.3	0.3	0.6	1.4	0.0	1.3	0.3	18.9	95.2
25	120.5	0.8	62.8	2.5	6.2	5.9	2.0	3.4	2.3	74.3	280.6
26	1,174.3	8.1	207.6	11.7	11.2	8.5	3.7	5.9	11.2	102.9	1,545.0
27	47.2	0.2	22.4	0.3	1.2	0.4	0.3	0.3	0.4	4.0	76.7
28	54.3	1.2	66.5	1.1	0.4	4.4	0.0	0.8	0.2	21.6	150.4
29	9.1	2.8	0.0	0.0	2.5	3.0	0.4	1.3	0.0	0.3	19.5
30	1,114.7	51.7	555.0	17.1	45.5	69.2	20.1	49.1	38.3	463.1	2,423.9
31	742.7	38.4	261.5	8.8	15.9	29.4	10.9	15.7	11.5	342.8	1,477.6
32	236.8	3.1	67.2	3.4	2.7	6.1	1.1	4.6	2.2	60.8	388.2
33	384.6	12.2	192.1	10.8	5.2	29.0	3.2	20.8	5.3	133.5	796.7
34	61.9	4.1	60.5	4.4	3.1	8.7	1.3	9.7	0.8	87.4	241.9
35	30.9	0.3	9.9	3.9	0.6	0.5	0.0	0.4	0.5	40.7	87.8
36	8.7	0.4	4.4	0.2	0.0	1.2	0.1	1.0	0.2	0.2	16.4
37	142.3	3.6	74.2	3.5	2.7	0.9	0.9	3.0	1.4	21.6	254.1
38	31.4	0.3	21.6	0.3	1.3	0.7	0.1	0.1	0.3	10.8	66.9
39	352.3	8.8	379.3	12.3	14.8	39.9	4.5	24.1	7.0	498.9	1,341.9
40	4.3	1.3	47.3	0.5	0.5	11.7	0.2	3.1	1.6	23.0	93.5
Total	23,142.3	1,021.5	8,364.0	482.3	767.4	1,042.5	158.0	726.2	462.7	6,631.1	42,798.0

for Japan. These imports will be the exports of the counterpart countries. For producing such export goods, new outputs will be induced in each counterpart country. Such output impacts via imports or exports are normally called spillover impacts in IO analysis. Table 11 shows the detailed spillover impacts by country and sector. China, Japan and the United States will enjoy relatively large spillover impacts from the Saemangeum development project followed by Taiwan, and Indonesia, etc. At the sectoral level, "Other chemical", "Metal products", "Industrial chemical", "Mining", "Machinery", and "Electricity and gas" show relatively high output impacts.

5.4 Simulation Analysis based on Different Scenarios

Different city designs will have different economic impacts. The SFCD proposed is just one of the possible design options. For checking the performance of such a design, we should compare its economic impacts with other possible designs.

The public investment for social infrastructure is basically fixed for each possible

Table 12 Different Industrial Investment Scenarios

(million US$)

Sector	Manufacturing-oriented (Taiwan)	Agriculture-oriented (Philippines)	Foreign-dependent (Singapore)
1	153	1,412	0
2	366	1,786	0
3	198	193	39
4	975	2,884	49
5	0	0	0
6	223	2,654	32
7	803	2,313	97
8	959	4,701	317
9	446	1,104	254
10	2,644	1,687	379
11	1,487	974	800
12	2,024	256	1,292
13	80	86	0
14	188	311	626
15	3,513	3,268	6,005
16	898	584	276
17	4,130	988	1,462
18	2,709	453	1,839
19	1,188	241	1,643
20	3,317	568	7,879
21	2,168	7,360	5,407
22	4,246	815	757
23	1,536	832	220
24	902	130	1,017
25	873	1,824	660
26	0	0	0
27	0	0	0
28	0	0	0
29	0	0	0
30	5,876	7,472	8,067
31	2,887	2,699	5,318
32	1,034	794	1,018
33	3,425	2,372	4,609
34	966	3,053	3,300
35	1,607	2,057	227
36	1,121	1,264	913
37	836	1,436	1,371
38	177	264	324
39	8,266	3,385	6,023
40	0	0	0
Total	62,219	62,219	62,219

design, therefore the main proxy reflecting the difference among the possible city designs should be the industrial investment. Table 12 gives three different scenarios which respectively represent three different industrial investment patterns. Scenario 1 is a "Manufacturing-oriented-type city", which is based on Taiwan's industrial structure; scenario 2 shows an "Agriculture-oriented-type city", which is based on the Philippines's industrial structure; and scenario 3 reflects a "Foreign-dependent-type city", which is based on Singapore's industrial structure. For simplicity of comparison the total amount of industrial investment is fixed for each scenario, which is the same as that used in the SFCD.

The economic impacts based on different investment patterns can be estimated by the IO model we proposed in the previous sectors. The simulation results based on the different scenarios are shown in Table 13. Obviously, the SFCD gives the largest impacts

Table 13 Simulation Analysis based on Different Scenarios

(million US$)

Impact on →	Output	GDP	Employment (persons)
SFCD	147,224	44,943	2,146,285
Manufacture-oriented (Taiwan)	149,441	44,049	1,797,843
Agriculture-oriented (Philippines)	139,444	41,354	1,645,269
Foreign-dependent (Singapore)	152,592	44,491	1,902,323

on employment and GDP compared to other scenarios. The output impact of the SFCD is less than that of the "Manufacture-oriented-type city" and "Foreign-dependent type city". If a policymaker's purpose is to maximize output, the design which gives relatively large output impacts may be the best choice. However, in many cases, GDP and employment are more meaningful and desirable indices to be used, since they are closer to the concept of social welfare. In this sense, the SFCD seems to be a good choice.

6. Conclusions

This paper developed an interdisciplinary interface between economics and architecture for evaluating the economic impacts of small city development. Two kinds of closed IO models, namely a static IO model and a quasi-dynamic interregional IO model were employed in the paper. For checking the performance of these models, Saemangeum's Flux City Design Plan was used as the analysis target. According to the simulation results, it can be concluded that: (1) when a traditional open IO model is employed in economic impact analysis, underestimation may occur since the impact by way of household income cannot be evaluated significantly; (2) when a static IO model is used, overestimation may occur since the average production technology is assumed and the dynamic technological change is not explicitly considered; and (3) a strong feedback function can be achieved by linking the detailed program of a city design plan with the quasi-dynamic interregional closed input-output model.

Appendix: Detailed Simulation Results at the Sector Level

Table A1 Detail of Impacts estimated by the SCIO Model

(million US$)

	Impacts of public investment			Impacts of private investment		
Sector	Output	GDP	Employment	Output	GDP	Employment
1	507	284	42,166	1,595	893	132,526
2	598	293	49,838	1,875	919	156,332
3	125	70	4,775	352	197	13,451
4	635	167	26,115	2,006	529	82,470
5	366	185	2,970	724	367	5,884
6	554	24	1,784	1,740	76	5,607
7	749	78	3,703	2,354	245	11,633
8	870	167	7,896	2,738	526	24,858
9	588	82	1,681	1,849	257	5,285
10	718	163	8,583	2,303	521	27,528
11	1,294	280	13,293	5,656	1,225	58,110
12	799	79	1,290	2,669	262	4,307
13	114	16	436	356	50	1,357
14	355	92	2,130	1,109	288	6,660
15	3,433	421	11,519	11,685	1,433	39,208
16	2,315	553	17,450	5,707	1,364	43,017
17	5,522	948	29,643	17,368	2,982	93,238
18	1,260	286	8,486	6,251	1,420	42,108
19	453	68	2,547	1,485	222	8,345
20	278	24	753	871	74	2,357
21	61	13	181	217	46	640
22	450	87	2,764	2,000	385	12,286
23	1,078	151	7,243	3,264	457	21,925
24	34	7	245	104	23	759
25	224	47	3,019	724	151	9,751
26	1,375	270	3,002	4,361	857	9,524
27	114	37	920	359	115	2,884
28	414	135	7,088	63,526	20,753	1,087,658
29	18,577	6,641	200,490	0	0	0
30	2,566	1,229	120,066	8,909	4,267	416,916
31	1,398	422	24,354	4,504	1,358	78,446
32	1,427	439	5,684	4,481	1,379	17,848
33	3,162	1,665	39,417	9,816	5,169	122,362
34	3,911	1,572	14,018	12,231	4,917	43,841
35	1,322	936	37,461	4,007	2,837	113,560
36	1,233	491	22,565	3,862	1,537	70,683
37	1,717	505	65,010	5,452	1,604	206,397
38	97	45	3,666	310	144	11,721
39	4,980	2,261	94,069	14,524	6,594	274,374
40	84	40	1,364	251	120	4,078
Total	65,758	21,272	889,688	213,598	66,562	3,269,934

Table A2 The Economic Impacts of Tourism on Jeollabuk-do

(million US$)

	Impact on output				Impact on GDP				Impact on employment			
Sector	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
1	111	124	185	236	62	70	103	132	9,207	10,328	15,336	19,646
2	67	75	112	143	33	37	55	70	5,592	6,273	9,322	11,940
3	10	11	17	22	6	6	9	12	387	434	646	827
4	136	153	226	290	36	40	60	76	5,592	6,273	9,312	11,930
5	8	8	13	15	4	4	7	8	61	68	107	126
6	121	136	202	259	5	6	9	11	391	439	652	835
7	164	183	272	349	17	19	28	36	808	906	1,346	1,724
8	158	178	265	339	30	34	51	65	1,438	1,613	2,404	3,081
9	236	265	394	505	33	37	55	70	675	757	1,126	1,444
10	265	296	435	557	60	67	98	126	3,167	3,539	5,193	6,659
11	83	92	122	158	18	20	26	34	850	946	1,253	1,618
12	118	128	266	208	12	13	26	20	190	207	429	335
13	14	15	27	26	2	2	4	4	53	59	102	100
14	6	7	12	15	2	2	3	4	38	42	71	90
15	478	529	915	949	59	65	112	116	1,605	1,776	3,069	3,184
16	36	40	63	76	9	10	15	18	273	305	477	571
17	83	91	120	155	14	16	21	27	447	490	646	830
18	16	18	28	39	4	4	6	9	107	118	186	260
19	5	6	9	15	1	1	1	2	30	34	48	86
20	3	3	14	18	0	0	1	2	8	9	39	49
21	6	7	9	12	1	1	2	3	18	20	27	35
22	25	28	38	49	5	5	7	9	153	170	232	302
23	17	19	62	80	2	3	9	11	115	128	414	536
24	5	5	8	10	1	1	2	2	34	38	61	71
25	650	728	1,088	1,395	136	152	227	291	8,752	9,799	14,658	18,783
26	242	271	408	514	48	53	80	101	529	593	891	1,122
27	21	23	35	45	7	8	11	14	168	188	281	358
28	43	47	61	79	14	15	20	26	731	807	1,049	1,359
29	0	0	0	0	0	0	0	0	0	0	0	0
30	186	206	348	440	89	99	167	211	8,708	9,640	16,291	20,602
31	476	532	789	1,017	143	160	238	307	8,284	9,261	13,740	17,709
32	245	273	387	498	76	84	119	153	977	1,089	1,542	1,983
33	144	159	212	275	76	84	111	145	1,793	1,980	2,638	3,426
34	172	192	258	334	69	77	104	134	618	687	923	1,196
35	49	54	76	110	34	38	54	78	1,377	1,526	2,164	3,115
36	6	6	9	12	2	3	4	5	106	118	167	215
37	1,592	1,786	2,651	3,397	468	525	780	999	60,268	67,604	100,372	128,588
38	2,522	2,825	4,214	5,398	1,170	1,310	1,955	2,504	95,446	106,928	159,501	204,310
39	464	563	815	1,051	211	256	370	477	8,763	10,639	15,399	19,863
40	40	44	64	83	19	21	31	39	644	721	1,042	1,342

Table A3 The Economic Impacts of Tourism on the Rest of the ROK

(million US$)

Sector	Impact on output				Impact on GDP				Impact on employment			
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
1	1	1	2	2	1	1	1	1	82	92	139	176
2	1	1	1	1	0	0	1	1	54	61	91	115
3	0	0	0	0	0	0	0	0	8	9	14	18
4	2	2	3	3	0	0	1	1	64	72	107	136
5	1	2	3	3	1	1	1	2	12	14	20	26
6	1	2	2	3	0	0	0	0	4	5	7	9
7	2	2	3	4	0	0	0	0	10	11	17	21
8	2	3	4	5	0	0	1	1	20	23	34	44
9	2	2	3	3	0	0	0	0	4	5	8	10
10	101	113	168	214	23	26	38	48	1,206	1,350	2,009	2,559
11	110	124	183	233	24	27	40	51	1,132	1,277	1,880	2,399
12	57	63	100	117	6	6	10	12	91	102	162	189
13	2	3	4	5	0	0	1	1	9	10	15	19
14	1	1	2	2	0	0	1	1	7	8	12	15
15	99	110	169	210	12	14	21	26	331	371	566	706
16	8	9	13	16	2	2	3	4	57	64	97	124
17	93	103	155	196	16	18	27	34	497	554	830	1,054
18	51	57	88	111	12	13	20	25	344	385	594	747
19	6	7	11	14	1	1	2	2	35	40	60	77
20	6	7	11	14	1	1	1	1	17	19	30	38
21	14	16	24	31	3	3	5	7	42	47	72	92
22	54	60	92	118	10	12	18	23	331	371	563	723
23	27	31	56	72	4	4	8	10	184	206	375	481
24	2	3	4	5	1	1	1	1	18	20	30	39
25	38	43	64	82	8	9	13	17	512	574	860	1,099
26	20	22	33	42	4	4	7	8	43	48	72	91
27	1	1	1	2	0	0	0	1	7	8	11	15
28	20	23	34	43	7	7	11	14	346	389	578	738
29	0	0	0	0	0	0	0	0	0	0	0	0
30	43	48	73	92	21	23	35	44	2,013	2,259	3,412	4,316
31	27	30	45	57	8	9	14	17	468	526	791	1,000
32	62	70	103	132	19	21	32	41	247	277	412	526
33	89	100	149	188	47	52	78	99	1,108	1,243	1,855	2,347
34	170	192	287	367	68	77	115	147	611	689	1,028	1,314
35	12	13	20	25	8	9	14	18	331	372	566	717
36	1	1	1	2	0	0	0	1	13	14	22	27
37	16	17	26	33	5	5	8	10	587	661	992	1,257
38	1	1	2	3	1	1	1	1	49	56	83	106
39	85	96	143	182	38	43	65	82	1,601	1,809	2,706	3,431
40	4	4	6	8	2	2	3	4	57	64	96	122

Table A4 Impacts on Jeollabuk-do's Output estimated by the QIRIO Model

	Impacts of public investment				Impacts of private investment			
Sector	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
1	25	177	86	85	163	468	276	239
2	30	207	102	101	190	546	325	285
3	7	49	24	24	40	115	69	60
4	31	220	108	106	204	587	347	300
5	23	159	79	78	91	257	154	134
6	25	177	86	85	161	465	274	238
7	34	239	117	115	217	627	370	321
8	40	284	139	153	260	749	442	433
9	27	187	92	96	171	493	291	268
10	10	66	31	29	63	179	102	84
11	28	194	90	85	281	797	448	370
12	26	174	77	70	177	489	259	209
13	5	34	16	15	31	89	50	41
14	14	93	42	69	87	243	132	197
15	145	995	470	455	1,036	2,909	1,656	1,410
16	150	1,031	514	511	760	2,145	1,292	1,128
17	199	1,339	622	583	1,268	3,512	1,969	1,622
18	21	139	67	80	229	639	366	386
19	7	51	24	41	50	143	82	122
20	4	30	49	49	27	78	157	136
21	0	3	2	2	3	9	7	6
22	5	37	20	19	60	169	104	88
23	14	96	162	149	84	238	484	393
24	1	7	3	3	6	18	11	9
25	4	27	15	14	25	71	49	41
26	61	422	207	202	390	1,115	661	567
27	5	37	18	18	33	96	57	49
28	11	74	33	30	69	196	107	85
29	0	0	0	0	0	0	0	0
30	106	732	412	407	782	2,206	1,500	1,303
31	56	382	192	188	366	1,036	629	542
32	45	310	145	136	285	809	459	378
33	105	719	335	319	656	1,848	1,039	872
34	94	657	309	290	600	1,713	974	804
35	57	392	187	208	343	968	559	545
36	53	366	175	165	339	959	553	460
37	73	525	246	231	474	1,398	790	654
38	4	32	16	16	27	85	51	44
39	220	1,761	872	833	1,286	4,227	2,530	2,121
40	3	19	9	8	16	45	26	21
Income	1,009	7,051	3,499	3,456	6,416	18,425	11,051	9,594

Table A5 Impacts on the Rest of the ROK's Output estimated by the QIRIO Model

Sector	Impacts of public investment				Impacts of private investment			
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
1	7	50	25	25	50	143	87	76
2	8	59	30	29	60	170	104	90
3	1	8	4	4	8	22	14	12
4	9	63	32	31	64	182	111	96
5	2	11	5	5	11	32	19	17
6	10	70	35	35	71	203	123	107
7	14	96	48	48	96	276	168	146
8	15	104	53	52	105	301	183	159
9	11	75	38	37	76	216	132	115
10	36	253	128	125	246	704	427	369
11	57	400	200	197	503	1,443	869	753
12	27	184	92	91	190	541	327	282
13	2	16	8	8	16	46	28	24
14	9	62	31	30	61	174	105	90
15	80	555	283	279	575	1,639	1,005	872
16	7	47	24	24	50	143	88	77
17	174	1,193	597	587	1,189	3,354	2,024	1,753
18	64	440	226	225	652	1,846	1,130	993
19	22	151	76	76	149	427	260	227
20	13	94	49	48	89	256	161	140
21	4	25	14	14	27	76	51	46
22	24	165	89	89	215	612	390	343
23	55	384	226	220	352	1,009	712	610
24	1	8	4	4	8	22	13	12
25	11	75	38	38	74	212	129	113
26	29	199	101	99	203	580	354	307
27	2	15	7	7	15	42	26	22
28	16	112	56	55	107	307	186	160
29	0	0	0	0	0	0	0	0
30	59	413	210	207	430	1,228	750	652
31	35	244	123	121	245	700	426	370
32	47	330	166	163	319	917	556	482
33	100	696	349	344	675	1,929	1,169	1,013
34	156	1,094	549	540	1,040	2,992	1,813	1,570
35	28	196	99	98	197	562	344	299
36	25	175	88	87	175	500	304	264
37	37	259	131	129	259	742	452	392
38	2	15	8	7	15	43	26	23
39	107	748	376	371	710	2,034	1,235	1,072
40	3	18	9	9	18	51	31	27
Income	392	2,729	1,381	1,361	2,761	7,893	4,814	4,178

Table A6 Impacts on Jeollabuk-do's GDP estimated by the QIRIO Model

	Impacts of public investment				Impacts of private investment			
Sector	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
1	14	99	48	48	91	262	155	134
2	14	101	50	50	93	268	159	140
3	4	27	14	14	22	64	39	34
4	8	58	28	28	54	155	91	79
5	12	81	40	40	46	130	78	68
6	1	8	4	4	7	20	12	10
7	4	25	12	12	23	65	38	33
8	8	54	27	29	50	144	85	83
9	4	26	13	13	24	68	40	37
10	2	15	7	7	14	41	23	19
11	6	42	20	18	61	173	97	80
12	3	17	8	7	17	48	25	21
13	1	5	2	2	4	13	7	6
14	4	24	11	18	23	63	34	51
15	18	122	58	56	127	357	203	173
16	36	246	123	122	182	513	309	269
17	34	230	107	100	218	603	338	279
18	5	32	15	18	52	145	83	88
19	1	8	4	6	8	21	12	18
20	0	3	4	4	2	7	13	12
21	0	1	0	0	1	2	1	1
22	1	7	4	4	12	33	20	17
23	2	13	23	21	12	33	68	55
24	0	2	1	1	1	4	2	2
25	1	6	3	3	5	15	10	8
26	12	83	41	40	77	219	130	111
27	2	12	6	6	11	31	18	16
28	3	24	11	10	23	64	35	28
29	0	0	0	0	0	0	0	0
30	51	351	197	195	375	1,057	718	624
31	17	115	58	57	110	312	190	163
32	14	95	45	42	88	249	141	116
33	55	379	176	168	346	973	547	459
34	38	264	124	116	241	689	392	323
35	40	278	133	147	243	686	396	386
36	21	146	70	66	135	382	220	183
37	22	155	72	68	139	411	232	192
38	2	15	7	7	12	39	24	21
39	100	800	396	378	584	1,919	1,148	963
40	1	9	4	4	8	22	12	10

Table A7 Impacts on the Rest of the ROK's GDP estimated by the QIRIO Model

	Impacts of public investment				Impacts of private investment			
Sector	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
1	4	28	14	14	28	80	49	42
2	4	29	15	14	29	83	51	44
3	1	4	2	2	4	12	8	7
4	2	17	8	8	17	48	29	25
5	1	5	3	3	6	16	10	9
6	0	3	2	2	3	9	5	5
7	1	10	5	5	10	29	17	15
8	3	20	10	10	20	58	35	31
9	1	10	5	5	11	30	18	16
10	8	57	29	28	56	159	97	84
11	12	87	43	43	109	312	188	163
12	3	18	9	9	19	53	32	28
13	0	2	1	1	2	6	4	3
14	2	16	8	8	16	45	27	23
15	10	68	35	34	70	201	123	107
16	2	11	6	6	12	34	21	18
17	30	205	103	101	204	576	348	301
18	14	100	51	51	148	419	257	225
19	3	23	11	11	22	64	39	34
20	1	8	4	4	8	22	14	12
21	1	5	3	3	6	16	11	10
22	5	32	17	17	41	118	75	66
23	8	54	32	31	49	141	100	85
24	0	2	1	1	2	5	3	3
25	2	16	8	8	15	44	27	24
26	6	39	20	20	40	114	69	60
27	1	5	2	2	5	14	8	7
28	5	36	18	18	35	100	61	52
29	0	0	0	0	0	0	0	0
30	28	198	100	99	206	588	359	312
31	11	73	37	37	74	211	128	111
32	15	101	51	50	98	282	171	148
33	53	366	184	181	355	1,016	615	533
34	63	440	221	217	418	1,203	729	631
35	20	138	70	70	139	398	244	212
36	10	70	35	35	70	199	121	105
37	11	76	38	38	76	218	133	115
38	1	7	4	3	7	20	12	11
39	49	339	171	169	322	923	561	487
40	1	9	4	4	9	24	15	13

Table A8 Impacts on Employment in Jeollabuk-do estimated by the QIRIO Model

	Impacts of public investment				Impacts of private investment			
Sector	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
1	2,092	14,684	7,166	7,058	13,507	38,925	22,945	19,879
2	2,461	17,231	8,477	8,447	15,837	45,542	27,069	23,742
3	270	1,872	932	929	1,534	4,382	2,636	2,310
4	1,291	9,063	4,428	4,361	8,381	24,151	14,254	12,348
5	189	1,293	642	637	741	2,091	1,251	1,088
6	81	570	278	274	519	1,498	883	765
7	168	1,180	576	568	1,074	3,100	1,827	1,586
8	367	2,574	1,258	1,388	2,359	6,795	4,011	3,932
9	76	536	262	273	488	1,409	832	767
10	115	793	373	349	757	2,140	1,215	1,000
11	285	1,995	928	872	2,888	8,186	4,602	3,804
12	42	280	123	113	286	788	418	338
13	19	131	60	57	120	341	189	157
14	82	559	252	414	521	1,459	795	1,180
15	488	3,338	1,576	1,526	3,476	9,760	5,558	4,731
16	1,133	7,771	3,874	3,854	5,727	16,172	9,739	8,501
17	1,069	7,189	3,340	3,128	6,808	18,853	10,570	8,707
18	138	937	450	538	1,546	4,304	2,468	2,600
19	42	286	135	230	284	803	459	685
20	12	81	134	131	74	210	426	368
21	1	9	6	6	9	25	21	19
22	33	227	122	118	371	1,041	636	539
23	94	643	1,085	1,002	564	1,595	3,251	2,639
24	7	51	26	24	46	130	79	65
25	52	361	205	194	337	956	657	547
26	133	922	452	441	853	2,436	1,442	1,237
27	42	294	145	143	268	770	458	396
28	183	1,261	568	516	1,185	3,352	1,826	1,461
29	0	0	0	0	0	0	0	0
30	4,982	34,264	19,291	19,056	36,602	103,237	70,175	60,992
31	967	6,657	3,346	3,276	6,379	18,036	10,956	9,433
32	178	1,234	578	541	1,134	3,223	1,829	1,503
33	1,308	8,963	4,172	3,982	8,179	23,036	12,955	10,869
34	338	2,353	1,106	1,038	2,152	6,141	3,493	2,881
35	1,616	11,113	5,308	5,881	9,709	27,447	15,840	15,451
36	973	6,704	3,201	3,027	6,199	17,543	10,127	8,416
37	2,767	19,891	9,299	8,752	17,936	52,914	29,902	24,749
38	155	1,197	596	587	1,015	3,220	1,937	1,679
39	4,165	33,267	16,479	15,731	24,294	79,849	47,786	40,069
40	45	313	147	134	260	739	417	333

Table A9 Impacts on Employment in the Rest of the ROK estimated by the QIRIO Model

Sector	Impacts of public investment				Impacts of private investment			
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
1	590	4,115	2,081	2,052	4,154	11,880	7,242	6,285
2	705	4,910	2,484	2,448	4,960	14,183	8,646	7,504
3	42	295	149	147	298	853	520	451
4	371	2,585	1,307	1,289	2,618	7,487	4,563	3,960
5	13	88	45	44	91	259	158	137
6	32	226	114	113	228	653	398	345
7	68	472	239	235	476	1,362	830	721
8	136	945	478	471	955	2,732	1,665	1,445
9	31	214	108	107	216	619	377	327
10	434	3,028	1,525	1,498	2,935	8,409	5,108	4,415
11	584	4,115	2,058	2,027	5,164	14,820	8,924	7,736
12	43	297	149	146	307	873	527	455
13	9	63	31	31	61	176	106	92
14	53	371	185	182	365	1,042	629	543
15	268	1,863	949	935	1,928	5,500	3,371	2,924
16	51	354	182	179	377	1,075	664	577
17	935	6,405	3,206	3,153	6,385	18,003	10,867	9,411
18	430	2,962	1,521	1,516	4,392	12,431	7,612	6,687
19	121	847	428	425	837	2,398	1,462	1,276
20	36	256	133	131	241	694	436	378
21	10	73	42	42	78	224	151	135
22	145	1,015	548	549	1,317	3,759	2,394	2,107
23	370	2,578	1,519	1,479	2,367	6,779	4,783	4,097
24	8	59	30	29	56	162	98	85
25	145	1,013	511	506	998	2,861	1,740	1,517
26	63	435	220	217	444	1,267	772	670
27	17	118	59	59	119	340	207	180
28	273	1,911	956	939	1,829	5,258	3,178	2,747
29	0	0	0	0	0	0	0	0
30	2,777	19,339	9,809	9,679	20,118	57,465	35,097	30,495
31	609	4,242	2,139	2,111	4,265	12,188	7,412	6,437
32	188	1,313	660	649	1,272	3,650	2,216	1,918
33	1,245	8,675	4,354	4,288	8,410	24,051	14,569	12,626
34	559	3,922	1,967	1,937	3,726	10,725	6,497	5,628
35	796	5,542	2,816	2,782	5,575	15,931	9,752	8,483
36	459	3,199	1,615	1,593	3,196	9,143	5,565	4,830
37	1,404	9,789	4,942	4,872	9,817	28,089	17,098	14,838
38	81	568	287	283	571	1,633	994	862
39	2,024	14,126	7,108	7,015	13,405	38,422	23,333	20,255
40	43	300	151	148	291	834	506	438

Table A10 The Economic Impacts of the Aerospace Industry on Jeollabuk-do

(million US$)

	Impact on output				Impact on GDP				Impact on employment			
Sector	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
1	0	12	9	12	0	7	5	7	0	992	719	998
2	0	14	10	14	0	7	5	7	0	1,186	869	1,208
3	0	2	1	2	0	1	1	1	0	70	51	71
4	0	15	11	15	0	4	3	4	0	609	442	612
5	0	1	1	1	0	1	1	1	0	12	8	12
6	0	12	9	12	0	1	0	1	0	39	29	40
7	0	16	12	17	0	2	1	2	0	81	59	82
8	0	19	15	21	0	4	3	4	0	176	140	194
9	0	13	10	14	0	2	1	2	0	37	28	39
10	0	5	3	5	0	1	1	1	0	57	39	54
11	0	10	7	9	0	2	1	2	0	102	71	98
12	0	15	11	15	0	1	1	1	0	25	17	24
13	0	2	2	2	0	0	0	0	0	8	6	8
14	0	6	7	9	0	2	2	2	0	36	40	56
15	0	48	34	47	0	6	4	6	0	159	114	157
16	0	9	6	9	0	2	2	2	0	65	48	66
17	0	85	61	84	0	15	10	14	0	458	327	452
18	0	15	11	16	0	3	3	4	0	98	77	111
19	0	6	6	9	0	1	1	1	0	35	35	49
20	0	7	5	7	0	1	0	1	0	18	13	18
21	0	0	0	0	0	0	0	0	0	1	1	1
22	0	28	20	28	0	5	4	5	0	169	123	171
23	0	22	15	20	0	3	2	3	0	146	99	136
24	0	72	53	73	0	16	12	16	0	527	384	536
25	0	3	2	3	0	1	0	1	0	36	25	35
26	0	29	21	29	0	6	4	6	0	64	46	64
27	0	2	2	2	0	1	1	1	0	19	14	19
28	0	7	5	6	0	2	1	2	0	112	78	107
29	0	0	0	0	0	0	0	0	0	0	0	0
30	0	58	42	58	0	28	20	28	0	2,696	1,962	2,709
31	0	32	23	33	0	10	7	10	0	563	408	573
32	0	22	15	21	0	7	5	6	0	86	60	83
33	0	45	32	44	0	24	17	23	0	561	397	547
34	0	43	30	41	0	17	12	17	0	153	106	147
35	0	35	27	38	0	25	19	27	0	987	777	1,084
36	0	25	17	24	0	10	7	10	0	456	318	447
37	0	33	23	32	0	10	7	9	0	1,250	870	1,199
38	0	3	2	3	0	1	1	1	0	103	75	105
39	0	91	65	90	0	41	29	41	0	1,719	1,222	1,703
40	0	2	1	1	0	1	1	1	0	25	17	24

References

Arqfuture (2009), Ciudad de Saemangeum, *Future*, 16, 17, pp. 69-77

Erenburg, S. J. (1993), The Real Effects of Public Investment on Private Investment, *Applied Economics*, 25(6), pp. 831-837

Institute of Developing Economies, JETRO (2003), *Asian International Input-Output Table 2000*, Statistical Data Series 89, 90

Isard, W. (1951), Interregional and Regional Input-Output Analysis: A model of a space economy, *Review of Economics and Statistics*, 33-4, pp. 318-28

Isard, W. and R.E. Kuenne (1953), The Impact of Steel upon the Greater New York-Philadelphia Industrial Region, *Review of Economics and Statistics*,35(4), pp. 289-301

Jeollabuk-do and UDIK (2008), *Saemangeum Comprehensive Development Plan For International Urban Idea Competition: Appendix/Design Guidelines*

Lahr, Michael L. and E. Dietzenbacher (2001), *Input-Output Analysis: Frontiers and Extensions*, Palgrave

Leontief, W. (1987), Input-Output Analysis, in J. Eatwell, M. Milgate and P. Newman (eds.), *The New Palgrave: A Dictionary of Economics*, 2, pp. 860-64

Leontief, W. (1947), Introduction to a Theory of the Internal Structure of Functional Relationships, *Econometrica*, pp. 361-373

Miller, R and P.D. Blair (1985), *Input-Output Analysis: Foundations and Extensions*, Prentice-Hall, Englewood Cliffs, NJ

Miller, R and P.D. Blair (2009), *Input-Output Analysis: Foundations and Extensions*, Cambridge University Press

Monadjemi, Mehdi S. (1996), Public Expenditure and Private Investment: A study of the UK and the USA, *Applied Economics Letters*, 3(10), pp. 641-644

Morrison, W.I. and P. Smith (1974), Nonsurvey Input-Output Techniques at the Small Area Level: An evaluation, *Journal of Regional Science*, 14(1), pp. 1-14

Moses, Leon N. (1955), The Stability of Interregional Trade Patterns and Input-Output Analysis, *American Economic Review*, 45-5, pp. 803-32

Polenske, K.R. (1968), Empirical Implementation of a Multiregional Input-Output Gravity Trade Model, in Carter, A.P. and A. Brody (eds.), *Contributions to Input-Output Analysis*, North Holland

Round, J.I. (1978), On Estimating Trade Flows in Interregional Input-Output Models, *Regional Science and Urban Economics*, 8-3, pp. 289-302

Sasaki, K., M. Shinmei, and S. Kunihisa (1987), Multi-regional Model with Endogenous Price System for Evaluating Road Construction Projects, *Environment and Planning A*, 19, pp. 1093-1114

Sawyer, C.H. and R.E. Miller (1983), Experiments in Regionalization of a National Input-Output Table, *Environment and Planning A*, 15, pp. 1501-20

Schaffer, W. and K. Chu (1969), Nonsurvey Techniques for Constructing Regional Interindustry Models, *Regional Science Association*, 23, pp. 83-101

Tsukamoto, Y. (2008a), *Design Guidelines of Saemangeum Flux City*, Tokyo Institute of Technology+Yoshihara Tsukamoto/Atelier Bow-Wow

Tsukamoto, Y. (2008b), *Analysis Guidelines of Saemangeum Flux City*, Tokyo Institute of Technology+Yoshihara Tsukamoto/Atelier Bow-Wow

Input-Output Analysis of Dispatched Employees in Japan

Mikio Suga[*]

Abstract

In October 2008, when the global financial crisis affected Japan, the media reported that "dispatched employees" who had been hired to work on manufacturing production lines were being fired in large numbers. The general public came to realize that Japanese manufacturing industry depended greatly on dispatched employees and that dispatched workers' jobs are very unstable. However, the dependency of Japanese final demands on dispatched employees has not been explained clearly. One reason there is no such analysis is that no official data about the number of dispatched employees exactly match the input-output table. This study estimates the number of dispatched employees by input-output sector for the years 2000 and 2005 using the Census of Establishments and Enterprises for 2001 and 2006. By using this, inducements of dispatched employees by final demand are analyzed.

Keywords: dispatched workers, temporary employees, input-output analysis

1. Introduction

In October 2008, when the global financial crisis affected Japan, the media reported that "dispatched employees" who had been hired to work on manufacturing production lines were being fired in large numbers. They named the situation *Haken-giri* meaning "the killing of dispatched employees (using a samurai sword)". One of the most popular topics at the end of 2008 was the appearance of *Haken-mura*, the homeless camp in *Hibiya Koen* Park in front of the Imperial Palace. The general public came to realize that Japanese manufacturing industry depended greatly on dispatched employees and that the dispatched workers' jobs are very unstable.

The increase of informal labor is not a peculiar phenomenon internationally. The ROK, the nearest neighboring country to Japan, has experienced a similar but more drastic increase of informal labor. Today, ROK companies have competitive strength vis-à-vis Japanese companies in terms of technology, yet we cannot ignore that ROK labor costs are low. It seems that the competition with newly-developed industrialized countries, including the ROK, is the major reason that informal labor has increased in Japan.

Given this situation, it seems relevant to consult input-output tables to analyze how many dispatched employees lost their jobs when final demands, including exports, decreased significantly. (Here, "final demands" is a term commonly used in input-output analysis and includes final consumption expenditures, gross capital formation, and exports.) However, the dependency of Japanese final demands on dispatched employees has not been explained clearly. This seems peculiar, since the input-output table, which provides the most suitable data for analyzing inducements of employees by final demands, has been compiled every five years since 1955. (Here "inducements" refers to direct and indirect impact of changes in final demand on employment.) Perhaps one reason there is

[*] Faculty of Economics, Hosei University, 2-17-1 Fujimi, Chiyoda-ku, Tokyo 102-8160, Japan

no such analysis is that no official data about the number of dispatched employees exactly match the input-output table. This study attempts to fill that gap in scholarship. It estimates the number of dispatched employees by input-output sector for the years 2000 and 2005 using the *Census of Establishments and Enterprises* for 2001 and 2006. By using this, inducements of dispatched employees by final demand are analyzed.

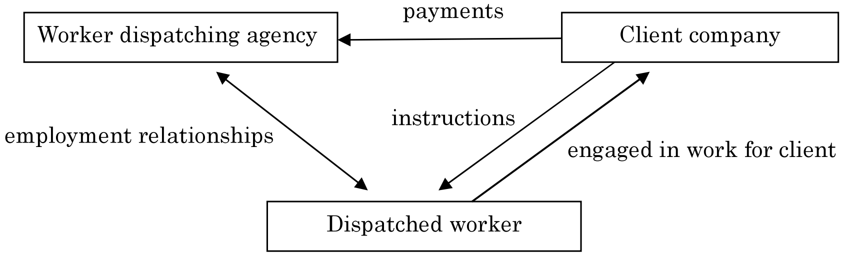
The increase in number of dispatched employees in the 2000s was associated with the revision of the Worker Dispatching Law. The Japan Institute for Labour Policy and Training (2003) described how the law's revision in 1999 "essentially, posed no restrictions, and dispatched workers have been able to engage in all work except those associated with harbor transportation duties, construction, security guards, medical-related duties, and duties related to manufacturing." The 2004 revision deregulated the situation further, and dispatched employees were allowed to work on production lines in manufacturing. Since the law was revised substantially between 2000 and 2005, the input-output tables for years 2000 and 2005 provide suitable data for analyzing the changes in the Japanese economy's dependency on dispatched employees.

2. The Definition of "Dispatched Worker"

Japan's Worker Dispatch Law[1] defines a "dispatched worker" as a worker, employed by an employer, who becomes the object of "worker dispatching". It also defines "worker dispatching" as "causing a worker(s) employed by one person so as to be engaged in work for another person under the instruction of the latter, while maintaining his/her employment relationship with the former, but excluding cases where the former agrees with the latter that such worker(s) shall be employed by the latter" (Japan Institute for Labour Policy and Training, 2009). Figure 1 more clearly illustrates the complicated relationships among these three parties.

The term "dispatched worker" is not commonly used in other countries. In the United States, dispatched workers are called "temporary staff" or "temporary employees". No state or federal labor laws define temporary employment status, since dispatching or temporary staffing is not regulated in the United States. The 2007 North American Industry Classification System specifies "561320 Temporary Help Services" as "establishments primarily engaged in supplying workers to clients' businesses for limited periods of time

Figure 1 The Relationships among Dispatched Workers, Worker Dispatching Agencies, and Client Companies



[1] The "dispatched employees" and "dispatched workers" here have similar meanings. As described later, the former is used by the *Census of Establishments and Enterprises* and the latter by the Worker Dispatch Law.

to supplement the working force of the client. The individuals provided are employees of the temporary help service establishment. However, these establishments do not provide direct supervision of their employees at the clients' work sites." (US Census Bureau, 2007). The Japan Standard Industrial Classification specifies "9121 Worker dispatching services", following this definition legally. The definitions of "worker dispatching service" in Japan and "temporary help service" in the United States are similar in terms of their industry classification. Therefore, in this paper, "dispatched" and "temporary staff" or "temporary help" are used interchangeably.

3. Statistics for Dispatched Employees by Industry: The *Census of Establishments and Enterprises*

Several large sample surveys in Japan have analyzed the number of dispatched employees by industry. The characteristics and summary tables related to dispatched employees are explained below. Because of the sectionalism of Japanese statistics agencies, there are no shared definitions for the items surveyed among government agencies and even among the statistics from the same agency. There are items that have similar (but not exactly the same) definitions, and official translations of those definitions differ, leading to confusion.

The *Census of Manufacturers (Kogyo Tokei Chosa)* is the annual survey covering Japanese manufacturing industry. The survey's statistical unit is the establishment, which operates in one physical location only. It collects the number of "workers supplied by other companies" and includes workers from worker dispatching agencies. It also includes workers from related companies, including parent companies and subsidiaries (Table 1). Misleadingly for US users of the data, "temporary workers," as defined in the census, are not dispatched workers or temporary staff. The term refers to persons other than regular workers who are employed for less than one month or under daily agreements. "Regular workers" means "full-time workers," "part-time workers" and "workers supplied by other companies." "Full-time workers" and "part-time workers" combined almost correspond to "employees" in US statistics, such as those in the US *Economic Census*.

The *Census of Commerce (Shogyo Tokei Chosa)* is conducted every five years and a simplified survey is conducted once inbetween. It covers the retail and wholesale industries, and its statistical unit is the establishment. It collects both the "number of

Table 1. Summary Statistics from the Census of Manufacturers for the Year 2005

	Total	Male	Female
1. Number of persons employed (2+3)	5,774,397	4,073,293	1,701,104
2. Sole proprietors and unpaid family workers	91	66	25
3. Regular workers	5,774,306	4,073,227	1,701,079
3a. Full-time workers	4,348,058	3,495,908	852,150
3b. Part-time workers	937,217	250,967	686,250
3c. Workers supplied by other companies	489,031	326,352	162,679
4. Temporary workers	79,893	49,539	30,354

Source: Ministry of Economy, Trade and Industry, *Census of Manufacturers* 2005.

Table 2 Summary Statistics from the *Census of Commerce* for the Year 2004

	Incorporated body			Individual		
	Total	Male	Female	Total	Male	Female
1. Number of persons engaged (2+7-8+9)	10,156,616	5,215,610	4,941,006	2,177,273	1,017,015	1,160,258
2. Number of employees (3+4+5+6)	9,504,515	4,988,461	4,516,054	2,061,438	971,273	1,090,165
3. Paid officials	966,489	673,735	292,754	-	-	-
4. Sole proprietors	-	-	-	713,817	522,448	191,369
5. Unpaid family workers	-	-	-	277,049	49,980	227,069
6. Regular employees	8,538,026	4,314,726	4,223,300	1,070,572	398,845	671,727
6a. Full-timers	4,659,543	3,287,092	1,372,451	433,659	175,261	258,398
6b. Part-timers	3,878,483	1,027,634	2,850,849	636,913	223,584	413,329
7. Number of temporary employees	265,451	111,270	154,181	106,858	42,194	64,664
8. Number of workers dispatched to other companies among employees and temporary employees	72,200	39,365	32,835	3,947	2,138	1,809
9. Number of workers dispatched from other companies	458,850	155,244	303,606	12,924	5,686	7,238

Source: Ministry of Economy, Trade and Industry, *Census of Commerce* 2004.

workers dispatched to other companies among employees and temporary employees" and the "number of workers dispatched from other companies" (Table 2). "Temporary workers" here are not dispatched workers, and the term is the same as in the *Census of Manufacturers*. The "number of persons employed" and "regular workers" in the *Census of Manufacturers* and the "number of employees" and "regular employees" in the *Census of Commerce* appear similar, but their definitions differ. The former includes dispatched workers from other companies, while the latter does not. The category "regular employees" consists of "full-time" and "part-time" and corresponds to "employees" in US statistics such as the US *Economic Census*, although it differs from "regular workers" in the *Census of Manufacturers*.

Neither the *Census of Manufacturers* nor the *Census of Commerce* covers service industries. The *Census of Establishments and Enterprises (Jigyosho Kigyo Tokei Chosa)* covers almost all types of industries including service industries, but excludes farming, fishing and forestry, live-in housekeepers, and embassies. Formerly conducted every five years with a simplified survey conducted at the same time as the *Census of Commerce*, it has already been abolished, and the final survey in 2006 will be replaced by the *Economic Census* to be conducted in 2012. Statistical units in both surveys are the establishment and the enterprise, since the survey seeks to capture company structures.

The *Census of Establishments and Enterprises* (referred to as the "*Census*" hereafter) collects the number of employees "dispatched to separately operated establishments or subcontractors" (hereafter "dispatched to other") and number of employees "dispatched from separately operated establishments" (hereafter "dispatched from other") (Table 3). The number of "dispatched to other" is larger than "dispatched from other" because one person can be dispatched to multiple workplaces. Under this definition, dispatched employees include workers from worker dispatching agencies, workers from other establishments of the same company, and subcontractors. The definition of "regular employees" is the same as in the *Census of Commerce*.

Table 3 Summary Statistics from the *Census of Establishments* and Enterprises for the Year 2006

	Total	Male	Female
1. Number of employees (2+3+4+5)	54,184,428	31,097,080	23,087,348
2. Individual proprietors	2,700,499	1,907,705	792,794
3. Family employees working without pay	775,542	149,739	625,803
4. Paid directors	3,930,365	2,825,433	1,104,932
5. Employees (6+7)	46,778,022	26,214,203	20,563,819
6. Regular employees	45,150,330	25,421,057	19,729,273
6a. Full-time	29,157,978	20,095,910	9,062,068
6b. Other than full-time	15,992,352	5,325,147	10,667,205
7. Non-regular workers	1,627,692	793,146	834,546
8. Number of employees dispatched to separately operated establishments or subcontractors	1,817,623	1,014,082	803,541
9. Number of employees dispatched from separately operated establishments	2,809,942	1,609,450	1,200,492

Source: Statistics Bureau, *Census of Establishments and Enterprises* 2006.

4. Estimation of Number of Dispatched Employees by Sector of Input-Output Table

As mentioned above, no official data for the number of dispatched employees or subcontractors exactly match the input-output table. Since the *Census* covers almost all of the industries in Japan and collects the number of dispatched employees, it is a suitable source for the estimation thereof.

However, problems arise in using data from the *Census*. First, industries in the *Census* do not match the sectors in the input-output table. The definition of "sector" in the Japanese input-output table is an "activity" that produces a single type of commodity, and this form of input-output table is called a "commodity-by-commodity table" in input-output-analysis terminology. An industry in the *Census* comprises establishments having similar characteristics, and since an establishment can produce more than one commodity, an industry in the *Census* can also produce more than one commodity. Moreover, the reference years of the *Census* and input-output table do not coincide. The *Census* was conducted for 2001 and 2006; the input-output table was compiled for the years 2000 and 2005. The one-year lag means the conversion technique will generate some non-negligible inconsistency.

To overcome this problem, I assumed that the ratio of the number of regular employees to that of dispatched employees has a similar value in the industry of the *Census* and its closely matched sector in the input-output table. Here, "closely matched" means that the data do not "exactly match" under the statistical definition, but the approximation based on information in the input-output table is compiled from censuses and surveys.

Consider an example involving the steel industry and the iron and steel sector. In the 2006 *Census*, the steel industry's "number of regular employees" was 229,275, and the number of employees "dispatched to other" was 12,699. Therefore, the ratio of the number of employees dispatched to that of regular employees is:

$$12{,}699 / 229{,}275 = 0.055$$

The number of employees "dispatched from other" in the steel industry was 25,719.

Therefore the ratio becomes:

$$25{,}719 / 229{,}275 = 0.112$$

The iron and steel sector's "number of regular employees" in the official 2005 input-output table was 291,060. The estimated number of employees "dispatched to other" becomes:

$$291{,}060 \times 0.055 = 16{,}121$$

and the estimated number of employees "dispatched from other" becomes:

$$291{,}060 \times 0.112 = 32{,}650$$

Table 4 shows the ratio of the number of employees "dispatched to/from other" to that of regular employees by selected industry. The ratio of the number of "dispatched to other" employees to that of regular employees did not change significantly. However, the ratio of the number of "dispatched from other" employees to that of regular employees increased significantly in three manufacturing industries, increased moderately in the medical service, health and social security, and nursing care industry, and was almost unchanged in the construction industry.

Table 5 shows the estimated number of employees "dispatched to/from other" by

Table 4 The Ratio of the Number of Employees "Dispatched to/from Other" to that of Regular Employees by Selected Industry

Sector	A. Dispatched to other		B. Dispatched from other	
	2001	2006	2001	2006
20 General machinery	0.026	0.027	0.072	0.120
21 Electrical machinery	0.057	0.058	0.088	0.194
22 Transportation equipment	0.053	0.052	0.089	0.158
25 Construction	0.014	0.019	0.056	0.060
30 Commerce	0.009	0.010	0.039	0.048
47 Medical service, health and social security, and nursing care	0.004	0.004	0.051	0.058

Table 5 Number of Employees "Dispatched to/from Other" by Selected Industry (in thousands)

Estimated (Input-Output Table)

	Sector	A. Dispatched to other			B. Dispatched from other		
		2000	2005	Change	2000	2005	Change
20	General machinery	24	25	+2	66	111	+45
21	Electrical machinery	99	74	-25	154	249	+95
22	Transportation equipment	49	48	-1	82	146	+64
25	Construction	59	68	+9	235	211	-24
30	Commerce	96	93	-3	403	456	+53
47	Medical service, health and social security, and nursing care	16	20	+4	203	290	+87
	Other	805	1,623	+818	1,262	1,637	+375
	Total	1,151	1,957	+806	2,417	3,114	+697

Actual (Census of Establishments and Enterprises)

		2001	2006	Change	2001	2006	Change
	Total	1,361	1,818	+456	2,484	3,225	+741

selected industry, with totals. The actual total is also shown for reference. The estimated and actual total numbers are plausibly similar. There were more than 400,000 “dispatched from other” employees in 2005 in the general machinery, electrical machinery, transportation equipment, commerce, and medical service, health and social security, and nursing care sectors, which is a considerable increase from 2000. Their numbers in the construction sector decreased.

5. Changes in the Number of Employees “Dispatched from Other” Induced by Final Demand Sector

Using the number of employees “dispatched to/from other” by sector as estimated above, their inducements by final demand sector are calculated. The model is the ordinary static Leontief model shown below:

$$L = l\,[I - (I - M)\,A]^{-1}\,Z$$

$$Z = [(I - M)\,F,\,e]$$

where L is a matrix of which 57×8 elements consist of the inducements of “dispatched employees from other”, l is a row vector of which 57 elements consist of coefficients of employees to output, I is an identity matrix of which 57 diagonal elements equal 1, M is a matrix of which 57 diagonal elements consist of import coefficients, A is a matrix of which 57×57 elements consist of input coefficients, F is a matrix of which 57×7 elements consist of the domestic final demand, e is a column vector of which 57 elements consist of exports, and Z is a 57×8 matrix. The static Leontief model assumes that labor inputs change proportionally to outputs. Regular employees will not be fired when outputs decrease. However, dispatched employees will be fired because their numbers are, by their nature, “adjustable”.

Table 6 shows the inducement of employees “dispatched from other” by final demand sector in 2005. The findings from Table 6 are as follows. First, the inducement of dispatched employees by consumption expenditure (public) is the largest and by exports is the third-largest, with the former about twice the size of the latter. Second, the dispatched employees in the general machinery, electrical machinery, and transportation equipment sectors fall mainly between 41% and 52%, and are induced by exports. Third, 54% of dispatched employees in the construction sector are induced by gross domestic fixed capital formation (private). Fourth, 57% of the dispatched employees of the commerce sector are induced by consumption expenditure. Fifth, 74% of the dispatched employees in the medical service, health and social security, and nursing care sector are induced by consumption expenditures of general government.

Table 7 shows changes in the inducement of employees “dispatched from other” by final demand sector from 2000 to 2005. The findings from Table 7 are as follows. First, the increase in inducements of dispatched employees by consumption expenditure (public) and exports are 256,000 and 242,000, respectively, and almost the same. Second, the increase in dispatched employees in the general machinery, electrical machinery, transportation equipment, and commerce sectors falls mainly between 48% and 62%, induced by exports.

Table 6 Inducement of Employees "Dispatched from Other" by Final Demand Sector in 2005 (in thousands)

	Sector	Consumption expenditure outside households	Consumption expenditure (private)	Consumption expenditure of general government	Consumption expenditure of general government (social fixed capital depreciation)	Gross domestic fixed capital formation (public)	Gross domestic fixed capital formation (private)	Increase in stocks	Exports	Total
20	General machinery	0	5	1	0	2	57	1	45	111
21	Electrical machinery	7	44	2	1	5	68	0	122	249
22	Transportation equipment	0	32	3	1	1	31	1	76	146
25	Construction	1	18	4	1	69	115	0	3	211
30	Commerce	14	259	18	2	11	84	2	67	456
47	Medical service, health and social security, and nursing care	3	72	215	1	0	0	0	0	290
	Other	62	814	167	33	68	258	7	242	1,651
	Total	87	1,244	410	39	157	612	11	555	3,114
Share within row total (percentage)										
20	General machinery	0	5	1	0	2	51	1	41	100
21	Electrical machinery	3	18	1	0	2	27	0	49	100
22	Transportation equipment	0	22	2	1	1	21	1	52	100
25	Construction	0	9	2	0	33	54	0	1	100
30	Commerce	3	57	4	0	2	18	0	15	100
47	Medical service, health and social security, and nursing care	1	25	74	0	0	0	0	0	100
	Other	4	49	10	2	4	16	0	15	100
	Total	3	40	13	1	5	20	0	18	100

Third, the 72% increase in dispatched employees in the medical service, health and social security, and nursing care sector is induced by the consumption expenditure of general government. Fourth, 90% of the decrease in dispatched employees in the construction sector is induced by gross domestic fixed capital formation (public).

Table 7 Changes in the Inducement of Employees "Dispatched from Other" by Final Demand Sector from 2000 to 2005 (in thousands)

	Sector	Consumption expenditure outside households	Consumption expenditure (private)	Consumption expenditure of general government	Consumption expenditure of general government (social fixed capital depreciation)	Gross domestic fixed capital formation (public)	Gross domestic fixed capital formation (private)	Increase in stocks	Exports	Total
20	General machinery	0	2	0	0	-1	20	2	22	45
21	Electrical machinery	4	17	1	0	-4	18	-0	59	95
22	Transportation equipment	0	12	1	0	-0	10	2	38	64
25	Construction	-0	2	0	0	-22	-6	0	1	-24
30	Commerce	-1	18	3	1	-6	11	1	27	53
47	Medical service, health and social security, and nursing care	1	24	63	0	-0	0	0	0	87
	Other	7	181	39	11	-5	42	7	95	377
	Total	11	256	106	12	-37	95	12	242	697
Share within row total (percentage)										
20	General machinery	0	5	1	0	-2	43	5	48	100
21	Electrical machinery	4	18	1	0	-4	19	-0	62	100
22	Transportation equipment-	0	19	1	1	-0	16	2	60	100
25	Construction	0	-8	-1	-1	90	24	-0	-4	100
30	Commerce	-2	33	5	1	-11	20	2	52	100
47	Medical service, health and social security, and nursing care	1	27	72	0	-0	0	0	0	100
	Other	2	48	10	3	-1	11	2	25	100
	Total	2	37	15	2	-5	14	2	35	100

6. The Effect of the Decrease in Exports from 2008 to 2009

From 2008 to 2009, during the worldwide financial crisis, nominal GDP decreased by 30,895 billion yen. Exports made the largest contribution to the decrease (94%).

Let us estimate the effect of the decrease in exports from 2008 to 2009. Since real exports in 2005 prices have not yet been published by the Cabinet Office, it is estimated as follows. First, the deflator (=100 for 2005) is estimated by dividing each year's deflator by the 2005 deflator and multiplying by 100. Second, real exports in 2005 prices are estimated by dividing nominal exports by the deflator (=100 for 2005) and multiplying by 100. As per these estimated results, real exports increased by 17,928 billion yen (in 2005 prices) from

Table 8 Nominal GDP by Expenditure (in billion yen)

	2008	2009	Growth	Contribution
GDP (expenditure approach)	505,114	474,219	-30,895	100%
Private Consumption	291,751	282,588	-9,162	30%
Private Residential Investment	16,407	13,614	-2,794	9%
Private Non-Residential Investment	81,603	63,977	-17,625	57%
Private Inventory	1,209	-1,402	-2,611	8%
Government Consumption	93,375	93,776	+401	-1%
Public Investment	19,746	20,053	+307	-1%
Public Inventory	289	187	-102	0%
Exports	88,494	59,474	-29,020	94%
Imports (Deduction)	-87,758	-58,047	+29,711	-96%

Source: Cabinet Office, Economic and Social Research Institute, website address: http://www.esri.cao.go.jp/jp/sna/qe094-2/gdemenu_ja.html, last accessed on 7 April 2010

Table 9 Changes in Real Exports, 2000-2005 and 2008-2009

	Nominal exports	Deflator (= 100 for calendar year 2000)	Deflator (= 100 for calendar year 2005)	Real exports (in 2005 prices)
2000	55,256	100.0	102.4	53,985
2005	71,913	97.7	100.0	71,913
Change	16,657	-2.3	-2.4	17,928
2008	88,494	99.6	101.9	86,806
2009	59,474	88.0	90.1	66,029
Change	-29,020	-11.6	-11.9	-20,776

Source: Nominal exports and deflators (=100 for calendar year 2000), Cabinet Office, Economic and Social Research Institute, website address: http://www.esri.cao.go.jp/jp/sna/qe094-2/gdemenu_ja.html, last accessed on 7 April 2010

2000 to 2005, and decreased by 20,776 billion yen (in 2005 prices) from 2008 to 2009. The ratio of the two values is:

$$20{,}776 / 17{,}928 = 1.16$$

The increase in inducements of dispatched employees by exports from 2000 to 2005 was 242,000. Therefore, it can be estimated that:

$$242 \times 1.16 = 280$$

That is, 280,000 dispatched employees lost their jobs from 2008 to 2009, induced by the decrease in exports.

According to the Labor Force Survey, the number of dispatched workers from temporary labor agencies was 1,400,000 in 2008 and 1,080,000 in 2009, a decrease of 320,000. Considering that exports and domestic final demand changed simultaneously, the decrease of 280,000 dispatched employees appears reasonable.

7. Conclusion

In this paper, the number of dispatched employees by input-output sector is estimated using Japan's *Census of Establishments and Enterprises*. Since the results of input-output analysis using this estimate appear reasonable, this estimating methodology seems promising.

From the input-output analysis, 280,000 dispatched employees lost their jobs because of the decrease in exports from 2008 to 2009. These dispatched employees worked on production lines in manufacturing industry increased after the Worker Dispatching Law was altered in 2004. Now, in 2010, Japan's government is discussing regulation of dispatched employees. As a result, exporters hesitate to hire dispatched employees whom they may not be able to fire during the next recession. Under Japanese workplace conventions, it is difficult for workers to become formal employees after they have been dispatched workers. Sectors with potential to absorb dispatched workers who lost their jobs are commerce, and medical service, health and social security, and nursing care. It remains to be seen how dispatched employees can shift from exporting industries to such areas.

References

Japan Institute for Labour Policy and Training, 2003, "Revised Worker Dispatching Law Passed", *Japan Labor Bulletin*, Vol. 42, No. 8, August 2003

Japan Institute for Labour Policy and Training, 2009, *Act for Securing the Proper Operation of Worker Dispatching Undertakings and Improved Working Conditions for Dispatched Workers*, http://www.japaneselawtranslation.go.jp/law/detail_main?vm=&id=75, English translation of act by Japan Institute for Labour Policy and Training, last accessed on 7 April 2010

Bureau of Census, 2007, *2007 NAICS Definitions*, http://www.census.gov/naics/2007/def/ND561320.HTM, page last modified on 9 August 2007, last accessed on 7 April 2010

Appendix

Table A-1 Ratio of Number of Employees "Dispatched to/from Other" to Regular Employees

	Sector	A. Dispatched to other		B. Dispatched from other	
		2001	2006	2001	2006
1	Agriculture, forestry, and fisheries	0.006	0.011	0.031	0.035
2	Mining	0.019	0.034	0.056	0.052
3	Foods	0.013	0.012	0.042	0.071
4	Beverage, tobacco and feeds	0.028	0.027	0.068	0.102
5	Textile products	0.014	0.019	0.028	0.037
6	Wearing apparel and other textile products	0.009	0.007	0.009	0.021
7	Timber and wooden products	0.012	0.012	0.037	0.058
8	Furniture and fixtures	0.007	0.009	0.032	0.071
9	Pulp, paper, paperboard, building paper and paper products	0.029	0.021	0.044	0.070
10	Publishing, printing	0.010	0.008	0.027	0.040
11	Chemical products	0.040	0.054	0.070	0.105
12	Petroleum and coal products	0.024	0.065	0.077	0.081
13	Plastic products	0.020	0.019	0.064	0.121
14	Rubber products	0.023	0.024	0.053	0.117
15	Leather, fur skins and miscellaneous leather products	0.005	0.011	0.013	0.020
16	Ceramic, stone and clay products	0.019	0.028	0.099	0.156
17	Iron and steel	0.098	0.055	0.115	0.112
18	Non-ferrous metals	0.059	0.048	0.067	0.114
19	Metal products	0.013	0.017	0.063	0.099
20	General machinery	0.026	0.027	0.072	0.120
21	Electrical machinery	0.057	0.058	0.088	0.194
22	Transportation equipment	0.053	0.052	0.089	0.158
23	Precision instruments	0.026	0.028	0.055	0.133
24	Miscellaneous manufacturing products	0.014	0.015	0.047	0.075
25	Construction	0.014	0.019	0.056	0.060
26	Electricity	0.045	0.058	0.028	0.048
27	Gas and heat supply	0.039	0.036	0.073	0.143
28	Water supply	0.003	0.004	0.122	0.160
29	Waste management services	0.011	0.015	0.091	0.112
30	Commerce	0.009	0.010	0.039	0.048
31	Financial services and insurance	0.018	0.020	0.068	0.094
32	Real estate	0.021	0.042	0.062	0.058
33	Railway transport	0.056	0.032	0.029	0.037
34	Road transport	0.003	0.005	0.007	0.008
35	Freight forwarding	0.015	0.018	0.062	0.071
36	Water transport	0.026	0.041	0.043	0.064
37	Air transport	0.028	0.011	0.074	0.103
38	Storage facility services	0.032	0.034	0.238	0.278
39	Services relating to transport	0.043	0.065	0.103	0.143
40	Communication	0.008	0.020	0.061	0.069
41	Broadcasting	0.017	0.014	0.179	0.190
42	Survey and information services	0.105	0.132	0.134	0.146
43	Motion picture and video production, and distribution	0.077	0.040	0.043	0.054
44	Public administration	0.000	0.000	0.010	0.014
45	Education	0.002	0.004	0.029	0.035
46	Research	0.016	0.017	0.113	0.141
47	Medical service, health and social security, and nursing care	0.004	0.004	0.051	0.058
48	Advertising services	0.026	0.024	0.051	0.043
49	Goods rental and leasing services	0.011	0.017	0.052	0.052
50	Repair of motor vehicles and machinery	0.016	0.025	0.064	0.080
51	Amusement and recreational services	0.007	0.007	0.077	0.117
52	Eating and drinking places	0.003	0.005	0.006	0.007
53	Hotel and other lodging places	0.006	0.007	0.077	0.083
54	Cleaning, laundry and dyeing services	0.004	0.006	0.014	0.025
55	Other services	0.109	0.250	0.043	0.049
56	Office supplies	-	-	-	-
57	Activities not elsewhere classified	-	-	-	-

Table A-2 Number of Employees "Dispatched to/from Other" (in thousands)

		A. Dispatched to other			B. Dispatched from other		
	Sector	2000	2005	Change	2000	2005	Change
1	Agriculture, forestry, and fisheries	2	4	2	11	13	2
2	Mining	1	1	0	2	2	-1
3	Foods	13	13	-0	43	79	36
4	Beverage, tobacco and feeds	5	4	-1	12	16	4
5	Textile products	2	2	0	4	4	-0
6	Wearing apparel and other textile products	3	1	-2	3	3	0
7	Timber and wooden products	2	1	-0	5	7	1
8	Furniture and fixtures	1	1	0	4	9	5
9	Pulp, paper, paperboard, building paper and paper products	7	5	-3	11	15	5
10	Publishing, printing	4	3	-1	11	15	4
11	Chemical products	16	20	4	29	39	10
12	Petroleum and coal products	1	2	1	3	2	-1
13	Plastic products	8	8	0	26	54	28
14	Rubber products	3	3	0	6	14	8
15	Leather, fur skins and miscellaneous leather products	0	0	0	1	0	-0
16	Ceramic, stone and clay products	6	8	2	32	43	11
17	Iron and steel	30	16	-14	35	33	-3
18	Non-ferrous metals	9	6	-3	10	15	5
19	Metal products	9	11	2	42	65	23
20	General machinery	24	25	2	66	111	45
21	Electrical machinery	99	74	-25	154	249	95
22	Transportation equipment	49	48	-1	82	146	64
23	Precision instruments	5	4	-1	11	21	10
24	Miscellaneous manufacturing products	3	3	-0	9	12	3
25	Construction	59	68	9	235	211	-24
26	Electricity	8	10	2	5	8	3
27	Gas and heat supply	2	2	-0	3	6	3
28	Water supply	0	0	0	14	16	2
29	Waste management services	3	4	1	22	30	8
30	Commerce	96	93	-3	403	456	53
31	Financial services and insurance	31	30	-0	117	145	28
32	Real estate	6	11	5	18	16	-3
33	Railway transport	13	7	-7	7	8	1
34	Road transport	6	11	4	13	17	4
35	Freight forwarding	1	1	0	2	3	1
36	Water transport	4	5	1	6	8	1
37	Air transport	2	1	-1	4	5	1
38	Storage facility services	3	4	1	22	32	10
39	Services relating to transport	14	21	7	34	47	13
40	Communication	5	11	6	41	40	-1
41	Broadcasting	1	1	-0	11	13	2
42	Survey and information services	90	116	26	115	128	13
43	Motion picture and video production, and distribution	16	9	-7	9	12	3
44	Public administration	0	0	0	20	26	6
45	Education	3	8	5	60	74	14
46	Research	11	11	-0	80	93	13
47	Medical service, health and social security, and nursing care	16	20	4	203	290	87
48	Advertising services	5	4	-1	9	7	-2
49	Goods rental and leasing services	3	4	1	15	14	-1
50	Repair of motor vehicles and machinery	10	14	4	41	46	5
51	Amusement and recreational services	5	5	-0	52	75	24
52	Eating and drinking places	9	16	7	17	23	6
53	Hotel and other lodging places	4	4	-0	52	44	-8
54	Cleaning, laundry and dyeing services	3	4	1	11	18	7
55	Other services	421	1,197	777	167	237	70
56	Office supplies	-	-	-	-	-	-
57	Activities not elsewhere classified	-	-	-	-	-	-
	Total	1,151	1,957	806	2,417	3,114	697

Table A-3 Inducement of "Dispatched Employees from Other" by Final Demand Sector in 2005 (in thousands)

	Sector	Consumption expenditure outside households	Consumption expenditure (private)	Consumption expenditure of general government	Consumption expenditure of general government (social fixed capital depreciation)	Gross domestic fixed capital formation (public)	Gross domestic fixed capital formation (private)	Increase in stocks	Exports	Total
1	Agriculture, forestry, and fisheries	1	10	0	0	0	0	1	0	13
2	Mining	0	1	0	0	0	0	-0	0	2
3	Foods	5	69	3	0	0	0	1	1	79
4	Beverage, tobacco and feeds	2	14	0	0	0	0	0	0	16
5	Textile products	0	2	0	0	0	1	-0	1	4
6	Wearing apparel and other textile products	0	3	0	0	0	0	-0	0	3
7	Timber and wooden products	0	1	0	0	1	3	0	0	7
8	Furniture and fixtures	0	3	1	0	1	3	0	1	9
9	Pulp, paper, paperboard, building paper and paper products	1	7	1	0	1	2	0	3	15
10	Publishing, printing	0	7	2	0	0	2	0	2	15
11	Chemical products	1	12	9	0	1	3	0	13	39
12	Petroleum and coal products	0	1	0	0	0	0	-0	0	2
13	Plastic products	1	18	2	0	2	10	1	19	54
14	Rubber products	0	4	1	0	0	2	0	7	14
15	Leather, fur skins and miscellaneous leather products	0	0	0	0	0	0	-0	0	0
16	Ceramic, stone and clay products	1	8	1	0	8	15	0	10	43
17	Iron and steel	0	4	1	0	3	9	1	15	33
18	Non-ferrous metals	0	2	0	0	1	3	0	7	15
19	Metal products	1	13	2	1	11	25	1	12	65
20	General machinery	0	5	1	0	2	57	1	45	111
21	Electrical machinery	7	44	2	1	5	68	0	122	249
22	Transportation equipment	0	32	3	1	1	31	1	76	146
23	Precision instruments	0	4	1	0	0	6	-0	8	21
24	Miscellaneous manufacturing products	0	5	1	0	0	3	0	2	12
25	Construction	1	18	4	1	69	115	0	3	211
26	Electricity	0	5	1	0	0	1	0	1	8
27	Gas and heat supply	0	5	0	0	0	0	0	1	6
28	Water supply	1	12	1	0	0	1	0	1	16
29	Waste management services	1	9	12	3	0	2	0	2	30
30	Commerce	14	259	18	2	11	84	2	67	456
31	Financial services and insurance	3	98	7	1	4	15	0	16	145
32	Real estate	0	15	0	0	0	0	0	0	16
33	Railway transport	0	6	0	0	0	0	0	1	8
34	Road transport	1	9	1	0	1	3	0	3	17
35	Freight forwarding	0	2	0	0	0	1	0	1	3
36	Water transport	0	1	0	0	0	0	0	6	8
37	Air transport	0	3	0	0	0	0	0	2	5
38	Storage facility services	1	14	4	1	1	4	0	6	32
39	Services relating to transport	1	28	1	0	1	4	0	11	47
40	Communication	1	28	2	0	1	4	0	3	40
41	Broadcasting	0	9	1	0	0	1	0	1	13
42	Survey and information services	2	38	8	2	9	59	0	11	128
43	Motion picture and video production, and distribution	0	7	1	0	0	2	0	2	12
44	Public administration	0	1	17	8	0	0	0	0	26
45	Education	0	24	41	8	0	0	0	0	74
46	Research	2	23	14	1	2	18	0	33	93
47	Medical service, health and social security, and nursing care	3	72	215	1	0	0	0	0	290
48	Advertising services	0	4	1	0	0	1	0	1	7
49	Goods rental and leasing services	0	6	2	0	1	3	0	2	14
50	Repair of motor vehicles and machinery	1	26	4	1	2	7	0	6	46
51	Amusement and recreational services	8	65	0	0	0	0	0	1	75
52	Eating and drinking places	8	15	0	0	0	0	0	0	23
53	Hotel and other lodging places	12	28	0	0	0	0	0	4	44
54	Cleaning, laundry and dyeing services	0	16	1	0	0	0	0	0	18
55	Other services	4	132	19	3	13	43	0	22	237
56	Office supplies	-	-	-	-	-	-	-	-	-
57	Activities not elsewhere classified	-	-	-	-	-	-	-	-	-
	Total	87	1,244	410	39	157	612	11	555	3,114

Table A-4 Changes in Inducement of "Dispatched Employees from Other" by Final Demand Sector from 2000 to 2005 (in thousands)

	Sector	Consumption expenditure outside households	Consumption expenditure (private)	Consumption expenditure of general government	Consumption expenditure of general government (social fixed capital depreciation)	Gross domestic fixed capital formation (public)	Gross domestic fixed capital formation (private)	Increase in stocks	Exports	Total
1	Agriculture, forestry, and fisheries	0	2	0	0	-0	-0	0	0	2
2	Mining	-0	-0	-0	-0	-0	-0	-0	-0	-1
3	Foods	2	32	1	0	-0	0	0	1	36
4	Beverage, tobacco and feeds	0	4	0	0	-0	0	0	0	4
5	Textile products	-0	-0	0	0	-0	0	-0	0	-0
6	Wearing apparel and other textile products	0	0	0	0	-0	0	0	0	0
7	Timber and wooden products	0	0	0	0	-0	0	0	0	1
8	Furniture and fixtures	0	2	1	0	0	1	0	1	5
9	Pulp, paper, paperboard, building paper and paper products	0	2	1	0	-0	1	0	1	5
10	Publishing, printing	0	2	1	0	-0	0	0	1	4
11	Chemical products	0	2	3	0	-0	0	0	5	10
12	Petroleum and coal products	-0	-0	-0	-0	-0	-0	-0	0	-1
13	Plastic products	1	8	1	0	0	4	1	13	28
14	Rubber products	0	2	0	0	0	1	0	4	8
15	Leather, fur skins and miscellaneous leather products	-0	-0	0	0	-0	-0	0	0	-0
16	Ceramic, stone and clay products	0	2	0	0	-0	3	1	5	11
17	Iron and steel	-0	-1	-0	-0	-2	-3	1	2	-3
18	Non-ferrous metals	0	1	0	0	-0	1	0	3	5
19	Metal products	0	5	1	0	2	9	1	6	23
20	General machinery	0	2	0	0	-1	20	2	22	45
21	Electrical machinery	4	17	1	0	-4	18	-0	59	95
22	Transportation equipment	0	12	1	0	-0	10	2	38	64
23	Precision instruments	0	1	1	0	-0	3	0	5	10
24	Miscellaneous manufacturing products	0	1	0	0	-0	1	0	1	3
25	Construction	-0	2	0	0	-22	-6	0	1	-24
26	Electricity	0	2	0	0	-0	0	0	1	3
27	Gas and heat supply	0	2	0	0	0	0	0	0	3
28	Water supply	-0	1	0	0	-0	0	0	0	2
29	Waste management services	0	2	3	1	-0	0	0	1	8
30	Commerce	-1	18	3	1	-6	11	1	27	53
31	Financial services and insurance	-0	19	2	0	-1	2	0	6	28
32	Real estate	-0	-2	-0	-0	-0	-0	0	0	-3
33	Railway transport	-0	1	0	0	-0	0	0	0	1
34	Road transport	0	2	0	0	-0	1	0	1	4
35	Freight forwarding	0	1	0	0	-0	0	0	0	1
36	Water transport	-0	-0	-0	0	-0	-0	0	2	1
37	Air transport	0	1	0	0	-0	0	0	0	1
38	Storage facility services	0	4	1	1	-0	1	0	3	10
39	Services relating to transport	0	8	0	0	-0	1	0	3	13
40	Communication	-0	0	-0	-0	-1	-1	0	1	-1
41	Broadcasting	-0	1	0	0	-0	0	0	0	2
42	Survey and information services	-0	2	1	1	2	6	0	2	13
43	Motion picture and video production, and distribution	0	2	0	0	-0	0	0	1	3
44	Public administration	0	0	3	3	0	0	0	0	6
45	Education	0	6	6	2	0	0	0	0	14
46	Research	0	4	2	0	-2	-1	1	9	13
47	Medical service, health and social security, and nursing care	1	24	63	0	-0	0	0	0	87
48	Advertising services	-0	-1	-0	-0	-0	-0	0	-0	-2
49	Goods rental and leasing services	-0	-0	0	0	-1	-1	0	0	-1
50	Repair of motor vehicles and machinery	0	2	1	0	-1	0	0	2	5
51	Amusement and recreational services	2	20	0	0	0	0	0	1	24
52	Eating and drinking places	2	4	0	0	0	0	0	0	6
53	Hotel and other lodging places	-3	-7	0	0	0	0	0	2	-8
54	Cleaning, laundry and dyeing services	0	6	1	0	0	0	0	0	7
55	Other services	1	39	7	1	0	10	0	11	70
56	Office supplies	–	–	–	–	–	–	–	–	–
57	Activities not elsewhere classified	–	–	–	–	–	–	–	–	–
	Total	11	256	106	12	-37	95	12	242	697

The Prediction of CO_2 Emissions up to 2020 in Japanese Economic Activities

Yasuhiko Sasai[a], Toshiaki Hasegawa[b], Takeshi Imagawa[c] and Mitsuhito Ono[d]*

Abstract

The estimation of CO_2 emissions is performed using two simulations.[1] The first simulation clarifies the amount of CO_2 emitted by each industrial sector or households. The second simulation clarifies whether thermal power generation is substituted for by nuclear power generation, and how much it affects CO_2 emissions. We made these estimations by the JIDEA model, the dynamic econometric model based on the input-output table developed by ITI [2] and academics from Chuo University. Our simulation shows that even if all the thermal power generation were substituted with nuclear, Hatoyama's objective of cutting CO_2 25% by 2020 is unattainable.

Keywords: Japanese economic activities, estimation of CO_2 emissions, thermal power generation, nuclear power generation, econometric model, JIDEA

1. The Method for Estimating CO_2 Emissions and the Forecasts thereof

1-1. The Necessity of a Dynamic Model based on an IO Table

A dynamic econometric model based on an IO table is the most suitable method for forecasting the amount of CO_2 emissions caused by economic activities. We can point out three reasons for this.

First, the CO_2 emissions are closely linked to industrial production. To forecast the industrial production sector by sector, an IO-based dynamic model is indispensable.

Second, the amount of CO_2 emissions depends on the consumption for each energy source. Accordingly, it is necessary to know the amount of energy consumption of industries by energy source. For this purpose, an IO-based model linked to the material IO table can deliver the necessary data in sufficient detail for our study.

Third, it is necessary that the evolution of industrial structure corresponding to economic growth should be appropriately included in the model.

Our estimation of CO_2 emissions is performed using two simulations. With the first simulation, we want to clarify the amount of CO_2 that would be emitted by each industrial sector or households, and the relationship between the primary and secondary sectors of energy consumption. In this simulation, we assume that the sector of electric power generation consists of only two parts: "commercial electric power" and "electric power

* JIDEA Team, Japan: [a] Associate Economist, ITI, 8-10, 1-Chome, Akasaka, Minato-ku, 107-0052, Japan; [b] Professor, Department of Economics, Chuo University Hachioji, Japan; [c] Professor Emeritus, Chuo University; [d] Chief Economist, ITI

[1] This simulation result was reported at the 18th Inforum World Conference held in Hikone from 5 to 12 September 2010

[2] Institute for International Trade and Investment

self-generated".

The second simulation focuses on "commercial electric power (columns)" which is composed of three sectors: "nuclear energy", "thermal energy" and "water and other energy". In this simulation, we want to clarify whether thermal power generation is substituted for by nuclear power generation, and how much it affects CO_2 emissions.

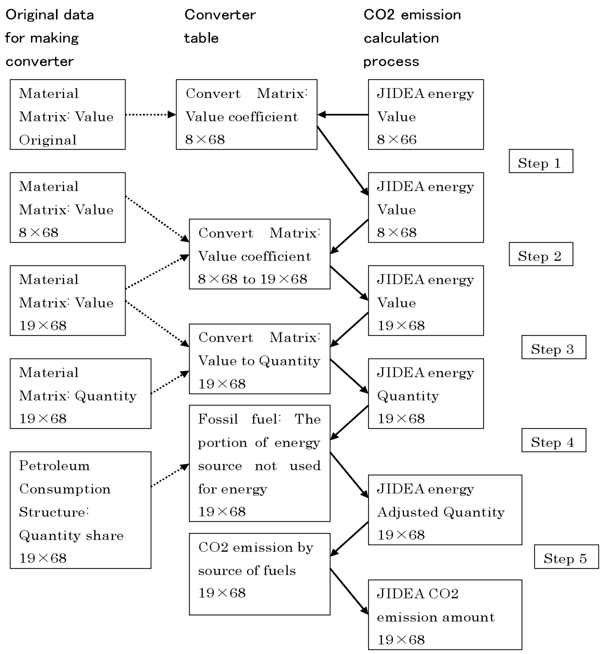
As the method for calculating CO_2 emissions, we applied almost the same calculation process for these two simulations; they differ only in the final step, where the intermediate coefficient of the "commercial electric power" sector is altered because of the substitution for thermal power by nuclear power. It should be noted that the total demand for electricity is always the same before and after the substitution for thermal power generation by nuclear power.

1-2. The Outline of the Procedure for CO_2 Emission Estimation

The outline of the procedure for estimating CO_2 emissions is shown in Figure1-1.

Using the JIDEA model, we can obtain how much energy will be necessary for each industry over the coming 15 years; the necessity of energy consumption is expressed in monetary terms. To estimate CO_2 emissions, it is necessary to know the quantity of energy consumed by energy source measured in material units. For this purpose, we can use "the material matrix" which the Japanese government statistical office publishes every five years.[3] The material matrix works as a bridging table between the monetary terms and physical terms. In the material matrix table, each row expresses the quantity of goods as

Figure 1-1 The Outline of the Mechanisms to Estimate CO_2 Emissions



3 Source: Ministry of Internal Affairs and Communications, 2009

Table 1-1 Example of the Material Matrix of the Input-Output Table in 2000

Row-code	Row-item	Column-code	Column-item	Unit-code	Unit	Quantity	Value
711011	Coal	71101	Coal, crude oil, natural gas	060	t	3,324	16
711011	Coal	114101	Tobacco	060	t	4,766	31
711011	Coal	151101	Spinning	060	t	322	2
711011	Coal	151401	Dyeing	060	t	1,718	13
711011	Coal	151901	Cord, Nets	060	t	86	1
711011	Coal	151909	Other textile products	060	t	322	2
711011	Coal	152209	Other clothes	060	t	172	2
711011	Coal	181101	Pulp	060	t	64,921	307
711011	Coal	181201	Paper	060	t	1,104,785	5,354
711011	Coal	181202	Corrugated paper	060	t	92,542	433
711011	Coal	182909	Sanitary paper	060	t	17,250	136
711011	Coal	201101	Chemical fertilizer	060	t	202,527	879
711011	Coal	202901	Inorganic pigments	060	t	10,616	92
711011	Coal	202903	Salt	060	t	174,691	1,502
711011	Coal	202909	Other inorganic chemicals	060	t	5,222	45
711011	Coal	203101	Basic petrochemicals	060	t	65,738	440
711011	Coal	203102	Petroleum based aromatics	060	t	34,795	305
711011	Coal	203201	Aliphatic intermediates	060	t	1,422,479	6,560
711011	Coal	203202	Cyclic intermediates	060	t	293,928	1,464
711011	Coal	203301	Synthetic rubber	060	t	290,650	1,372
:	:	:	:	:	:	:	:

Source: Ministry of Internal Affairs and Communications, 2009

well as their value. Each row has its own unit depending on its material nature. The columns are by industry, the same as in a normal IO table. As the unit of quantity is different in each row, a column total is meaningless. A part of the material matrix is shown in Table 1-1. From this table, we can get each industry's material coefficient by dividing the quantity by the value.

The First Step. The two columns of the JIDEA model of "electricity" and "city gas" should be classified in more detail. If we want to calculate the precise amount of CO_2 emissions, the sector of "commercial electric generation" should be divided into "electric power generation" and "electricity self-generated", because these two sectors have different input structures. The city gas sector should be divided also into "city gas supply" and "hot water supply". The respective dividing ratios can be obtained from the original IO table, which has more detailed classifications.

The Second Step. The JIDEA model has only 8 sectors related to energy sources. For more precise estimation of CO_2 emissions, the 8 sectors should be split into the 19 sectors[4] as shown in Table 1-2. As can be seen in Table 1-6, the CO_2 emissions by energy source are quite different than by energy. Fortunately the material IO matrix has split the energy sources into 19 sectors. Accordingly, the 8 sectors of the JIDEA model can be increased to 19. The JIDEA code corresponding to the material IO code is indicated in Table 1-2.

[4] Limestone is a source of CO_2 emissions in spite of its non-energy character

Table 1-2 Correspondence Table for Material IO Codes and JIDEA Codes

Item	Material matrix			JIDEA model	
	Original code	Energy code	Unit	JIDEA model item	Model code
Limestone	621011	1	t	Non-metallic ore	3
Coal	711011	2	t	Coal	4
Crude oil	721011	3	kl	Petroleum & gas exploration	5
Natural gas	721012	4	$1000m^3$		5
Gasoline	2111011	5	kl	Petroleum products	21
Jet fuel	2111012	6	kl		21
Kerosene	2111013	7	kl		21
Light oil	2111014	8	kl		21
Heavy oil A	2111015	9	kl		21
Heavy oil B and C	2111016	10	kl		21
Naphtha	2111017	11	kl		21
LPG	2111018	12	t		21
Other petroleum products	2111019	13	-		21
Cokes	2121011	14	t	Coal products	22
Other coal products	2121019	15	-		22
Power stations	5111001	21	miilion kw	Electric power	54
Home-generated electricity	5111041	22	million kw		54
City gas	5121011	23	$1000m^3$	City gas & hot water	55
Self-generated electricity	5122011	24	GJ		55

Source: Ministry of Internal Affairs and Communications, 2009, and the JIDEA model

CO_2 is emitted not only from hydrocarbon fuels but also from some kinds of chemical reactions. The most important reaction is the calcium carbonate reaction in which calcium carbonate changes into calcium oxide and CO_2:

$$CaCO_3 \rightarrow CaO + CO_2$$

This reaction takes place in a furnace when limestone ($CaCO_3$) is heated above 900℃. Calcium oxide (CaO) acts as a reducing agent in the furnace. Accordingly, we assumed that when limestone is used as an intermediate input in "iron and steel", "cement" and the "glass industry", limestone becomes a source of CO_2 emissions.

The Third Step. The values for energy in 19 sectors, increased from the 8 sectors of the JIDEA model, are converted into 19 sectors for quantities by a value-to-quantity coefficient matrix. Part of the coefficient matrix converting value to quantity is shown in Table 1-3. Table 1-3 additionally contains 4 sectors related to "iron and steel" which are used to calculate the amount of "limestone" required to produce steel products.

The Fourth Step. Fossil fuels are not always used only as energy, but also as materials required to produce other materials. The proportion of fossil fuels not used for energy differs by sector. The proportion of fossil fuels used as energy is published in "The Statistics on Consumption Structure of Petroleum and Other Energy Materials".[5] Part of these statistics is shown in Table 1-4.

[5] The statistics are published by METI but the publication of this series ended in 2001

Table 1-3 Example of Part of the Coefficient Matrix converting Value to Quantity

Item			Agriculture, Forestry, Fisheries	Metal mining	Non-metal mining	Coal	Crude oil, natural gas	Food	Beverages	Textiles	Clothing	Wooden products	..
	Energy-c	Unit	1	2	3	4	5	6	7	8	9	10	..
Limestone	1	t	0	0	1248.550562	0	0	0	0	0	0	0	..
Coal	2	t	0	0	0	207.75	0	153.7419355	0	136	86	0	..
Crude oil	3	kl	0	0	0	0	0	0	0	0	0	0	..
Natural gas	4	$1000m^3$	0	0	0	0	31.75	0	0	0	0	0	..
Gasoline	5	kl	11.27547021	11.28571429	11.27669173	11.33333333	11.3	11.28125	11.28205128	11.27272727	11.27586207	11.2761194	..
Jet fuel	6	kl	0	0	0	0	0	0	0	0	0	0	..
Kerosene	7	kl	37.35276172	37.75	37.34751773	38	37.5	37.35265073	37.35015291	37.35407407	37.35483871	37.34992459	..
Light oil	8	kl	14.84150492	15.04545455	14.84402146	15	15.15	14.8297491	14.89207048	14.80465116	14.65079365	14.84359272	..
Heavy oil A	9	kl	40.69087032	40.72093023	40.72366522	40.72857143	40.72413793	40.72143818	40.72119162	40.7210324	40.72207376	40.72289157	..
Heavy oil B and C	10	kl	47.85907473	47.44	47.57275902	47	47	47.67009455	47.99472235	47.57677734	47.50251256	47.50471063	..
Naphtha	11	kl	0	0	0	0	0	0	0	0	0	0	..
LPG	12	t	27.76982592	26.5	27.72384937	0	26.5	27.79219381	27.76029654	27.72990354	27.71917808	28.04310345	..
Coke	14	t	72	0	72.02926829	0	0	0	0	0	0	72	..
Power stations	21	million kw	0.069683555	0.069465649	0.06963628	0.069487983	0.069551367	0.055218371	0.054106871	0.06965825	0.06966307	0.069641492	..
Self-generated electricity	22	million kw	0	0.10331384	0.103165299	0.102863203	0.103365385	0.103110865	0.103208556	0.103134479	0.110714286	0.102895553	..
City gas	23	$1000m^3$	6.866666667	0	6.862068966	7	6.714285714	24.52235201	24.8765054	20.34416757	20.34274953	25.8037813	..
Heat supply	24	GJ	0	0	0	0	151.1	151.1185644	151.1193082	151.1178248	151.1176471	151.1188119	..

Source: calculated by the JIDEA team, Japan

Table 1-4 The Statistics on the Consumption Structure of Petroleum and Other Energy Materials

Industrial classification	Item	Fuel code	Fuel item	Unit	Input	Consumption						Output	End of the year
						Total	Material for other products	Boilers	Direct heating	Co-generation	Other		
:	:	:	:	:	:	:	:	:	:	:	:	:	:
	Total	2010	Crude oil	kl	1,957,592	1,863,869	1,840,883	22,986	-	-	-	61,396	54,986
2000	Chemical Industry	2010	Crude oil	kl	1,949,066	1,855,317	1,840,883	14,434	-	-	-	61,396	54,973
2030	Organic Chemicals	2010	Crude oil	kl	1,949,066	1,855,317	1,840,883	14,434	-	-	-	61,396	54,973
2031	Basic Petrochemical	2010	Crude oil	kl	219,795	219,795	219,795	-	-	-	-	-	-
2032	Aliphatic Chem Intermed	2010	Crude oil	kl	657,219	629,314	629,314	-	-	-	-	-	40,785
2036	Cyclo-intermed Chem	2010	Crude oil	kl	26,110	26,045	26,045	-	-	-	-	-	1,738
2039	Other Inorg Chem	2010	Crude oil	kl	1,045,942	980,163	965,729	14,434	-	-	-	61,396	12,450
2500	Ceramic & Stone	2010	Crude oil	kl	8,526	8,552	-	8,552	-	-	-	-	13
2590	Other Ceramic & Stone	2010	Crude oil	kl	8,526	8,552	-	8,552	-	-	-	-	13
2596	Calcium Sulfate	2010	Crude oil	kl	8,526	8,552	-	8,552	-	-	-	-	13
	Total	2110	Gasoline	kl	145,137	146,587	-	-	-	-	146,587	341	3,821
1200	Food Mnfg	2110	Gasoline	kl	4,084	4,068	-	-	-	-	4,068	-	60
1210	Animal Husbandry	2110	Gasoline	kl	341	340	-	-	-	-	340	-	1
1211	Meat Products	2110	Gasoline	kl	185	184	-	-	-	-	184	-	1
1212	Milk Products	2110	Gasoline	kl	76	76	-	-	-	-	76	-	-
1219	Other Animal Husbandry	2110	Gasoline	kl	80	80	-	-	-	-	80	-	-
1220	Fisheries Products	2110	Gasoline	kl	1,552	1,543	-	-	-	-	1,543	-	35
:	:	:	:	:	:	:	:	:	:	:	:	:	:

Source: Agency for Natural Resources and Energy, 2001

Table 1-5 The Ratio of Fossil Fuels not used as Energy

	..	12	13	14	15	16	17	18	19	20	21	..
	..	Pulp & paper	Printing & publishing	Inorganic chemicals	Petro chemicals	Organic chemicals	Synthetic resine	Synthetic fiber	Final chemicals	Pharmatheutics	Petro products	..
Limestone	..	1	1	1	1	1	1	1	1	1	1	..
Heavy oil A	..	0.0000	0.0000	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	..
Heavy oil B and C	..	0.0000		0.023380887	0.021813492		0.0000		0.000198601	0.0000	0.153862622	..
	..											..
Gasoline	..	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	..
Gas as biproduct of coke	..								0.9415		0.0000	..
Naphtha	..				0.9986	1.0000	1.0000	0.0000	0.9459		0.8896	..
LPG	..	0.0000	0.0000	0.1155	0.7375	0.8150	0.7414		0.6659	0.0000	0.6893	..
LNG	..	0.0000		0.0000	0.0000	0.4589	0.0000			0.0000		..
Converted oil	..				1.0000		1.0000				1.0000	..
Light oil	..	0.0000	0.0000	0.0000	0.0000	0.0090	0.2198	0.0000	0.1100	0.0000	0.0227	..
Crude oil	..				1	0.99222					1.0000	..
Furnace gas	..				0.0000							..
Coal	..	0.0000		0.0111	0.0000	0.0258	0.0155	0.0000	0.8878		0.5829	..
Coke from coal	..			0.3312	0.0000	0.3977			0.8051		1.0000	..
Coke from petroleum	..	0.0000		0.8626	0.0000	0.0959	0.0595	0.0000	0.0375		0.0309	..
Hydrocarbon gas from petroleum	..	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0159	..
Hydrocarbon oil	..			0.9686	0.0000	0.0000	0.0000	0.0000	0.4187	0.0000	0.0050	..
Natural gas	..			0.4537	0.0000	0.3572	0.6078				0.0000	..
Converter gas	..			0.2217	0.0000							..
Electric furnace gas	..				0.0000				0.0000			..
City gas	..	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	..
Kerosene	..	0.0000	0.0000	0.0000	0.0000	0.9178	0.0000	0.0000	0.0138	0.0000	0.9282	..

Note: The value for limestone is always “1”, except in the steel industry, and the cement and glass industry
Source: calculated by the JIDEA team, Japan

Table 1-6 Calorific Ratios and CO2 Emission Ratios by Fuel

	Quantity	Calorific value	CO_2 emissions per calorie	CO_2 emissions per unit of quantity
Fuel	Unit	MJ/Unit	kg-CO_2/GJ	t-CO_2/Unit
Coal for coke	t	31,814	81.61	2.596
Coal	t	25,426	94.75	2.409
Crude oil	kl	38,721	67.64	2.619
Natural gas	1000m^3	41,023	50.81	2.084
LNG*	t	54,418	49.57	2.698
Gasoline	kl	35,162	66.03	2.322
Kerosene	kl	36,418	67.62	2.463
Jet fuel	kl	37,255	66.82	2.489
Light oil	kl	38,511	68.01	2.619
Heavy oil A	kl	38,930	69.60	2.710
Heavy oil B and C	kl	41,023	72.68	2.982
Naphtha	kl	33,488	67.95	2.276
LPG	t	50,232	59.73	3.000
Reformed oil	kl	33,488	70.45	2.359
Hydrocarbon oil	t	41,023	77.09	3.162
Hydrocarbon gas	1000m^3	39,348	59.41	2.338
Petro coke	t	35,581	93.18	3.315
Coke	t	30,139	107.66	3.245
Coke furnace gas	1000m^3	20,093	42.36	0.851
Blast furnace gas	1000m^3	3,349	99.32	0.333
Revolver furnace gas	1000m^3	8,372	141.44	1.184
Electric furnace gas	1000m^3	8,372	183.25	1.534
Coal pit gas	1000m^3	36,000	50.26	1.809
Coal tar	t	32,065	89.15	2.859
Commercial electric power stations	million kWh	7,431,018		512.258
Self-generated electricity	million kWh	6,249,819		431.333
City gas	1000m^3	27,788		1.455
Heat supply	GJ	505		0.037

Source: Center for Global Environmental Research, 2008

From these statistics, we can derive the table "The Ratio of Fossil Fuels not used as Energy". Part of this table is shown in Table 1-5.

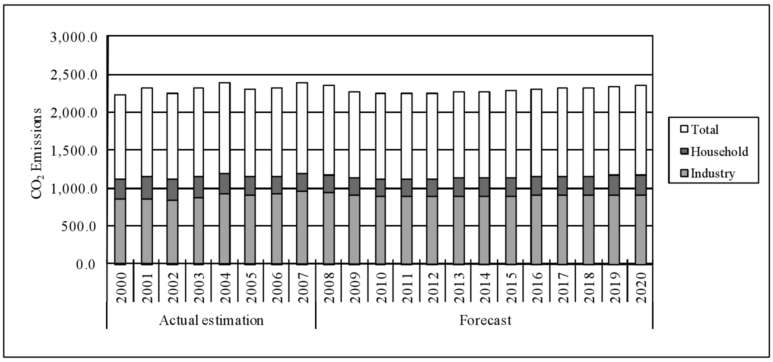
The Fifth Step. We apply the ratio of carbon contained in each hydrocarbon fuel to calculate the CO2 emissions by industry. The calorific and CO2-emission ratios by fuel are shown in Table 1-6.

2. The Results of the Prediction of CO_2 Emissions through Japanese Economic Activity

2-1. Overview of the Prediction of CO_2 Emissions

The results of the estimation and prediction of Japanese CO_2 emissions up to 2020 are

Figure 2-1 CO_2 Emissions by Households and Industry (unit: million tonnes)



Source: prepared by the JIDEA team, Japan

Table 2-1 Japanese CO_2 Emissions by Economic Activity

	CO_2 emissions by industry	CO_2 emissions by households	CO_2 emissions total	Relative share of households	GDP in real terms	CO_2 emissions	CO_2/GDP	CO_2/ population
Year	Quantity (100 million tonnes)			%	Index (2000 = 100)			
2000	850.6	261.7	1,112.3	23.5	100.0	100.0	100.0	100.0
2005	901.9	251.2	1,153.0	21.8	99.6	103.7	104.1	102.9
2010	893.8	227.6	1,121.4	20.3	97.2	100.8	103.7	100.8
2015	899.1	244.7	1,143.8	21.4	100.8	102.8	102.0	104.4
2020	910.9	265.5	1,176.4	22.6	105.6	105.8	100.1	110.1

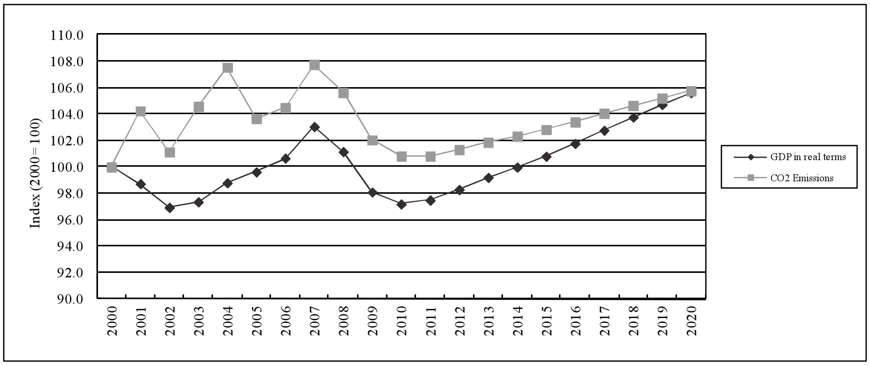
Source: prepared by the JIDEA team, Japan

summarized in Figure 2-1. CO_2 emissions leapt in 2004 and 2007, and shrank from 2008 to 2010; affected by the sub-prime loan shock, Japanese economic activities stagnated and CO_2 emissions shrank accordingly. Subsequently, CO_2 emissions will increase slightly. The main player in this increase will be the household sector, while CO_2 emissions from industrial activity are staying at an almost constant level (see Table 2-1 also).

It goes without saying that the CO_2 emissions correlate to industrial output, and are inversely related to industrial energy efficiency. To present these relationships more clearly, the indices of CO_2 emissions per unit of GDP and CO_2 emissions per capita were calculated and added on the right-hand side of Table 2-1.

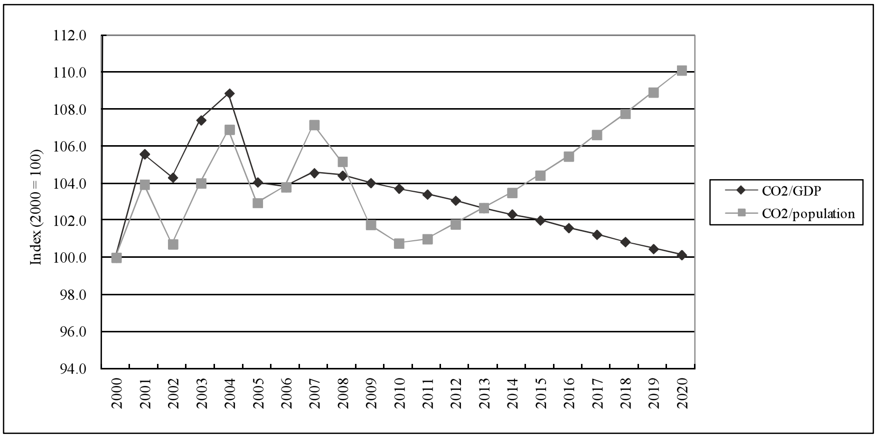
In comparison with the figures in 2000, total CO_2 emissions will increase slightly to 5.8% in 2020, while real GDP will increase to 5.6% in 2020 (Table 2-1 and Figure 2-2). Consequently CO_2 emissions per GDP in real terms will be almost the same in 2020. This means that the energy efficiency of Japan measured by CO_2 emissions per GDP in real terms will not change in this period (Table 2-1 and Figure 2-3). On the other hand, CO_2 emissions per capita will increase by 10.1%, and after 2010 especially. As a result, the share of households relative to the total amount of CO_2 emissions will decrease from 23.5% to 20.3% in 2010, then increase to 22.6% in 2020. In spite of population decline, the upgrading of living standards or the endless pursuit of comfortable living will be a cause

Figure 2-2 Indices of GDP and CO2 Emissions (2000 = 100)



Source: prepared by the JIDEA team, Japan

Figure 2-3 Indices of CO_2 Emissions per Unit of Real GDP and per Capita (2000 = 100)



Source: prepared by the JIDEA team, Japan

for augmenting energy consumption, especially of electricity by households.

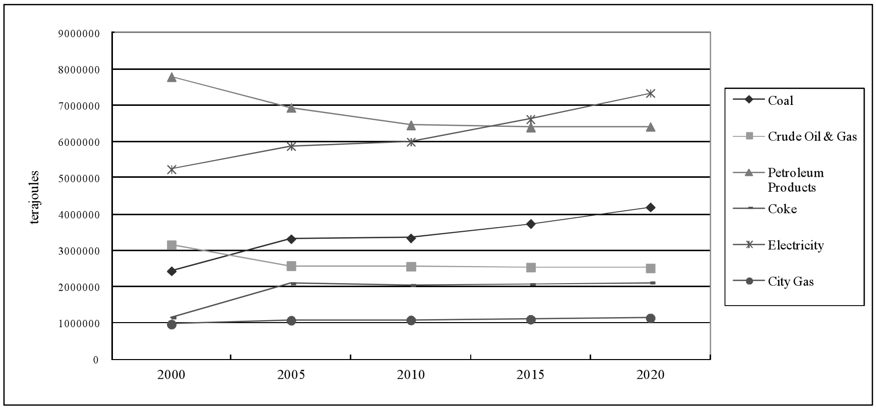
2-2. Prediction of Energy Consumption by Source

Needless to say, CO_2 emissions are closely linked to fossil fuel consumption. Figure 2-4 shows the consumption of energy by source in terajoules, including the secondary energies of electricity and city gas. Electricity, 30% of which comes from nuclear energy in Japan,[6] will increase rapidly. In contrast to the decline of crude oil and gas consumption after 2005, coal consumption will increase gradually. One note of caution that should be made is that the prices of coal, crude oil and natural gas are fixed at their levels in 2006 in

[6] A detailed discussion will be given in Section 3

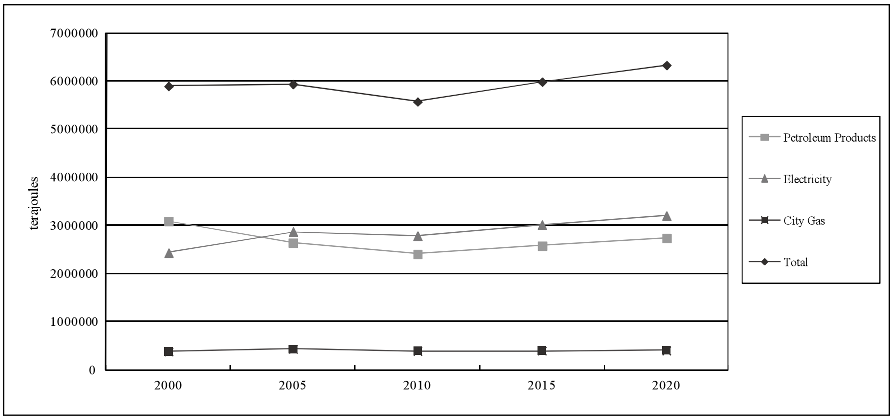
[7] The foreign exchange rate was also fixed at the 2006 level

Figure 2-4 Consumption of Energy by Source (unit: terajoules)



Source: prepared by the JIDEA team, Japan

Figure 2-5 Household Energy Consumption by Source (unit: terajoules)



Source: prepared by the JIDEA team, Japan

this prediction.[7]

The household energy consumption by source is presented in Figure 2-5. The consumption of petroleum products, decreasing in 2005 and 2010 because of economic recession, will increase up to 2020, while the consumption of electricity, though decreasing slightly in 2010, will also continue to increase.

2-3. The Prediction of CO_2 Emissions by Industry

There are two sources of CO_2 emission by industry: one is the secondary-energy producing sectors such as electric power (commercial and self-generated), city gas and heat supply; the other is a group of industries, excluding the secondary energy-producing sectors, or the non-secondary energy producing sectors. The total amount of CO_2 emissions by industry is the sum of the CO_2 emissions of these two sectors. Table 2-2 describes the

Table 2-2 Secondary Energy-Producing Sectors: CO_2 Emissions Indices and Relative Shares

Year	Secondary Energy-Producing Sectors				Non-Secondary Energy Producing Sectors	Total	Secondary Energy Producing Sectors	Non-Secondary Energy Producing Sectors
	Electric Power (Commercial)	Electric Power (Self-Gen)	City Gas	Heat Supply				
	Index (2000 = 100.0)						Share (%)	
2000	100.0	100.0	100.0	100.0	100.0	100.0	35.3	64.7
2005	108.0	95.5	102.5	77.7	102.4	103.7	36.0	64.0
2010	109.4	98.3	100.5	105.9	97.4	100.8	37.4	62.6
2015	118.8	104.4	94.5	101.5	96.6	102.8	39.1	60.9
2020	128.6	110.3	88.1	97.0	96.9	105.6	40.6	59.4

Source: prepared by the JIDEA team, Japan

estimation and prediction of CO_2 emissions by the secondary and non-secondary energy-producing sectors in the form of indices.

The share of CO_2 emissions by the secondary energy-producing sectors relative to the total amount of CO_2 emissions, shown on the right-hand side of Table 2-2, was 29.4% in 2000 and is predicted to be 36% in 2020. In particular the electric power (commercial) sector is clearly expanding as the index of electric power (commercial) will be 128.8 in 2020. What is much more interesting is the detailed picture of CO_2 emissions by industry excluding secondary energy-producing sectors. In this study the industrial activities are composed of 66 sectors.

In calculating the amount of CO_2 emitted by industries there is a problem with how to deal with the CO_2 emissions from the electric power sector. Each industrial sector uses electricity, but electricity is a secondary energy produced from fossil fuels or from other primary energies. An industry which only uses electricity emits no CO_2, while generating electricity itself inevitably emits a considerable amount of CO_2. Who should be responsible for the emission of CO_2, the producer or the consumer of electricity, or both? In this analysis the amount of CO_2 emissions by the electric power industry, which is one of the secondary energy producing sectors, was imputed to the amount of CO_2 emitted by the non-secondary energy producing sectors, the end-users of the electricity generated. The beneficiary-pays principle would be the most apt.

Table 2-3 presents the amount of CO_2 emissions predicted up to 2020 by the top 20 sectors listed in descending order of the amount of CO_2 emissions in 2020. The share of these 20 sectors relative to the total CO_2 emissions was calculated and put in the last row of the table. It was 82.8% in 2000, climbing up to a level of 85.1% in 2010, and its share will be 84.5% in 2020.

As Table 2-3 shows, the three biggest sectors measured in terms of the level of CO2 emissions are the sectors of "Iron & Steel" (first), "Transportation" (second) and "Cement" (third). In 2000, 46.1% of the total amount of CO_2 emissions was ascribed to these three sectors, and this figure will decrease to 42.8% in 2020.[8] The "Iron & Steel" sector will increase its CO_2 emissions up to 2020, although its 2010 level will be almost equal to

[8] From Table 2-3, the relative share of these three biggest sectors can be easily calculated

Table 2-3 CO_2 Emissions by Non-Secondary Energy-Producing Industries

(Upper 20 sectors) (unit: million tonnes)

Sector No.	Sector Name	2000	2005	2010	2015	2020
29	Iron & Steel	156.4	199.4	199.2	205.1	212.0
61	Transportation	118.8	115.3	121.0	116.2	112.5
26	Cement	116.8	73.1	76.0	71.2	65.1
50	Misc Manufacturing	1.9	70.3	63.9	62.5	61.5
64	Education & Research	52.0	57.0	55.2	58.5	62.8
67	Personal Services	39.6	38.2	39.7	39.5	39.4
12	Pulp & Paper	30.0	31.0	28.1	27.3	26.7
59	Trade	29.2	25.5	23.5	24.6	26.0
63	Public Services	23.6	24.6	23.1	22.7	22.4
16	Organic Chem	18.9	17.8	18.5	19.7	21.3
58	Water & Sewage	14.0	14.4	13.4	14.9	16.7
6	Food Products	17.3	18.2	15.6	15.3	15.0
14	Inorganic Chem	15.0	13.6	14.0	14.3	14.7
66	Advertizing	12.9	12.2	12.2	13.2	14.4
47	Other Vehicles	9.1	10.0	11.8	12.6	13.5
23	Plastic	8.9	9.8	9.4	10.1	11.1
60	Finance & Real Estate	9.7	9.7	9.6	9.9	10.3
1	Agri, Forestry & Fisheries	17.7	13.5	12.7	10.9	9.4
51	Construction	8.3	6.9	6.9	7.3	7.4
30	Non-Ferrous Metals	4.5	5.5	6.6	7.0	7.5
Sub Total		704.6	766.1	760.4	762.6	769.8
Grand Total		850.6	901.9	893.8	899.1	910.9
Share of Upper 20 Sectors (%)		82.8	84.9	85.1	84.8	84.5

Source: prepared by the JIDEA team, Japan

the 2005 level. Both the "Transportation" sector and the "Cement" sector will achieve reductions in their CO_2 emissions in 2020 to 95% and 55% of the 2000 level, respectively.

In the sectors ranked from 11 to 20 in this CO_2 emissions table, the "Food products" sector (12th) and the "Agriculture, forestry and fisheries" sector (18th) have a reduction in CO_2 emissions, while "Organic chemicals" (10th) and "Inorganic chemicals" (13th), although dropping to a lower level in 2005, will subsequently continually increase their CO_2 emissions up to 2020. Other sectors will more or less increase their levels of CO_2 emissions up to 2020, owing to the gradual recovery of the Japanese economy after 2010, although some of them will temporarily reduce their levels of CO_2 emissions in 2010.

Table 2-4 presents the annual average rate of CO_2 emissions from 2010 to 2020 by industry excluding the secondary energy producing sectors. The left-hand side of the table shows the upper 20 sectors ranked in order of their annual average rate of CO_2 emissions, while on the right-hand side, the lower 20 sectors are listed.

Comparing these two groups with one another, some of the industries ranked in the upper 20 sectors appear to be industries which are much more competitive in the international market than the industries in the lower 20 sectors, which can be categorized

Table 2-4 Annual Average Rate of CO_2 Emissions by Industry from 2010 to 2020

Upper 20 Sectors (unit: %)

Sector No.	Sector Name	2020 / 2010
42	Semiconductors & IC	2.24
58	Water & Sewage	2.18
48	Other Transportation Equipment	1.73
54	Electric Power	1.68
43	Electronic Parts	1.68
66	Advertizing	1.60
23	Plastic	1.59
62	Communication & Broadcasting	1.45
32	Metals for Construction	1.43
16	Organic Chemicals	1.40
20	Medicines	1.38
47	Other Vehicles	1.28
65	Information Services	1.28
64	Education & Research	1.27
46	Motor Vehicles	1.23
30	Non-Ferrous Metals	1.22
22	Coal Products	1.07
36	Other General Machines	1.02
59	Trade	0.97
35	Special Industrial Machinery	0.90

Lower 20 Sectors (unit: %)

Sector No.	Sector Name	2020 / 2010
9	Clothing	-5.73
15	Petrochemicals	-5.46
2	Metal Ores	-5.30
4	Coal	-4.10
1	Agriculture, Forestry & Fisheries	-2.99
39	Computers	-2.31
26	Cement	-1.54
13	Printing & Publishing	-1.45
27	Pottery	-1.25
3	Non-Metal Ores	-1.08
52	Civil Engineering (Public)	-1.03
11	Furniture	-0.95
10	Wood Products	-0.88
28	Other Ceramics	-0.87
38	Electric Machinery, Household	-0.81
5	Crude Oil & Natural Gas	-0.78
61	Transportation	-0.73
7	Beverages and Tobacco	-0.50
12	Pulp & Paper	-0.49
6	Food & Animal Food	-0.41

Source: prepared by the JIDEA team, Japan

as declining industries.

2-4. The Typology of Industries: Emitting less CO_2 or more in 2020

As already mentioned at the beginning of this paper, CO_2 emissions correlate strongly with industrial output and are inversely related to industrial energy efficiency (or the inverse of energy per unit of output).

The relationships among the annual rate of increase in CO_2 emissions, the growth rate of industrial output and the rate of increase in energy per unit of output can be tactically described using a form of 3D graph. Figure 2-6 is a coordinate graph showing positive and negative numbers. Out of 66 sectors, the industries ranked in the upper 30 sectors for CO_2 emissions, excluding secondary energy producing sectors, are represented in this graph.

The vertical axis in Figure 2-6 indicates the growth rate of real output by industry (b) from 2010 to 2020 and the horizontal axis indicates the rate of increase in energy per unit of output (c) (or the inverse of energy efficiency) in the same period. The greater the increase in the energy per unit of output, the more deterioration there is in the energy efficiency.

On the diagonal line of 45 degrees rising upward toward the left-hand side of the graph, the following relationship is always maintained: the sum of the growth rate of output (b) and the rate of increase in energy per unit of output (c) comes to zero, which means the rate of increase in CO_2 emissions (a) is zero.[9] Therefore, industries placed over the diagonal line in Figure 2-6 such as “Glass”, “Water and sewage”, “Business services”, “Plastic products”, “Electronic Parts” and “Iron and steel”, etc., are categorized as industries with increasing CO_2 emissions, while industries placed under the diagonal line in the graph are denoted as industries with decreasing CO_2 emissions. Among these are “Transportation”, “Food products”, “Civil engineering”, “Agriculture, forestry, and fisheries”, and “Metal products”.

Industries in the first quadrant of Figure 2-6 are industries both with increasing growth rates for output and with increasing rates for energy per unit of output, which will be the main agents accelerating CO_2 emissions, although only the four sectors of “Plastic products”, “Electronic parts”, “Other vehicles” and “Iron and steel” are classified in this group.

Industries in the second quadrant of the graph are those with increasing output but decreasing energy per unit of output, contributing to a lowering of the level of CO_2 emissions, although dependent on which side of the diagonal line of 45 degrees they are positioned. The 20 sectors selected and placed in this quadrant are “Business services”, “Water and sewage”, “Glass”, “Transportation”, “Food products”, “Civil engineering (public)”, “Government services”, “Pulp and paper”, “Organic chemicals”, “Other public services”, “Plastics”, “Other metals”, “Construction”, “Final chemicals”, “Trade”, “Non-ferrous metals”, “Special machines”, “Finance”, “Inorganic chemicals” and “Personal services”.

The four industries in the third quadrant of the graph are industries with both declining output and decreasing energy per unit of output, which include “Agriculture, forestry and fisheries”, “Other ceramics”, “Metal products” and “Miscellaneous products”. The reduction in agricultural energy per unit of output is especially remarkable. This is mainly because of the lasting downward trend in agricultural output. The historical picture will give some help. The reduction in agricultural production in Japan was about 2% annually from 1994 to 2003,[10] while the direct on-farm energy consumption decreased by 5% from 1990-92 to 2002-04, although Japan’s share in total OECD on-farm energy consumption was 10% in 2000-04, second to the United States, whose share was 23%.[11]

The only two sectors located in the fourth quadrant of the graph are “Petroleum products” and “Cement”, with decreasing output but increasing energy per unit of output. According to the projection of domestic demand for petroleum products up to 2014 by METI (the Ministry of Economy, Trade and Industry), the demand for fuel oil such as gasoline, naphtha, kerosene, light oil and heavy oil should decrease from 201.0 million kiloliters in 2008 to 160.8 million kiloliters in 2014, although the reason is not given in the report.[12]

---

9 CO_2 emissions = CO_2 emissions ratio × real output × energy per unit of output

Taking the rates of increase in CO_2 emissions, real output and energy per unit of output as *a*, *b* and *c*, the following formula can be introduced, as the CO_2 emissions ratio is constant: $a = b + c$. On the diagonal 45-degree line in Figure 2-6, *b* and *c* have the same value with opposite signs. Therefore *a*, the rate of increase in CO2 emissions, should be zero.

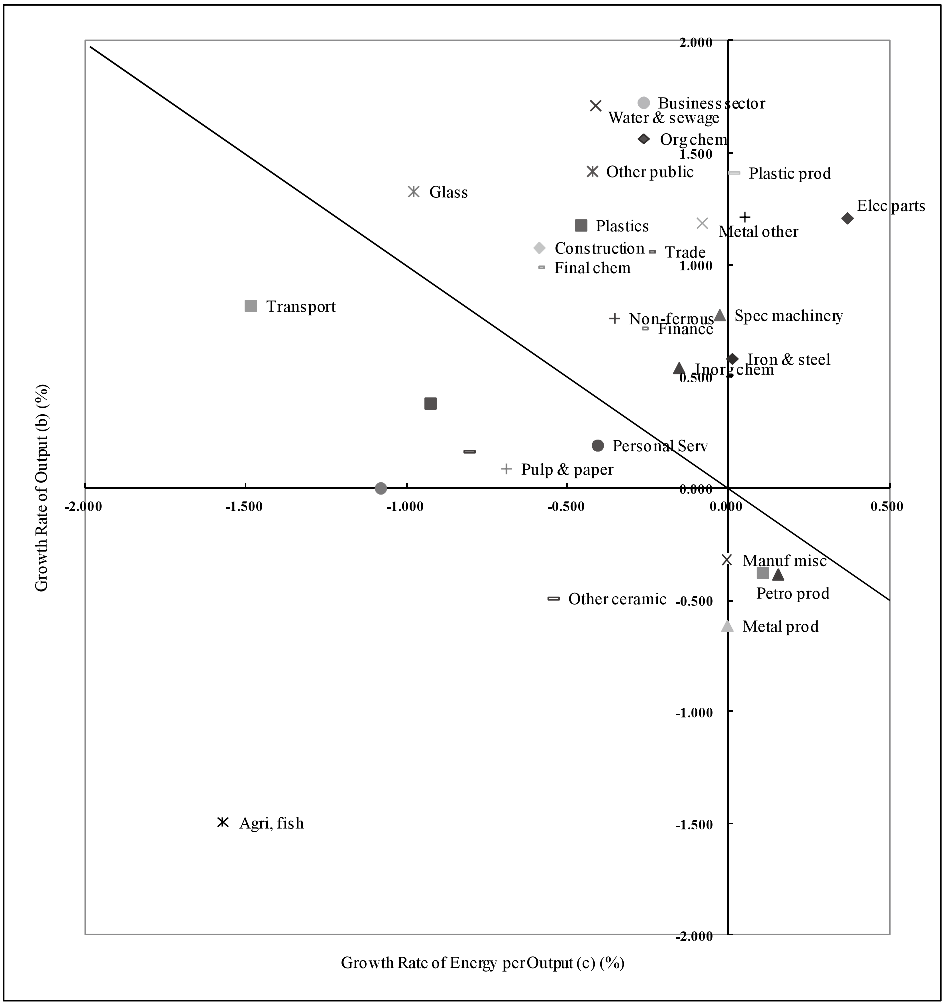
10 Calculated from the data available from the Department of National Accounts, Economic and Social Research Institute, Cabinet Office (2005)

11 OECD (2008)

12 Ministry of Economy, Trade and Industry (2010)

Figure 2-6 Relations between the Growth Rate of Real Output and the Rate of Increase in Energy per Unit of Output

(unit: %)



Source: prepared by the JIDEA team, Japan

2-5. Remaining Problems revealed from the Comparison

CO_2 emissions in Japan are also estimated by two other institutions. One is the National Institute for Environmental Studies, Japan (NIES) and the other is the Keio Economic Observatory of Keio University (KEO). Although simple comparison of the three sets of results, including JIDEA's, is not fruitful since the methods and databases used are definitely different from each other, if the estimates for the year 2000 are compared, JIDEA's estimate is the highest, second is that of KEO, and that of NIES is the lowest (see Table 2-5). In other words, since NIES's estimate is regarded as the official figure for Japan's CO_2 emissions, those of both JIDEA and KEO are overestimates.

The reasons for the overestimation of CO_2 emissions by the JIDEA team seem to be

Table 2-5 CO_2 Emissions estimated by Three Institutes

Year	NIES[*1] (2010)	KEO[*2] (2008)	JIDEA[*3] (2009)	Real GDP[*3] (2000 prices)	NIES (2010)	KEO (2008)	JIDEA (2009)	Real GDP (2000 prices)
	Million tonnes			Trillion yen	Index (2000=100)			
1990	1,143	1,208	1,314	456,526	91.2	90.7	109.2	88.0
1995	1,227	1,313	1,239	489,183	97.8	98.6	103.0	94.3
2000	1,254	1,331	1,203	518,893	100.0	100.0	100.0	100.0
2005	1,286		1,209	516,916	102.5		100.5	99.6
2006	1,267		1,226	522,289	101.0		101.9	100.7
2007	1,301		1,265	534,720	103.7		105.1	103.1
2008	1,214		1,239	524,897	96.8		103.0	101.2
2009			1,195	509,027			99.3	98.1
2010			1,179	504,332			98.0	97.2
2015			1,177	505,827			97.9	97.5
2020			1,182	510,026			98.3	98.3

Sources:*1 National Institute for Environmental Studies, Japan, 2010a;
*2 Keiichiro Asakura, Hitoshi Hayami, et al, 2001;
Satoshi Nakano, Hitoshi Hayami, Masao Nakamura and Masayuki Suzuki, 2008;
*3 Data prepared by JIDEA team, Japan

the following:

The conversion coefficient of value to quantity

The data of the IO table are expressed in value terms. To estimate CO_2 emissions, as already mentioned in section 1, the values need to be converted to quantities in the material table.

JIDEA's conversion table is based on the material IO table for the year 2000 and adjusted up to 2020. This is mainly because the material matrix is published every five years and the base year of the JIDEA model is also the year 2000. Since the relationship between material and quantity in the material IO table changes year by year, it may cause a relatively large distortion in JIDEA's estimation of CO_2 emissions.

The aggregation of industrial sectors

The JIDEA model is composed of 66 industrial sectors and has 8 sectors related to energy, while the IO-based table has 19 energy-related sectors. Therefore the 8 sectors in the JIDEA model should be split into 19 sectors consistent with the IO-based table of 2000. The dividing ratios in 2000 were kept constant and applied to the data from 1990 to 2020. This may be one of the causes of some distortions in the prediction.

Import and export definitions

The imports and the exports in the final demand components are not included as sources of CO_2 emissions. The IO table used in the JIDEA model is of the competing-import type, namely, imported goods and domestically produced goods are not differentiated, and are input goods. Thus imported materials are mixed in with the intermediate inputs and household consumption.

Another problem unsolved is how to calculate the CO_2 emissions caused from the energy supplied to foreign ships or airplanes and to Japanese ones in another country. According to the definition of domestic input in the IO table, which JIDEA's database is following, the former is counted in exports and the latter is categorized as imports.

The iron and steel industry

The “Iron and steel” industry, one of the main sectors emitting an enormous amount of CO_2, has a very complicated mechanism in its energy consumption and CO_2 emission. The process of making iron from iron ore, coke and limestone, and steel from iron, is very complicated and differs according to the method of production. To calculate CO_2 emissions more precisely, the emission of CO_2 gas should be measured at every stage of the process. The JIDEA model uses a simplified process in estimating CO_2 emissions from the amount of the input materials of coke and limestone, whereas the other institutions employ more sophisticated calculation processes. This difference may be crucial for obtaining a better estimation of CO_2 emissions.

3. Simulation of the Reduction of CO_2 Emissions using Nuclear Power

We made a forecast of the Japanese economy and its CO_2 emissions up to 2020, which is shown in the previous section. In this section, we will make two simulations as to how much we can reduce CO_2 emissions in 2020 by substituting nuclear power for thermal power generation.

In the first case, or scenario, it is assumed that the current expansion plan for nuclear power generation will be realized by 2020. We term this the practical case.

The second case is how to accomplish the medium-to-long term target of a 25% reduction on the 1990-level of CO_2 emissions in 2020, which was advocated by former Prime Minister Yukio Hatoyama. We term this the extreme case.

For the methodology, please refer to the technical note at the end of this section.

3-1. The Practical Case

The assumptions[13] for the simulation are shown below and in Table 3-1.

The nuclear power generation capacity will be increased by 11.35 million kW,[14] from 49.47 million kW in FY 2007 to 60.82 million kW in FY 2020.

The average utilization rate is 88.0%,[15] which is higher than the 60.9% in FY 2007 (see Figure 3-1).

The total amount of power generation from nuclear energy will be 468.8 billion kWh in FY 2020. This is a 77.7% increase on the level in FY 2007.

These presumptions are based on the assumptions of Japan’s National Institute for Environmental Studies for the medium-to-long term projection of Japanese national greenhouse gas emissions.[16]

[13] Although the assumed figures are given for fiscal years (FY), our model data are for calendar years (CY). We disregard the differences as they are not that great.

[14] This is the total capacity of the planned nuclear power generators which are to go into operation by the end of FY 2009.

[15] This rate should be derived by assuming that the stoppage of a plant for regular inspections would be some 38 days, which is the average for the United States.

[16] National Institute for Environmental Studies, Japan, 2010b

Table 3-1 The Trends in Japanese Nuclear Power Generation Factors and Projections for 2020

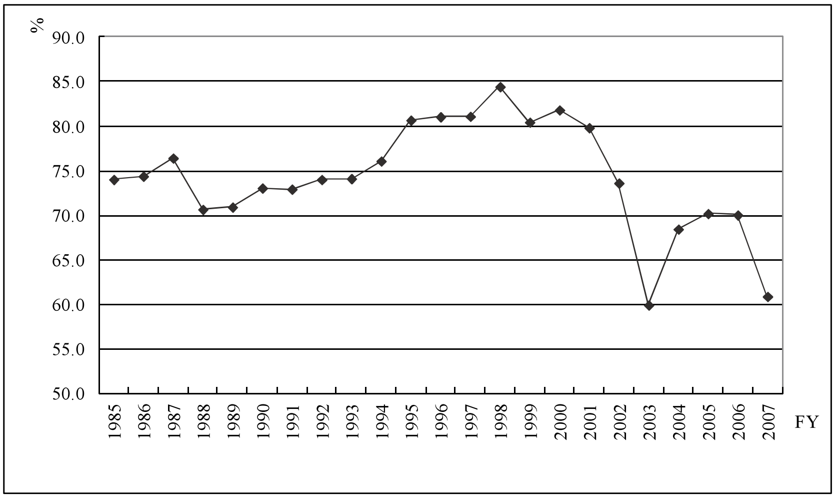
(units: number; million kW; billion kWh; %)

FY	No. of generators (CY)	Total capacity of generators	Annual outputs of electric power generated by nuclear power	Utilization rate	Share of nuclear generation
1985	32	24.52	159.0	74.0	27.2
1986	32	25.68	167.3	74.4	28.7
1987	35	27.88	186.6	76.4	30.0
1988	35	28.70	177.6	70.6	27.4
1989	37	29.28	181.9	70.9	26.6
1990	39	31.48	201.4	73.0	27.3
1991	41	33.24	212.3	72.9	27.8
1992	41	34.42	223.1	74.0	28.8
1993	45	38.38	249.1	74.1	31.8
1994	48	40.37	269.0	76.1	32.2
1995	49	41.19	291.1	80.7	34.0
1996	50	42.55	302.1	81.0	34.6
1997	52	44.92	319.1	81.1	35.6
1998	52	44.92	332.2	84.4	36.8
1999	51	44.92	316.5	80.4	34.5
2000	51	44.92	321.9	81.8	34.3
2001	51	45.74	319.8	79.8	34.6
2002	52	45.74	294.9	73.6	31.2
2003	52	45.74	240.0	59.9	25.7
2004	52	47.12	282.4	68.4	29.1
2005	54	49.58	304.8	70.2	30.8
2006	55	49.47	303.4	70.0	30.5
2007	55	49.47	263.8	60.9	25.6
2020	**63**	**60.82**	**468.8**	**88.0**	-

Note: Utilization rate = Annual outputs of electric power generated by nuclear power divided by total capacities of generators × 24h × 365 days

Sources: Ministry of Economy, Trade and Industry, 2010b
The number of nuclear generators is as specified by the Federation of Electric Power Companies of Japan (2010).

Figure 3-1 Nuclear Generator Utilization Rate



Source: calculated by the JIDEA team, Japan

Table 3-2 The Results of CO_2 Reduction

(units: million tonnes; %)

CY	CO_2 emissions	Estimation figures	Reduction rate
2000	1,254	1,366	
2020	Baseline	1,357	
	Practical case	1,248	-8.0

Notes: 1. Practical case: substitution of thermal power generation with 1,357 for nuclear power generation.
2. The reduction rate is calculated against the baseline figure of 1,357.
Source: JIDEA team, Japan, estimate

The results for CO_2 reduction by substituting thermal power generation for nuclear power generation are shown in Table 3-2.

In the practical case, which assumes that the current construction plan for nuclear power plants will be realized by 2020 with a high utilization rate, we can expect only an 8.0%[17] reduction of CO_2 emissions in 2020 compared to the baseline figure.

3-2. The Extreme Case

In this subsection, we calculate what amount of thermal power generation should be replaced by nuclear power to realize the medium-to-long term target of a 25% reduction on the 1990 level of CO_2 emissions in 2020.

As our model uses calendar-year data against the fiscal-year observation data, there is a discrepancy observed in the CO_2 emissions volume even in the base year. In order to eliminate the residual,[18] we created adjusted data by reducing the error of the observation and estimated data in 2000. We will use this adjusted data for this simulation as we have to make comparison with the historical figures for 1990.

The estimated figures are calculated by setting the ratio of fossil fuels not used as energy and the conversion matrix of value to quantity at the 2000 level. Therefore the figures shown here are theoretical ones.

The results are shown in Table 3-3.

Our simulation shows that almost all of the thermal power generation should be substituted for by nuclear power, even when we assume an 88% utilization rate for accomplishing the 25% cut in CO_2 emissions in 2020.

This means that we would have to use 2.25 times the number, as of the end of 2009, of nuclear power generators, whose capacity is 11,010.17 million kW.

[17] We recognize that this reduction rate may be overestimated, as we assumed an increasing trend for nuclear power generation in this model.

[18] This may be derived by: 1) the difference in calendar year and fiscal year data; 2) the coarseness of the material matrix; and 3) the correspondence between the value and material matrix is set to 2000, etc.

Table 3-3 The trends for CO_2 Emissions in Japan

(unit: million tonnes)

CY	CO_2 Emissions[1]	Estimation[2]	Adjusted[3]
1990	1,143	1,313	1,200
1991	1,153	1,330	1,217
1992	1,161	1,350	1,237
1993	1,154	1,204	1,092
1994	1,213	1,448	1,336
1995	1,226	1,381	1,268
1996	1,239	1,899	1,787
1997	1,235	2,246	2,133
1998	1,199	1,546	1,434
1999	1,234	1,532	1,420
2000	1,254	1,366	1,254
2001	1,238	1,409	1,296
2002	1,276	1,372	1,260
2003	1,282	1,409	1,296
2004	1,281	1,430	1,318
2005	1,286	1,383	1,270
2006	1,267	1,378	1,266
2007	1,301	1,416	1,303
2008	1,214	1,385	1,272
2009		1,336	1,223
2010		1,317	1,205
2011		1,315	1,202
2012		1,319	1,206
2013		1,323	1,210
2014		1,327	1,214
2015		1,331	1,219
2016		1,336	1,224
2017		1,342	1,229
2018		1,347	1,235
2019		1,352	1,239
2020	Baseline	1,357	1,244
	Extreme	967	855
% Change on 1990		-28.7	-25.2

Notes: 1. CO_2 emissions (FY) published by the Ministry of the Environment
2. Estimation by model (CY 2000 = base)
3. Adjusted: applying a constant-term adjustment for 2000

Sources: Japan Center for Climate Change Actions (2010) and estimation by JIDEA team, Japan.

Technical Note I:

Substituting Nuclear Power for Thermal Power

For the electric power sector, the JIDEA model only distinguishes one sector, but in the detailed IO table, it consists of four sectors: "nuclear power"; "thermal power"; "water and other powers"; and "electric power self-generated". Accordingly, to create a simulation to substitute "nuclear power" for "thermal power", we need to calculate these four sectors' intermediate inputs separately, and after calculation unify these four sectors' inputs into one coefficient, namely, the "electric power total coefficient".

In the framework of the IO table, the flow of the calculations expressed in the equations is as follows: taking "electric power total" as *E*, "electricity produced by nuclear power" as *N*, "thermal power" as *T*, "water and other power" as *O*, and "electric power self-generated" as *H*, the intermediate inputs of each form of power generation by input materials are notated as E_i, N_i, T_i, O_i and H_i, respectively, then:

$$E_i = N_i + T_i + O_i + H_i$$

$$\sum_{i=1}^{n} E_i = \sum_{i=1}^{n} N_i + \sum_{i=1}^{n} T_i + \sum_{i=1}^{n} O_i + \sum_{i=1}^{n} H_i$$

Dividing E_i, A_i, Ti and O_i by their totals and making them into the coefficients e_i, n_i, t_i and o_i , then:

$$e_i = E_i / \sum_{i=1}^{n} E_i \quad , \quad n_i = N_i / \sum_{i=1}^{n} N_i \quad , \quad t_i = T_i / \sum_{i=1}^{n} T_i \quad , \quad o_i = O_i / \sum_{i=1}^{n} O_i \quad ,$$

$$h_i = H_i / \sum_{i=1}^{n} H_i$$

Then we can calculate:

$$N_i = n_i N \,,\ \ T_i = t_i T \,,\ \ O_i = o_i O \,,\ \ H_i = h_i H \,,\ \ E_i = e_i E$$

$$e_i = (N_i + T_i + O_i + H_i) / E$$

Now we assume that the production of electricity by "nuclear power" increases at the rate α and the same amount of electricity substitutes for that of "thermal power". The total electricity has not changed but the relative weighting of the above mentioned four sectors has. Accordingly the "unified electric power coefficient" should be changed. If the changed amount of electricity from "nuclear power" is termed *N'*, and from "thermal power" *T'*, then:

$$N' = (1+\alpha)N \,, \quad T' = T - \alpha N$$

After the substitution of "thermal power" with "nuclear power", if the coefficient of the total unified electric power is termed e'_i, then the following identity is obtained:

$$e'_i = (n_i N' + t_i T' + o_i O + h_i H) / E$$

Table 3-4 The Changes in the Input Coefficients according to Case

Sector No.	Sector	Baseline	Practical Case	Extreme Case
4	Coal mining	0.020577	0.017392	0.001936
5	Petroleum & gas exploration	0.039468	0.033363	0.003729
9	Clothing	0.000115	0.000120	0.000144
10	Timber	0.000019	0.000018	0.000013
11	Furniture	0.000587	0.000558	0.000417
13	Printing & publishing	0.002639	0.002567	0.002219
14	Inorganic basic chemicals	0.000183	0.000159	0.000042
19	Final chemicals	0.000548	0.000474	0.000117
21	Petroleum refinery products	0.017781	0.015865	0.006564
22	Coal products	0.003314	0.003058	0.001813
28	Other ceramic, stone & clay products	0.000035	0.000031	0.000013
30	Non-ferrous metals refinery products	0.000018	0.000022	0.000040
31	Processed non-ferrous metal products	0.000703	0.000794	0.001239
33	Other metal products	0.000482	0.000482	0.000481
40	Communication equipment	0.000006	0.000006	0.000005
43	Electronic Parts	0.000008	0.000008	0.000007
45	Electric illuminators, batteries & others	0.000011	0.000010	0.000009
50	Miscellaneous manufactured products	0.012546	0.011702	0.007608
51	Construction	0.038653	0.039077	0.041135
54	Electric power	0.029740	0.030070	0.031671
55	Gas & hot water supply	0.000081	0.000079	0.000069
56	Water supply & treatment	0.006520	0.006661	0.007346
57	Trade	0.014931	0.013611	0.007203
58	Financial & insurance services	0.033912	0.033116	0.029252
59	Transportation services	0.017994	0.015795	0.005122
60	Communication & broadcasting	0.003515	0.003407	0.002880
62	Education, research & medical services	0.024198	0.024869	0.028126
63	Information services	0.016678	0.016187	0.013800
64	Business services	0.092103	0.090674	0.083738
65	Personal services	0.000464	0.000468	0.000489
66	Office supply & NEC	0.004249	0.004417	0.005230
	Total	0.382077	0.365059	0.282454

Note: Where the value of the input coefficient is 0, the sector is not listed in the table.
Source: calculated by the JIDEA team, Japan

Technical note II:

Brief Explanation of the JIDEA Model Version 7

The JIDEA (Japanese Interindustry Dynamic Econometric Analysis) model is a complete multi-sector model whose main blocks consist of final demand, value-added, and a matrix of intermediate input coefficients (direct requirement matrix). While the final demand and value-added components can be looked at as aggregate variables they are generated within the model using industry-level data and econometric methods.

JIDEA is based on the Japanese Input-Output Table (66×66 sectors) over a 22-year horizon from 1985 to 2006. This IO Table consists of the base table, the extension table (both published for the years 1985-2006, but the base year changes every 5 years), and the link table based on 1995 and 2000. A complete time series of input-output tables, including final demand and value-added components, has been derived, consistent with the 2000 link table.

One characteristic feature of JIDEA is that it can estimate the effects of international trade by using BTM, the world Bilateral Trade Model provided by Inforum, University of Maryland, which integrates the export-import estimation in its national models of the Inforum member countries. The analysis of international trade effects is thus done jointly with Inforum and its members.

The main components and variables determined within JIDEA are calculated as follows:

Final Demands is the sum of household consumption, government expenditure, the fixed capital formation of the government and private sectors, and exports minus imports, etc. All are expressed in real terms.

- Per capita household consumption by sector is estimated by per capita disposable income and the relative level of consumer prices to total consumption.
- Private fixed capital formation, which is considered as the demand for investment goods, is estimated by the investment function by industry as purchasing investment goods. The investment function is based on lagged output, and amount of capital stock, etc.
- Sectoral exports are estimated by function using the world price and foreign demand index from the BTM of Inforum.
- Imports are determined simultaneously with output using the function of import share to domestic demand which is determined by the relative price and time trends.

Output in real terms is estimated by the Gauss-Seidel method with the following equation:

$$q = A \times q + f - m(q,..),$$

where:

q = the vector of the amount of domestic production;

A = the matrix of the intermediate input coefficient;

f = the vector of the sum of the final demand, imports not included;

$m(q,..)$ = imports as a linear function of domestic demand

Output in Current Prices (Value-Added Side) is the sum of intermediate costs and value-added, which consists of labor compensation, corporate profits, capital consumption allowances, and indirect taxes minus subsidies, etc.

- Total value-added is calculated by adding up the results of the equation for each of the value-added components by sector. This total value-added is then converted to unit value-added by dividing by real output in each sector, which is derived from the real side.
- Domestic production prices are estimated by the Gauss-Seidel method using intermediate input coefficients and the sum of unit value-added. Import prices are also used in the solution. Algebraically, the solution can be expressed as:

$$p = p' \times AD + pm \times AM + v,$$

where:

p = the vector of the domestic production price;
p' = the vector of domestic demand price;
AD = the domestic portion of the input-output matrix (imports not included);
pm = the vector of import prices;
AM = the matrix of imports of intermediate inputs;
v = the vector of unit value-added

References and Data Sources

Agency for Natural Resources and Energy (2001): *Statistics on the Consumption Structure of Petroleum and Other Energy Materials*, Ministry of Economy, Trade and Industry, http://www.meti.go.jp/statistics/tyo/sekiyuko/archives.html (retrieved 1 December 2010)

Asakura, Keiichiro, Hitoshi Hayami, *et al* (2001): *The Input-Output Table for Environmental Analysis*, Keio University Press

Center for Global Environmental Research (2008): *Embodied Energy and Emission Intensity Data for Japan Using Input-Output Tables: Inventory Data for LCA*

Department of National Accounts, Economic and Social Research Institute, Cabinet Office (2005): *Annual Report on National Accounts*, pp. 188-191

The Federation of Electric Power Companies of Japan (2010): INFOBASE, *c. Atomic Power*, http://www.fepc.or.jp/library/data/infobase/pdf/info_d.pdf (retrieved 1 December 2010)

Japan Center for Climate Change Actions (2010): *4-1. The Amount of Greenhouse Gas Emissions in Japan (1990-2008)*, http://www.jccca.org/chart/chart04_01.html (retrieved 1 December 2010)

Ministry of Economy, Trade and Industry (2005): *Long-Term Projections for Energy Supply and Demand*

Ministry of Economy, Trade and Industry (2010a): *Projections for Energy Supply and Demand*, http://www.meti.go.jp/committee/materials2/downloadfiles/g100409a06j.pdf (retrieved 31 July 2010)

Ministry of Economy, Trade and Industry (2010b): *The White Paper on Energy 2009*,
http://www.enecho.meti.go.jp/topics/hakusho/2007energyhtml/excel/213-4-2.xls (retrieved 1 December 2010)

Ministry of Internal Affairs and Communications (2009): *Material Input-Output Table 2000*, Statistical Bureau, Director-General for Policy Planning & Statistical Research and Training Institute, http://www.stat.go.jp/data/io/ichiran.htm (retrieved 1 December 2010)

Nakano, Satoshi, Hitoshi Hayami, Masao Nakamura and Masayuki Suzuki (2008): *The Input-Output Table for Environmental Analysis and its Application*, Keio University Press

National Institute for Environmental Studies, Japan (2010a): *National Greenhouse Gas Inventory Report of Japan*, April

National Institute for Environmental Studies, Japan (2010b): *National Greenhouse Gas Inventory Report of Japan*, April, Table 1, p. 2, http://www-gio.neis.go.jp/aboutghg/nir/2010/NIR_ JPN_2010_v3.0E.pdf (retrieved 14 August 2010)

National Institute for Environmental Studies, Japan (2010c): *Assumptions for the Medium-to-Long Term Projections of Japanese National Greenhouse Gas Emissions*, http://www-iam.nies.go.jp/aim/prov/middle_report.htm (retrieved 11 August 2010)

OECD (2008): *Environmental Performance of Agriculture in OECD Countries Since1990*, OECD Publishing, Paris. See Figure 1.4.2., p. 79

SUBMISSION GUIDE

Three complete copies of each manuscript and a file copy on CD-ROM/diskette should be sent to the following Business Office of the Journal:

Economic Research Institute for Northeast Asia (ERINA)
13th Floor, Bandaijima Building, Bandaijima 5-1, Chuo-ku,
Niigata City, 950-0078, Japan

The manuscripts must be typed and double-spaced, on one side of 8½×11-inch paper or A4 metric white paper, and the total length should not exceed 50 pages.

The manuscript contained on the CD-ROM/diskette should be saved as either:
a) a Microsoft Word file
b) an MS-DOS text file

The first page should include: *Title*, *Author(s) Name(s)*, *Abstract* (not more than 150 words), and *Keywords* (not more than seven items). Affiliation should appear as an asterisked footnote (*) on the first page of the text, with a superscript asterisk before the author's name.

Appendices, if any, should appear at the end of the paper, before any *References*.

Figures should be originals on 8½×11-inch paper or A4 metric white paper with large enough lettering to permit photographic reproduction.

Tables and *Figures* should be on separate sheets and numbered using Arabic numerals. The position of *Tables* and *Figures* should be indicated in the manuscript.

Footnotes should be numbered consecutively, and be double-spaced. They may appear at the bottom of each page of the text. Acknowledgements, if any, should be made in *Footnote 1*, with a superscript "1" at the end of the *Title*.

References should be listed alphabetically at the end of the paper in the following standard format:

Book:	Author(s) (year), Title, Page Number(s), Publisher, City of Publication
Published Article:	Author(s) (year), "Title", Journal, Volume Number, Page Number(s), Publisher, City of Publication
Unpublished Article:	Author(s) (year), "Title", Type of Paper, Page Number(s), University or Foundation

JESNA