Chapter 2 Site location of CDM projects: I-O analysis

Summary

This chapter considers which region is preferable as a site location of CDM projects in China from a variety of viewpoints such as own value-added acquisition rate, spillover effect, alleviation of regional imbalance, economic effects by CDM investment, and amount of CO_2 and SO_2 reduction of CDM projects, using a Multi-Regional Input-Output Table China 2000. It turns out that the most preferable region as a site location of CDM is South coast followed by Southwest and Central region.

2-1 Introduction

CDM is a kind of international investment projects to reduce GHGs (Greenhouse gases) emissions. Though CDM project itself is on a basis of private contract, the project needs to be approved or certificated by CDM Executive Board, host and investment countries. Therefore, it is usual that the governmental organizations of host and investing country discuss various issues before implementing CDM projects. One of the most important issues for the host country would be is the site location of CDM projects. Despite that there are plentiful viewpoints to evaluate the site location of CDM projects, these viewpoints would be broadly classified into two categories: effects in the project-construction phase and those in the project-operating phase. Generally speaking, economic effects, or income effects, are emphasized in the project-construction phase, while environment improvement effect, or resource saving effects, are still more emphasized in the phase of project-operation.

As to a measure of income effects of an investment project, the most well knows would be "output inducement coefficient" in the framework of I-O analysis. However, this output means so-call gross output including intermediate inputs, therefore, this measure has no direct relation with income, or value-added. Then, in section 2-2, we adopt "acquisition rate of value-added" as a measure of income gain from the project-construction phase. And the host government would be concerned with resource conservation by CDM. The more resource consumption the CDM project can save, the more preferable the project is for the country. Then, in section 2-3 we adopt an indicator called "spillover rate of process innovation" as a measure of resource conservation in the project-operating phase. This indicator is to measure how much an innovation can realize resource consumption in other sectors that the innovation actually happened. Moreover, one of the most important issues for China to keep its development sustainable is mitigation of regional income imbalance that has been becoming serious recently. Therefore, in section 2-4 we takes regional matters into consideration as a criterion to determine a site location of CDM projects. And, section 2-5, we will show that the effect of CDM would be influenced a great deal by the site location of the project through some cases of scenario analysis in the I-O framework.

We use China Multi Regional I-O Table 2000(hereinafter MRIO) compiled by Institute of Developing Economies (IDE, 2003) in Japan. In this table, China is divided into eight regions and all the transactions of goods and services including not only intra-regional intermediate inputs but also inter regional intermediate inputs are recorded in detail (see Table2-1 and Figure2-1). Industry sectors are divided into 17 sectors (see Table 2-2).

2-2 Ultimate acquisition rate of value-added

2-2-1 Home production rate

In order to make any goods and services, necessary are such three kinds of inputs as domestic goods, imported goods, and value-added. A term of "local content rate" is often used as a measure of the home production ratio. Local content rate is usually defined as follows:

$$\text{Local content rate} = \frac{\text{Value of domestic goods inputs} + \text{Value - added}}{\text{Value of total inputs}}$$

What the local content rate mean that the value of "domestic goods inputs" is a part of "domestically produced value". However, note that the value of domestic goods inputs in the numerator is again divided into such three elements as domestic goods, imported goods, and value-added. Then, what it boils down to is that the value of goods would be divided ultimately into either value-added or imports. The above-mentioned definition of the local contents rate overlooks the fact that in order to produce goods imported goods such as raw material or fuels are again requires.

In a word, taking indirect inputs of imports into consideration, we notice the true home production rate should be the ratio of value-added that remains within the country ultimately and the import ratio also turns to be the ratio of the leaking value ultimately to foreign countries. Therefore we would like to name this ratio "ultimate acquisition rate of value-added". Contribution to the regional economic development is one of the important points of views as far as CDM project is an investment projects. Therefore, it is useful to know how a CDM would lead to income increase in the host region when the project starts.

Then, let us explain the method of defining the "ultimate value-added ratio". The following two supply-demand balance equations hold for domestic goods and imported goods respectively in non-competitive import type of input output tables.

$$\mathbf{x} = \mathbf{A^d x} + \mathbf{f^d} \qquad (2\text{-}1)$$

$$\mathbf{m} = \mathbf{A^m x} + \mathbf{f^m} \qquad (2\text{-}2)$$

In solving (2-1)by domestic output $\mathbf{x}$, the equilibrium output equation will be derived using Leontief's inverse matrix.

$$\mathbf{x} = (\mathbf{I} - \mathbf{A}^{\mathbf{d}})^{-1}\mathbf{f}^{\mathbf{d}} \tag{2-3}$$

The j th row of Leontief's inverse matrix shows how much the production of each industry is induced when the final demand against j th industry increases by one unit. Therefore, pre-multiplying the value-added ratio before Leontief's inverse matrix, we will get the amount of value-added generated directly and indirectly by one unit final demand of each industry.

$$\mathbf{t}^{\mathbf{d}} = \mathbf{v}(\mathbf{I} - \mathbf{A}^{\mathbf{d}})^{-1} \tag{2-4}$$

The equation (2-4) can be rewritten as (2-4') using the diagonal matrix and the aggregation vector. This is "ultimate value-added ratio"

$$\mathbf{t}^{\mathbf{d}} = [1 \quad \cdots \quad 1]\begin{bmatrix} v_1 & & 0 \\ & \ddots & \\ 0 & & v_n \end{bmatrix}(\mathbf{I} - \mathbf{A}^{\mathbf{d}})^{-1} = ?\hat{\mathbf{v}}(\mathbf{I} - \mathbf{A}^{\mathbf{d}})^{-1} \tag{2-4'}$$

On the other, amount of the imports required directly and indirectly by one unit final demand of each industry also can be defied by pre-multiplying the import IO coefficient matrix before Leontief's inverse matrix as follows. This is "ultimate import ration"

$$\mathbf{t}^{\mathbf{m}} = ?\mathbf{A}^{\mathbf{m}}(\mathbf{I} - \mathbf{A}^{\mathbf{d}})^{-1} \tag{2-5}$$

Here, let us confirm the total of "ultimate value-added ratio" and "ultimate import ratio" is equal to 10. As quite natural, the sum total of domestic input coefficients, import input coefficients, and value-added ratio in each column is1.0.

$$\boldsymbol{\iota}(\mathbf{A}^{\mathbf{d}} + \mathbf{A}^{\mathbf{m}} + \hat{\mathbf{v}}) = \boldsymbol{\iota} \tag{2-6}$$

A little modification will derive $\boldsymbol{\iota}(\mathbf{A}^{\mathbf{m}} + \hat{\mathbf{v}}) = \boldsymbol{\iota}(\mathbf{I} - \mathbf{A}^{\mathbf{d}})$, and then we get the following equation.

$$\boldsymbol{\iota}(\mathbf{A}^{\mathbf{m}} + \hat{\mathbf{v}})(\mathbf{I} - \mathbf{A}^{\mathbf{d}})^{-1} = \boldsymbol{\iota} \tag{2-7}$$

The left side of (2-7) is the same as the total of (2-4') and (2-5), therefore, the total of ultimate value-added ratio and ultimate import ratio is 1.0.

2-2-2 Value-added division of labor

Apply the same idea of "ultimate acquisition rate of value-added" to a multi regional input output table we can calculate the regional distribution of value-added, i.e., regional division of labor rate. Let us use two-sector regional I-O table to simplify the explanation. The supply-demand balance in import-exogenous model is shown as follows.

$$\begin{bmatrix} \mathbf{x}_1 \\ \mathbf{x}_2 \end{bmatrix} = \begin{bmatrix} \mathbf{X}_{11}i + \mathbf{X}_{21}i + \mathbf{d}_1 + \mathbf{e}_1 - \mathbf{m}_1 \\ \mathbf{X}_{21}i + \mathbf{X}_{22}i + \mathbf{d}_2 + \mathbf{e}_2 - \mathbf{m}_2 \end{bmatrix} \quad (2\text{-}8)$$

where $\mathbf{x}_i$ is a row vector of the region *i*, $\mathbf{d}_i$, $\mathbf{e}_i$, $\mathbf{m}_i$ are respectively row vectors of domestic demands, exports and imports[1]. $\mathbf{X}_{ij}$ is an *n* by *n* square matrix of intermediate inputs from region *i* to region *j*.

On the other hand, the following relation holds on the value added. Capital **V** is a row vector of the account of value added and lower case **v** means value added ratio. The Output is expressed as a diagonal matrix.

$$\begin{bmatrix} \mathbf{V}_{11} & \mathbf{V}_{12} \\ \mathbf{V}_{21} & \mathbf{V}_{22} \end{bmatrix} = \begin{bmatrix} \mathbf{v}_{11} & \mathbf{v}_{12} \\ \mathbf{v}_{21} & \mathbf{v}_{22} \end{bmatrix} \begin{bmatrix} \hat{\mathbf{x}}_1 & \mathbf{0} \\ \mathbf{0} & \hat{\mathbf{x}}_1 \end{bmatrix} \quad (2\text{-}9)$$

Let us modify the equation (2-9) using input coefficients. In the multi-regional IO model, inter regional exports of intermediate goods are treated as endogenous variables.

$$\begin{bmatrix} \mathbf{x}_1 \\ \mathbf{x}_2 \end{bmatrix} = \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} \\ \mathbf{A}_{21} & \mathbf{A}_{22} \end{bmatrix} \begin{bmatrix} \mathbf{x}_1 \\ \mathbf{x}_2 \end{bmatrix} + \begin{bmatrix} \mathbf{d}_1 + \mathbf{e}_1 - \mathbf{m}_1 \\ \mathbf{d}_2 + \mathbf{e}_2 - \mathbf{m}_2 \end{bmatrix} \quad (2\text{-}10)$$

where $\mathbf{A}_{ij}$ is a matrix of input coefficients. In case $i=j$, $\mathbf{A}_{ij}$ is for intra-regional inputs, if not $\mathbf{A}_{ij}$ is for inter-regional inputs. With solving output $\mathbf{x}_i$, we will get the following equation for the equilibrium output. $\mathbf{B}_{ij}$ is a block of Leontief's inverse matrix.

$$\begin{bmatrix} \mathbf{x}_1 \\ \mathbf{x}_2 \end{bmatrix} = \left[\mathbf{I} - \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} \\ \mathbf{A}_{21} & \mathbf{A}_{22} \end{bmatrix} \right]^{-1} + \begin{bmatrix} \mathbf{d}_1 + \mathbf{e}_1 - \mathbf{m}_1 \\ \mathbf{d}_2 + \mathbf{e}_2 - \mathbf{m}_2 \end{bmatrix} = \begin{bmatrix} \mathbf{B}_{11} & \mathbf{B}_{12} \\ \mathbf{B}_{21} & \mathbf{B}_{22} \end{bmatrix} \begin{bmatrix} \mathbf{d}_1 + \mathbf{e}_1 - \mathbf{m}_1 \\ \mathbf{d}_2 + \mathbf{e}_2 - \mathbf{m}_2 \end{bmatrix} \quad (2\text{-}11)$$

The division of labor rate of value-added is the share of value-added distribution. Therefore as explained in the previous section, by pre-multiplying value-added ration before of Leontief's inverse matrix, we can get the division of labor rate of value-added t_{ij}, which is region *i*'s ultimate share in region *j*'s value-added.

$$\begin{bmatrix} \mathbf{t}_{11} & \mathbf{t}_{12} \\ \mathbf{t}_{21} & \mathbf{t}_{22} \end{bmatrix} = \begin{bmatrix} \mathbf{v}_{11} & \mathbf{v}_{12} \\ \mathbf{v}_{21} & \mathbf{v}_{22} \end{bmatrix} \begin{bmatrix} \mathbf{B}_{11} & \mathbf{B}_{12} \\ \mathbf{B}_{21} & \mathbf{B}_{22} \end{bmatrix} \quad (2\text{-}12)$$

2-2-3 Ultimate value added distribution in China

Estimated results are shown Table 2-3. We estimated in two cases 1)macro case and 2) three sector grouping case of primary-secondary-tertiary industry. The diagonal cells with shadow are for own share of value added. Though is natural the own share is the largest, we can see some difference in each region.

Own share	Regions
80% and over	Central region, Southwest
70% and over	Northeast, North coast , Northwest
Less than 70%	North municipalities, Central coast, South coast

Such three regions as North municipalities, Central coast and South coast are high- income regions and are also famous as regions where the government promoted “reform and open-door policy”. We can confirm imported inputs played an important role in those regions. As a matter of fact, leakage of value-added in those regions is relatively large, while in inland and Northeast regions are relatively autonomous. Therefore, the value of investment in inland and Northeast regions remains more in the own region as far as those regions can provide investment goods.

The interesting one might be a “northern coast”. Qingdao city is in this region and this city is famous for electric appliance industry because the headquarters of integrated appliance maker “Haier group” is here. Generally speaking own acquisition of value-added is low in the coast regions; however, that is relatively high in “northern coast” compared with other coast regions though this region is not a late-started region of economic development.

Table 2-4 shows the shares of value-added distribution in case of three sector grouping such as primary industry, secondary industry (manufacturing), and tertiary industry. The CDM in which we are interested is on manufacturing sector, we show the own region acquisition of value-added in manufacturing sector in the following table. The basic feature is the same as in the macro case, while the feature emerges even more clearly in this case. That is in North municipalities and South coast region, almost a half of value added would flow out of the region, while in Northeast, North coast, Central region, and Southwest, the flowing out is less than 30 %.

As s result, in determining CDM cite location, such three regions as North coast, Central region, and South west are preferable in a context of regional economic contribution of CDM projects.

Region name	Own acquisition of value-added in manufacturing	Region name	Own acquisition of value-added in manufacturing
Northeast	73.2%	South coast	53.4%
North municipalities	56.5%	Central region	77.5%
North coast	75.9%	Northwest	69.9%
Central coast	60.8%	Southwest	78.2%

2-3 Spillover ratio of innovation

2-3-1 Process innovation and product innovation

CDM is a transplantation of new technologies from developed countries. Innovation effects are reflected by changes in the input coefficients in the framework of IO analysis. Two types of innovation are distinguished; process innovation and product innovation.

Process innovation: efficiency improvement in an industry. More output can be produced with the same amounts of the inputs. Process innovation implies a shift of the production function and the isoquant. Hence, the coefficients in a column are changed.

Product innovation: efficiency improvement of an input. In each of the n production processes, the same amount of output can be obtained with a smaller amount of this product as an input. Hence, the coefficients in a row are changed.

CDM, in concrete terms, is corresponding investment project for energy saving, new energy usage, and so on. Innovation by CDM, therefore, is regarded as a kind of process innovation. We focus on process innovation in this report.

2-3-2 Spillover coefficient of process innovation

The standard import exogenous Leontief model is given by the following equation.

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{B}\mathbf{f} \qquad (2\text{-}13)$$

x and **f** are a vector of output and final demand, respectively. **A** is an $n \times n$ の input coefficient matrix, elements of which are expressed as a_{ij}. **B** is a Leontief's inverse matrix, elements of which are expressed as b_{ij}. As is well known, b_{ij} は means the induced output of industry j by one-unit increases in final demand for industry i.

An innovation in industry k is defined as shown in the following equation.

$$\bar{a}_{ik} = (1-\alpha)a_{ik} \quad (0<\alpha<1,\ i=1,\cdots,n) \qquad (2\text{-}14)$$

And $\bar{a}_{ij} = a_{ij}$ $(i=1,\cdots,n$ and $j \neq k)$, therefore all other coefficients remain the same. Using input coefficient matrix, process innovation is expressed as follows.

$$\bar{\mathbf{A}} = \mathbf{A} - \alpha(\mathbf{A}\mathbf{e}_k)\mathbf{e}'_k \qquad (2\text{-}15)$$

Supply-demand balance after process innovation is expressed as follows.

$$\bar{\mathbf{x}} = \bar{\mathbf{B}}\mathbf{f} \qquad (2\text{-}16)$$

As mentioned before, CDM corresponds to process innovation. The more resource consumption a CDM project can economize in the entire economy, the more effective the CDM is in the context of environmental conservation. The spillover effect of process innovation is defined as the ratio of the output change(decrease) that occurs in sectors other than the innovated industry k in the whole output change(decrease) in the economy. In short, this is an indicator to see how much the innovation in industry k can economize the output other than industry k.

$$s_k = \frac{\sum_{i \neq k} (\bar{x}_i - x_i)}{\sum_i (\bar{x}_i - x_i)} \tag{2-17}$$

Using the equation (2-15) and formula for the inverse of a sum of matrices (see Henderson and Searle (1981)), the difference of *ex ante* and *ex post* Leontief's inverse matrix yields the following equation.

$$\bar{\mathbf{B}} - \mathbf{B} = -\frac{a}{1 + a\mathbf{e}'_k \mathbf{BAe}_k} \mathbf{B}(\mathbf{Ae}_k)\mathbf{e}'_k \mathbf{B} \tag{2-18}$$

The equation (18) can be further transformed since $\mathbf{BA} = \mathbf{B} - \mathbf{I}$.

$$\bar{\mathbf{B}} - \mathbf{B} = -\frac{a}{1 + a\mathbf{e}'_k (\mathbf{B} - \mathbf{I})\mathbf{e}_k} (\mathbf{B} - \mathbf{I})\mathbf{e}_k \mathbf{e}'_k \mathbf{B} \tag{2-18'}$$

The denominator of the right hand side is a scalar of $1 + a(b_{kk} - 1)$ which shall be denoted as $h_k = 1 + a(b_{kk} - 1)$. And since $\bar{b}_{ij} - b_{ij} = \mathbf{e}'_i (\bar{\mathbf{B}} - \mathbf{B})\mathbf{e}_j$, each element of $\bar{\mathbf{B}} - \mathbf{B}$ is written as follows.

$$\bar{b}_{ij} - b_{ij} = -ab_{ik} b_{kj} / h_k \tag{2-19a}$$

$$\bar{b}_{kj} - b_{kj} = -a(b_{kk} - 1)b_{kj} / h_k \tag{2-19b}$$

Let us compare *ex ante* output $\mathbf{x} = \mathbf{Ax} + \mathbf{f}$ and *ex post* output $\bar{\mathbf{x}} = \bar{\mathbf{A}}\bar{\mathbf{x}} + \mathbf{f}$.

$$\bar{x}_i - x_i = -ab_{ik} \sum_j b_{kj} f_j / h_k \tag{2-20a}$$

$$\bar{x}_k - x_k = -a(b_{kk} - 1) \sum_j b_{kj} f_j / h_k \tag{2-20b}$$

The spillover effect of process innovation is defined as the ratio of the output change(decrease) that occurs in sectors other than the innovated industry k in the total output change(decrease) in the economy. Let us define the k th column sum of Leontief's inverse matrix $\mathbf{B}$ as c_k. Then, the spillover coefficient of process innovation s_k is defined as follows.

$$s_k = \frac{\sum_{i \neq k} (\bar{x}_i - x_i)}{\sum_i (\bar{x}_i - x_i)} = \frac{c_k - b_{kk}}{c_k - 1} \tag{2-21}$$

Note that the coefficient s_k. is independent of final demand f_j or innovation rate a.

2-3-3 Spillover rate of process innovation in China

As the equation (2-21) shows, s_k. depends on the magnitude of the overall backward linkage effect and its own feedback effect of the corresponding sector. As to the former effect, the larger its backward linkage effect is, the larger the spillover rate is. As to the latter factor, the larger its own feedback effect is, the smaller the spillover rate is. Therefore, talking of manufacturing sector, to some extent, the reverse results would be obtained comparing with value-added distribution. That is the spillover effect of manufacturing in a relatively independent region tends to be estimated relatively smaller.

The results are shown in Table 2-5, and the following table is the summary. As is mentioned before, manufacturing sector in such regions as Northeast and North coast are relatively independent sectors. Therefore, their spillover effects are estimated relatively small.

However, "manufacturing" in this section includes the following industries: Food products, Textiles, Wooden products, Paper & printing, Chemical products, Non-metal mineral, Metal products, Machinery, Transport equipment, Electronic products, Other manufacturing, Electricity, gas, & water, and Construction. Needless to say, input structures of those sectors are sharply different, then, it would be interesting to see spillover rates in every individual industry.

The results are shown in Table 2-6. The table shows the top 40 industries whose spillover effect is large. The most conspicuous sector is construction whose spillover effect is extremely large. The feature of construction industry is that the backward linkage is relatively large while the own feedback is extremely small. Then the spillover effect of construction sector of all of the regions is large. Another sector of notable characteristic would be Electricity, gas, & water. It is also imaginable that the share of own input in Electricity, gas, & water industry is relatively small. Therefore, spillover effect of Electricity, gas, & water industry is large in comparison with other manufacturing sectors.

As a result, from a point of view of spillover effect,

- CDM for manufacturing sector in Northwest would be most preferable.
- CDM for such infrastructure related sectors as Construction and Electricity, gas, & water industry would be preferable.

Spillover rate of manufacturing	Region
0.7 and over	Northwest
0.6 and over and less than 0.7	North municipalities, South coast, Southwest
Less than 0.6	Northeast, North coast, Central coast, Central region

2-4 The policy of China government

China's "Reform and Open Door Policy" adopted in 1978 is based on the philosophy of as quick economic reconstruction as possible. However, Chinese government has implemented the policies so discreetly that new policies were tried first in a certain region and as reviewing the outcome applicable region of new policies were gradually enlarged later. The region selected for a trial by the government was South coast region since this region has relatively long experience of foreign trade and comparative advantage regarding such infrastructure as electricity and transportation. Since then China has been enjoying a high growth of two digits. Actually, China's GDP of 451billion RMB in 1980 has became 8,940billion RMB in 2000 that is 20 times as large as of 1980[2]. According to the government report, China wants to keep 7% growth during 20 years as from 2000 so that GDP would be four times as large as the present.

On the other hand, since economic growth of the inland region is lower compared with the coastal region that has been pulled the economic growth of China, poverty problem in the inland region is still serious, so that "difference among regions" came to be recognized as one of the urgent matters by the government. Then, the government has changed the policy stress from the previous "Stronghold region base development policy" to "Regional balanced development policy" since 1990 in order to keep the nation's economic development sustainable. A typical policy measure for that is the "Large western region development[3]" plan started in 1999. This policy is a development package with a special stress on the western region of various preferential treatments including fiscal and commercial fund access.

More concretely, the "Large western region development" plan has such various multi-dimensional social aims as economic growth by the intra regional demand expansion, the ecological improvement, mitigation of ethnic friction, peace & security keeping, creation of job opportunity etc. In order to achieve these objectives, infrastructure maintenance or investment environment improvement has been doing by expanding financial assistance and social overhead investment[4].

Therefore, if CDM projects were regarded in the same context of the "Large western region development" plan, the west region would be the most preferable as a site location of CDM.

Let us allow to use per-capita GDP as a criterion of CDM site location. Table 2-7 shows the income distribution by region in China. North municipalities and Central coast belong to a high-income group. On the other, western region such as Central region, Northwest and Southwest are included in a low-income group and we can see in particular the per-capita GDP in Southwest is low. Therefore, in case Chinese government expects alleviation of regional gaps as a matter of the highest priority, South west would be the most favorable candidate as a site location of CDM projects.

2-5 Scenario analysis

2-5-1 Two aspects of CDM

As is mentioned before, CDM has two different effects; one is an economic effect (or an income effect) since CDM leads to investment demands and another is an effect on environment since CDM projects have resource saving function by its definition. However, note that investment projects consume some additional resources so that CDM has an increase factor of environmental burden. Therefore, we need to integrate those effects in order to evaluate overall effects of CDM.

This part of the research is for estimating overall effects of CDM. The main interest of our research group is to find win-win strategies between China and Japan, in other words, simultaneous solution of China's SO_2 related local pollution problem and Japan's urgent request of GHG reduction. As is well known China's main source of SO_2 is coal consumption and the largest user of coal in China is an electric power generator. And Japan's power generation technology is acknowledged for its high energy efficiency. Therefore, we consider CDM projects in power generating industry, or technological transfer from Japan to China.

The annual inclement of electric power capacity in recent China is about 5,000MW and approximately 60% is thermal power generation of that. Then, we assume in this paper that coal-fired power station of 3000MW would be replaced by CDM in the year 2000.

The estimation procedure of the effects by CDM has two steps.

Step1: Investment construction phase

We assume the investment timing is the year 2000. And then we determine the site location and size (3,000MW coal-fired power generation) of the CDM project. First, income effect of the investment in 2000 is estimated as follows:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1} \cdot \mathbf{CDM}, \qquad (2\text{-}22)$$

A vector CDM is of the values of investment by industry for the CDM project and x is a vector of output increase caused by the CDM. The elements in the vector CDM are for a construction of a hypothetical 3,000MW power plant based on a hearing of a power plant specialist (information source should be anonymous). The investment amount that we assumed in this report is shown in Table 2-8. Next, based on this vector x, we estimate CO_2 and SO_2 emissions.

$$\mathbf{SO_2} = \mathbf{Sx}, \qquad (2\text{-}23)$$

$$\mathbf{CO_2} = \mathbf{Cx}, \qquad (2\text{-}24)$$

where $\mathbf{SO_2}$ and $\mathbf{CO_2}$ are respectively vectors of SO_2 and CO_2 emissions and **S** and **C** are respectively diagonal matrices of SO2 and CO_2 intensity per unit output **x**. Matrices **S** and **C** are calculated as follows.

$$\mathbf{S} = (\mathbf{E} \times \mathbf{SE}) \cdot \hat{\mathbf{x}}^{-1}, \qquad (2\text{-}25)$$

$$\mathbf{C} = (\mathbf{E} \times \mathbf{CE}) \cdot \hat{\mathbf{x}}^{-1}, \qquad (2\text{-}26)$$

where **E** is a diagonal matrix of energy consumption, **SE** and **CE** are respectively diagonal matrices of $\mathbf{SO_2}$ and $\mathbf{CO_2}$ coefficient per unit energy consumption **E,** and symbol ^ means a diagonal matrix..

We can get data on energy consumption by industry and by region in China Energy Statistics Yearbook 2000-2002, while the industry classification in the Energy Statistics Yearbook is different from the 17-sector I-O classification of this essay. So that the energy consumption needs to be apportioned to correspond to the I-O classification using a proxy index as is shown in Table 2-9. Table 2-10 and Table 2-11 respectively show SO_2 and CO_2 emission coefficient. As to SO_2, we should be careful that the sulfur content rates of coal are different among regions of the source. The differences of sulfur content rates were adjusted by using regional SO_2 emission adjustment coefficients (see Table 2-12). Moreover, this essay does not consider waste-gas desulfurization in the calculation, so that the emissions of SO_2 in this essay are not necessarily "real emissions" but "potential emissions".

Step2a: Efficiency improvement in power generation by CDM project

According to the above-mentioned hearing of a power plant specialist, the efficiency of power generation by Japanese technology is 20 to 30 % as high as that operating in China. Therefore, we assumed the efficiency improvement by CDM is 25%. Then, the input coefficient of the electricity industry in the host region would be reduces by this improvement rate. However, since the CDM project we consider does not replace the whole capacity of power generation plants in the corresponding region, we need to adjust the efficiency improvement rate by the relative scale of CDM project in the whole regional capacity. Table 2-13 shows the adjusted rate of improvement in each region.

Step2b: Energy saving investment construction phase

We assume the operating period would be ten years from 2001 to 2010. Since the Chapter 3 of this report is for a macro estimation of Chinese economy, we use this estimation as the baseline forecast. Under the efficiency improved I-O structure, demand-supply balance is expressed as follows:

$$\bar{\mathbf{x}} = (\mathbf{I} - \bar{\mathbf{A}})^{-1}\mathbf{f} \,. \qquad (2\text{-}27)$$

CO_2 and SO_2 emissions are also defined as follows:

$$\overline{\mathbf{SO}_2} = \mathbf{S} \cdot \bar{\mathbf{x}}, \qquad (2\text{-}28)$$

$$\overline{\mathbf{CO}_2} = \mathbf{C} \cdot \bar{\mathbf{x}} \qquad (2\text{-}29)$$

The symbols with upper bar means those based on CDM technology. Therefore, the effect of CDM in operating phase (2001-2010) is calculated as follows:

$$\mathbf{ESO_2 = SO_2 - \overline{SO_2}} \tag{2-30}$$

$$\mathbf{ECO_2 = CO_2 - \overline{CO_2}} \tag{2-31}$$

2-5-2 Effects of construction phase of CDM

First, let us confirm the situation before the CDM investment is done from the analysis from MRIO in 2000. Table 2-14 shows the output and emissions of SO2 and CO_2 in the year 2000. The output is 19,984 billion RMB, where Central coast accounts for 23.1%, South coast accounts for 14.9%, and North coast accounts for 14.3%respectively, and the total of these three regions accounts for 50% or more.

This concentration of economic power is a reflection of the policy conversion, in particular, introduction of foreign capitals to the coastal region after the Southern lectures given by Deng Xioaping in 1992. With this economic boom after 1992, China total of emissions of CO_2 and SO_2 in 2000 respectively became as much as 956Mt-c and 34Megaton.

As to regional distribution of CO_2, Central region, Central coast and North east respectively accounts for 28.8%, 17%, and 11.9%. The reason CO_2 distribution is slightly different from that in income is due to the difference in industry structure and energy consumption pattern among regions.

On the other, as to SO_2 emissions, Central region, Central coast and Southwest respectively accounts for 28.1%, 16.9%, and 15.0%. The reason why the share of Southwest is conspicuously high is that this region consumes a large quantity of coal whose sulfur content rate is high (see Table 2-12).

Next, let us see emission coefficients. The national average of CO_2 emission coefficient is 47.9t-c/Million RMB and the regions whose CO_2 coefficient exceeded the national average are such four regions as Central region, Northwest, North municipalities, and Northeast. That is, in these regions CO_2 emissions per GDP is larger than those in other regions. On the other, the national average of SO_2 emission coefficient is 1.7ton/Million RMB and the regions whose SO_2 coefficient exceeded the national average are such three regions as Central region, Northwest and Southwest. In those areas, coal consumption is relatively large and the sulfur content rate in the consumed coal is high.

On the basis of such regional characteristics, let us simulate the economic and environmental effects when the CDM project is implemented in 2000. Table 2-15 shows the results that we obtained in the eight cases of simulations on the assumed CDM investment. We can see that the regions that enjoy large ripple effects are Central region, Central coast, and North coast no matter where the CDM investment is implemented. In other words, those regions are the suppliers of raw materials or intermediate goods to other regions in China.

As is sown in Table 2-16, the region where the own share of output inducement by CDM investment is large in North coast, Northeast, and Southwest, on the other own share is relatively small in Northwest, South coast, and Central coast.

Table 2-17 shows the total effects of output, CO_2 and SO_2 emissions in the phase of CDM construction. It is in the Central region that has the largest effect on output and CO_2 and SO_2 emissions. As to output increase effect, Central region is followed by North coast and Northeast, as to CO_2 emissions effect, followed by Northeast and Northwest, and as to SO_2 emission effect, followed by Southwest and Northwest. The reason of difference of the order is regional features on industrial structure and energy consumption pattern. And it is noteworthy that due to the high sulfur content rate in the western region, emissions in those regions are quite high.

2-5-3 Effects of operating phase of CDM

We assumed the crediting period for a proposed project activity should be a decade from 2001 to 2010. Table 2-18 shows the results of the simulations. Concerning CO_2 mitigation effect, the region recording the largest effect is Central region followed by South coast and Central coast. Concerning SO_2 reduction, reduction in Central region and South coast is also large. On the other hand, Southwest is third largest regions in terms of SO_2 reduction regardless Southwest is the regions where CO_2 reduction effect is the smallest like Northwest.

2-5-4 Net Effects of CDM

Since the year 2000 is supposed to be a construction period of the CDM project, emissions of CO_2 and SO_2 increase in 2000. Therefore, in order to get the net amount of the reduction of CO_2 and SO_2, emission increase in the construction period in 2000 should be subtracted from the emission reduction during the crediting period of 2001 to 2010. That is to say, the net effect of CDM in reductions of CO_2 and SO_2 respectively are defined as "(2-30) minus (2-23)" and "(2-31) minus (2-24)".

$$\mathbf{NSO_2=ESO_2-SO_2} \quad (2\text{-}32)$$

$$\mathbf{NCO_2=ECO_2-CO_2} \quad (2\text{-}33)$$

The net effects defined by (2-32) and (2-33) are shown in Table 2-19. The rank of the net effects form the largest is the order of South coast, Central region, and Central coast regarding the CO_2 mitigation volume as well as SO_2 reduction.

This research clarified that there are big differences in reduction of CO_2 and SO_2 depending to site locations where CDM project is implemented. For instance, South coast, the region of the largest CO_2 reduction, could reduce 4.5Mt-c that is almost six times as large as the reduction of 0.7Mt-c in Northwest, the region of the smallest CO_2 reduction. Similar simulation result is observed concerning SO_2 reduction. South coast, the region of the largest SO_2 reduction, could reduce 166.7 kiloton that is almost five times as large as the reduction of 34.3 kiloton in Northwest, the region of the smallest SO_2 reduction.

In the meantime, note that our research tends to overvalue CO_2 reduction effect compared with CER obtained by the present rules of CDM. This is because our research considers the overall effects including ripple effects to other industries and other regions using I-O analysis, while CER certificated by the CDM focuses on only the direct effect in the very establishment where the CDM project is actually done. Generally speaking, possible CER acquisition in case CDM project was implemented in *j*th industry would be defined as follows.

$$CO_2D_j = \sum_i C_i(a_{ij} \times r_j)y_j \qquad (2\text{-}34)$$

Where CO_2D_j is the amount of direct CO_2 reduction realized in *j*th industry, C_i is CO_2 coefficient of *i*th industry, a_{ij} is an input coefficient of *i*th industry to *j*th industry, r_j is the efficiency improvement rate in *j*th industry, and y_j is the output of to *j*th industry.

Therefore, if the output of the power generators as of 2000 is substituted in y_j, the direct CO_2 reduction in the power generation sector would be calculated. Then, ten times of CO_2D, the crediting period of CDM project, would be a proxy of CER obtained from this CDM project. It is a great feature of our study that the CO_2 reduction in a region reflects on the structure of the power generation sector in the region. In other words, even if the scales or types of CDM projects are same, that CER acquisitions are different among regions because of the difference in the baseline supposition.

Indirect reduction of CO_2 emissions is defined as the residual of ECO_2(2-30) minus CO_2D(2-34) times 10. CO_2ID is the indirect reduction from other industries than power generation sector during ten years.

$$CO_2ID = ECO_2 - CO_2D*10 \qquad (2\text{-}35)$$

And taking CO_2 emissions in the CDM investment into consideration, the final indirect reduction of CO_2 emissions is defined as follows. CO_2ID in (2-36) is smaller than CO_2ID in (2-35) by CO_2 emissions in the CDM investment.

$$CO_2ID = NCO_2 - CO_2D*10 \qquad (2\text{-}36)$$

Table 2-20 summarizes those simulation results. As for the amount of the CO_2 reduction, the indirect reduction is mach larger than the direct reduction in both Operating effects and Net effects.

Listing the regions in descending order on the scale of direct reduction; the rank is South coast, Central region, Central coast, and North municipalities, while on the scale of indirect reduction; the rank is Central region, South coast, Central coast, and North municipalities. However, as to the regional dispersion on CO_2 reduction, that in the indirect reduction is larger that in the direct reduction. For example, even though the difference in the direct reduction between Central coast and North municipalities is marginal, the difference in the indirect effect is as mush as 100Mt-c.

To wrap-up hereinbefore in this section, the simulation analysis suggests that site location of CDM should be determined cautiously taking into account not only CER acquisition but also how much large ripple effect the target industry has onto other industries and other regions.

2-6 Concluding remarks

This chapter considers which region is preferable as a site location of CDM projects from a variety of viewpoints. Table 2-21 is a summary table of the simulation analysis. Let us point out several fact-findings.

1) Southwest is most preferable as a site location of CDM according to the own value added acquisition rate criterion.
2) North west is most preferable as a site location of CDM according to the spillover criterion
3) Central region is most preferable as a site location of CDM according to the economic effects of the investment.
4) Central region is most preferable as a site location of CDM based on the reduction of CO_2 and SO_2 during the crediting period of CDM project.
5) South coast is most preferable as a site location of CDM based on the net effect of the reduction of CO_2 and SO_2.
6) Southwest is most preferable as a site location of CDM in order to mitigate regional imbalance.

Therefore, determination of the site location of CDM depends on the criterion of which China, the host country, makes a point. Needless to say, negotiation is held between the host country and the investment country on the cite location of CDM. Therefore we should be careful that the result of this research in not always applicable ant the situation or convenience of the investment country also would be considered in the process of bilateral negotiation.

Table 2-22 shows a ranking of supremacy concerning site location of CDM by applying various criterions. Each region is given a pint of 1 to 8 based on the score for each criterion shown in Table 2-21. As to criterions such as Value added, Spillover, and Output, points are give in ascending order, and as to criterions such as emissions of CO_2 and SO_2, points are given in descending order. Judging from the overall score of these criterions, the most preferable region as a site location of CDM is South coast followed by Southwest and Central region

Cooperation of the investment country and the host country is indispensable to implement CDM. However, the most of researches are from the viewpoint of the Annex I country (investment country) side and it used be rare that a viewpoint of the developing country side is emphasized. Therefore, we believe that this report will provide profitable information with not only the host country but also the investment country.

Since The Kyoto Protocol entered into force on 16 February 2005, Annex I countries could not help achieve their quantified reduction targets in the commitment period 2008 to 2012. It is said that application of domestic measures would not be enough for Japan to achieve the target; therefore it is inevitable for Japan to make use of the Kyoto mechanism. The recent price of CO_2 in the emission trading market seems to be on the unexpected boost trend, so that it is quite possible for a lot of countries to make particularly use of CDM or JI in Kyoto mechanism.

The main theme of last year's report of Kyoto University group is which country is preferable as a partner of CDM if Japan implements CDM. The tentative result was China was the most preferable partner for Japan when ancillary benefit accompanied with energy saving in China is taken into consideration. This report, on the same extension as the last year's report, made a proposal on which region in China is most suitable as a site location of CDM.

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Endnotes

1 Note that exports and imports among endogenous regions would be treated as endogenous intermediate inputs.

2 See China statistical yearbook 2001.

3 Western region refers to Northwest and Southwest in this chapter.

4 See Jin-Hu Wu(2003), p25.

Chapter 2 Tables and Figures

Table 2-1 Correspondence of region and province

Region name	Province name
Northeast	Heilongjiang, Jilin, Liaoning
North Municipalities	Beijing, Tianjin
North Coast	Hebei, Shandong
Central Coast	Jiangsu, Shanghai, Zhejiang
South Coast	Fujian, Guangdong, Hainan
Central Region	Shanxi, Henan, Anhui, Jiangxi, Hubei, Hunan
Northwest	Inner-Mongoria, Ningxia, Shaanxi, Gansu, Qinghai, Xinjiang
Southwest	Guangxi, Chongqin, Guizhou, Tibet, Sichuan, Yunnan

Source: Okamoto and Ihara(eds.) (2004), p.5.

Figure 2-1 Correspondence of region and province

Source: Institute of Developing Economies (2003), p.14.

Table 2-2 China's sector classification

17Sectors		**Basic sector classification**	
1	Agriculture	1	Agriculture
2	Mining	2	Coal mining and Processing
		3	Crude petroleum and natural gas products
		4	Metal ore mining
		5	Non-ferrous mineral mining
3	Food products	6	Manufacture of food and tobacco processing
4	Textile and wearing apparel	7	Textile goods
		8	Wearing apparel, leather, furs, down and related products
5	Wooden products	9	Sawmills and furniture
6	Paper and printing	10	Paper and products, printing and record medium reproduction
7	Chemical products	11	Petroleum processing and coking
		12	Chemicals
8	Non-metallic mineral products	13	Nonmetal mineral products
9	Metal products	14	Metals smelting and pressing
		15	Metal products
10	Machinery	16	Machinery and equipment
11	Transport equipment	17	Transport equipment
12	Electronic products	18	Electric equipment and machinery
		19	Electric and telecommunication equipment
13	Other manufacturing products	20	Instruments, meters, cultural and office machinery
		21	Maintenance and repair of machine and equipment
		22	Other manufacturing products
		23	Scrap and waste
14	Electricity, gas and water supply	24	Electricity, steam and hot water production and supply
		25	Gas production and supply
		26	Water production and supply
15	Construction	27	Construction
16	Trade and transport	28	Transport and warehousing
		29	Wholesale and retail trade
17	Services	30	Services

Source: Institute of Developing Economies (2003), p.24.

.

Table 2-3 Value added division of labor
(Unit:%)

	Northeast	North municipalities	North coast	Central coast	South coast	Central region	Northwest	Southwest
	Total	Total	Total	Total	Total	Total	Total	Total
Northeast	77.5	1.3	2.2	1.3	0.7	0.8	1.4	0.5
North municipalities	0.9	63.1	1.0	0.7	0.6	0.5	1.1	0.3
North coast	4.8	6.5	79.1	6.0	3.2	4.7	4.7	2.5
Central coast	3.2	1.9	3.9	64.8	4.9	4.0	3.2	2.5
South coast	1.6	0.9	1.3	3.3	59.5	2.0	2.0	2.7
Central region	3.7	4.1	4.6	7.9	6.0	81.4	6.2	4.4
Northwest	1.0	1.4	1.4	1.1	0.7	1.7	75.1	1.3
Southwest	0.7	0.5	0.7	1.3	2.7	1.3	2.2	82.9
Import	6.8	20.4	5.8	13.6	21.8	3.5	4.1	2.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 2-4 Value added division of labor

(Unit: %)

		Northeast			North municipalities			North coast			Central coast		
		Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
Northeast	Primary	67.9	13.8	9.3	0.4	0.5	0.2	0.6	1.3	0.5	0.3	0.6	0.2
	Secondary	11.3	48.3	16.9	0.4	0.8	0.4	0.6	1.0	0.6	0.3	0.6	0.3
	Tertiary	6.4	11.0	53.9	0.2	0.3	0.1	0.2	0.4	0.2	0.1	0.2	0.1
North municipalities	Primary	0.1	0.1	0.1	59.3	2.6	0.7	0.1	0.1	0.0	0.0	0.1	0.0
	Secondary	0.3	0.5	0.4	5.1	37.3	6.6	0.3	0.6	0.4	0.2	0.4	0.2
	Tertiary	0.2	0.4	0.3	10.3	16.6	70.9	0.3	0.4	0.2	0.1	0.3	0.1
North coast	Primary	0.9	1.6	1.1	1.8	2.2	0.9	61.5	14.2	4.8	1.1	2.0	0.8
	Secondary	1.4	2.6	1.9	2.0	3.7	2.0	11.5	47.7	12.9	1.5	3.2	1.5
	Tertiary	0.8	1.4	1.1	1.1	1.8	1.0	12.3	14.1	69.0	0.7	1.5	0.8
Central coast	Primary	0.2	0.3	0.3	0.3	0.2	0.1	0.3	0.5	0.2	63.2	4.3	2.2
	Secondary	1.1	2.2	1.6	0.6	1.4	0.6	1.4	2.6	1.5	9.9	43.4	11.4
	Tertiary	0.6	1.1	0.9	0.3	0.7	0.3	1.0	1.4	0.8	6.9	13.1	66.2
South coast	Primary	0.2	0.3	0.2	0.2	0.2	0.1	0.2	0.3	0.1	0.5	0.8	0.3
	Secondary	0.5	0.9	0.7	0.3	0.6	0.3	0.4	0.7	0.5	0.9	1.8	1.0
	Tertiary	0.3	0.6	0.5	0.2	0.3	0.2	0.3	0.4	0.3	0.5	1.0	0.6
Central region	Primary	0.9	1.6	1.1	1.2	1.5	0.7	1.0	1.6	0.7	1.5	3.0	1.2
	Secondary	0.9	1.8	1.3	1.3	2.3	1.3	1.3	2.4	1.3	1.9	4.0	1.8
	Tertiary	0.6	1.0	0.8	0.6	1.1	0.6	0.9	1.2	0.7	0.8	1.8	1.0
Northwest	Primary	0.3	0.6	0.4	0.7	0.7	0.3	0.3	0.4	0.2	0.2	0.4	0.2
	Secondary	0.2	0.4	0.3	0.3	0.7	0.3	0.3	0.5	0.2	0.2	0.5	0.2
	Tertiary	0.2	0.3	0.2	0.2	0.4	0.2	0.8	0.7	0.3	0.1	0.3	0.1
Southwest	Primary	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.5	0.2
	Secondary	0.2	0.3	0.3	0.1	0.3	0.1	0.2	0.3	0.2	0.3	0.7	0.3
	Tertiary	0.1	0.2	0.2	0.1	0.2	0.1	0.1	0.2	0.1	0.2	0.4	0.2
Import		4.4	8.2	6.2	12.9	23.5	12.0	4.0	6.8	3.9	8.4	15.2	8.8
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Own Region		85.6	73.2	80.0	74.6	56.5	78.2	85.2	75.9	86.7	79.9	60.8	79.9

Table 2-4 Value added division of labor (continued)

		South coast			Central region			Northwest			Southwest		
		Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
Northeast	Primary	0.1	0.3	0.1	0.2	0.4	0.2	0.3	0.6	0.3	0.1	0.2	0.1
	Secondary	0.1	0.4	0.2	0.2	0.5	0.3	0.5	0.9	0.6	0.1	0.3	0.2
	Tertiary	0.0	0.1	0.1	0.1	0.2	0.1	0.2	0.3	0.3	0.1	0.1	0.1
North municipalities	Primary	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
	Secondary	0.1	0.4	0.2	0.2	0.3	0.2	0.5	0.7	0.5	0.1	0.2	0.1
	Tertiary	0.1	0.2	0.1	0.1	0.2	0.1	0.3	0.4	0.3	0.1	0.1	0.1
North coast	Primary	0.5	1.1	0.5	0.8	1.7	0.8	0.7	1.3	0.8	0.4	0.8	0.4
	Secondary	0.7	1.9	0.9	1.4	2.7	1.7	1.5	2.8	1.9	0.7	1.6	0.9
	Tertiary	0.4	0.8	0.5	0.8	1.4	0.9	0.8	1.6	1.2	0.4	0.8	0.5
Central coast	Primary	0.4	0.7	0.3	0.3	0.5	0.3	0.2	0.3	0.2	0.1	0.3	0.1
	Secondary	1.2	3.6	1.7	1.6	2.9	1.8	1.3	2.3	1.6	0.9	2.0	1.1
	Tertiary	0.6	1.3	0.7	0.7	1.3	0.9	0.6	1.2	0.9	0.4	0.9	0.5
South coast	Primary	68.8	5.1	2.9	0.3	0.5	0.2	0.2	0.4	0.2	0.2	0.5	0.2
	Secondary	4.2	36.4	7.1	0.6	1.2	0.9	0.6	1.2	1.0	0.8	1.8	1.2
	Tertiary	7.2	11.9	63.0	0.4	0.7	0.5	0.4	0.8	0.6	0.4	1.0	0.7
Central region	Primary	1.2	2.2	1.0	68.8	16.6	5.8	1.1	2.3	1.2	0.8	1.6	0.8
	Secondary	1.2	3.3	1.7	11.3	47.2	12.5	1.6	3.4	2.2	1.1	2.7	1.6
	Tertiary	0.6	1.4	0.8	8.2	13.7	68.1	1.0	1.9	1.5	0.6	1.3	0.8
Northwest	Primary	0.2	0.3	0.1	0.3	0.8	0.3	70.8	14.7	5.0	0.2	0.5	0.3
	Secondary	0.1	0.4	0.2	0.4	0.9	0.5	5.9	42.4	9.0	0.3	0.7	0.5
	Tertiary	0.1	0.2	0.1	0.2	0.5	0.3	7.6	12.8	65.4	0.2	0.4	0.2
Southwest	Primary	0.4	0.8	0.3	0.3	0.5	0.2	0.4	0.8	0.4	75.1	14.4	4.6
	Secondary	0.5	1.3	0.6	0.4	0.7	0.4	0.6	1.1	0.8	7.9	48.5	10.7
	Tertiary	0.5	1.0	0.6	0.2	0.4	0.3	0.4	0.7	0.6	7.4	15.4	71.9
Import		10.7	25.1	16.1	2.4	4.4	2.7	2.7	5.1	3.6	1.7	4.0	2.3
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Own Region		80.2	53.4	73.1	88.3	77.5	86.4	84.3	69.9	79.4	90.4	78.2	87.1

Table 2-5 Spillover rate

Region	Sector	Spillover rate	Rank
Northeast	Primary	0.832	2
	Manufacturing	0.546	22
	Tertiary	0.793	7
North municipalities	Primary	0.868	1
	Manufacturing	0.630	17
	Tertiary	0.537	23
North coast	Primary	0.828	3
	Manufacturing	0.562	21
	Tertiary	0.739	12
Central coast	Primary	0.825	4
	Manufacturing	0.533	24
	Tertiary	0.685	15
South coast	Primary	0.793	6
	Manufacturing	0.670	16
	Tertiary	0.623	18
Central region	Primary	0.812	5
	Manufacturing	0.574	20
	Tertiary	0.744	11
Northwest	Primary	0.784	8
	Manufacturing	0.749	10
	Tertiary	0.718	13
Southwest	Primary	0.753	9
	Manufacturing	0.611	19
	Tertiary	0.687	14

Remark: Based on Non-Competitive IO.

Table 2-6 Spillover rate: Top 40 in 136 sectors

	Region	Industry	Spillover
1	A015	Construction	0.9993
2	F015	Construction	0.9969
3	D015	Construction	0.9968
4	B015	Construction	0.9956
5	G015	Construction	0.9954
6	E015	Construction	0.9946
7	C015	Construction	0.9932
8	H015	Construction	0.9929
9	E010	Machinery	0.9893
10	B002	Mining	0.9893
11	G013	Other manufacturing products	0.9810
12	D002	Mining	0.9794
13	E002	Mining	0.9757
14	G011	Transport equipment	0.9738
15	A013	Other manufacturing products	0.9658
16	C013	Other manufacturing products	0.9652
17	B010	Machinery	0.9650
18	B014	Electricity & gas & water supply	0.9645
19	B005	Wooden products	0.9616
20	G010	Machinery	0.9613
21	C014	Electricity & gas & water supply	0.9600
22	F012	Electronic products	0.9583
23	B008	Non metal mineral products	0.9576
24	H013	Other manufacturing products	0.9572
25	C011	Transport equipment	0.9557
26	G014	Electricity & gas & water supply	0.9537
27	A014	Electricity & gas & water supply	0.9492
28	C012	Electricity & gas & water supply	0.9471
29	G005	Wooden products	0.9466
30	D014	Electricity & Gas & Water	0.9461
31	B013	Other manufacturing products	0.9445
32	H008	Non metal mineral products	0.9445
33	H010	Machinery	0.9425
34	H014	Electricity & gas & water supply	0.9411
35	D013	Other manufacturing products	0.9390
36	G009	Metal products	0.9280
37	G007	Chemical products	0.9268
38	C008	Non metal mineral products	0.9252
39	A017	Services	0.9213
40	F014	Electricity & gas & water supply	0.9184

A	Northeast
B	North municipalities
C	North coast
D	Central coast
E	South coast
F	Central region
G	Northwest
H	Southwest

Table 2-7 Output per capita by regions

Regions \ Population & Output	Total Population	Total Output	Output per capita
	10Thousand Persons	10Thousand RMB	RMB/person
Northeast	10,655	194,725,934	18,276
North municipalities	2,383	94,194,435	39,528
North coast	15,823	284,949,149	18,009
Central coast	13,789	462,535,328	33,544
South coast	12,900	297,566,553	23,067
Central region	35,147	349,778,994	9,952
Northwest	11,548	112,247,043	9,720
Southwest	23,983	202,444,881	8,441

Source: calculated by China statistical yearbook 2001 (2001) and Multi-regional IO table in China 2000(2003).

Table 2-8 Investment amounts of CDM projects (3,000MW) by industry

(Million RMB)

	Sectors	Investment
1	Agriculture	0.0
2	Mining	0.0
3	Food	0.0
4	Textile and wearing apparel	0.1
5	Wooden products	1.0
6	Paper and printing	0.0
7	Chemical products	0.0
8	Non-metallic mineral products	0.0
9	Metal products	0.3
10	Machinery	862.2
11	Transport equipments	41.3
12	Electronic products	1,254.9
13	Other manufacturing products	0.6
14	Electricity, gas and water supply	0.0
15	Construction	1,156.8
16	Trade and transportation	417.8
17	Services	0.0
	Total	3,735.0

Table 2-9 Energy consumptions by region and industrial sectors

17 Sectors		Classification of industrial sectors in China Energy Statistics Yearbook [A]	Source of data
1	Agriculture		Energy balance table by region*
2	Mining	Coal mining and dressing Petroleum and natural gas extraction Ferrous metals mining and dressing Nonferrous metals mining and dressing Nonmetals minerals mining and dressing Logging and transport of wood and bamboo	Output of coal (10^4ton) ,oil(10^4ton), natural gas(10^8cu.m) by region**
3	Food products	Food processing Food production Beverage production Tobacco processing	Gross output value of light industry by region (100 million RMB)**
4	Textile and wearing apparel	Textile industry Garments and other fiber products Leather, furs, down and related products	Output of cloth by region (100 million RMB)**
5	Wooden products	Timber processing, bamboo, cane, palm & straw products Furniture manufacturing	Gross output value of light industry by region (100 million RMB)**
6	Paper and printing	Papermaking and paper products Printing and record medium reproduction Cultural, educational and sports articles	Gross output value of light industry by region (100 million RMB)**
7	Chemical products	Petroleum processing and coking Raw Chemical materials and chemical products Medical and pharmaceutical products Chemical fiber Rubber products Plastic products	Gross output value of heavy industry by region (100 million RMB)**
8	Non-metallic mineral products	Nonmetal mineral products	Gross output value of heavy industry by region (100 million RMB)**
9	Metal products	Smelting and pressing of ferrous metals Smelting and pressing of nonferrous metals Metal products	Gross output value of heavy industry by region (100 million RMB)**
10	Machinery	Ordinary machinery Equipment for special purpose	Gross output value of heavy industry by region (100 million RMB)**
11	Transport equipment	Transportation equipment	Gross output value of heavy industry by region (100 million RMB)**
12	Electronic products	Electric equipment and machinery Electric and telecommunication equipment	Gross output value of heavy industry by region (100 million RMB)**
13	Other manufacturing products	Instruments, meters, cultural and office machinery Other manufacturing products	Gross output value of heavy industry by region (100 million RMB)**
14	Electricity, gas and water supply		Energy balance table by region*
15	Construction		Energy balance table by region*
16	Trade and transport		Energy balance table by region*
17	Services		Energy balance table by region*

Source of data
A: Energy consumption by sector in China Energy Statistics Yearbook2000-2002 (2005).
*: Energy consumption by region and industrial sectors in China Energy Statistics Yearbook2000-2002 (2005).
**: The energy consumption by region in industrial sectors is calculated by the indexes of the output value and output amount in China Statistical Yearbook 2001.

Table2-10 Energy calories and CO_2 emission coefficient by energy in China

Energy	Calories conversion factors		CO_2 emission coefficient	
	Unit	Average calories	Unit	Conversion coefficient
<Coal>				
Raw coal	Kcal/kg	5000	t-c/toe	1.065
Cleaned coal	Kcal/kg	6300	t-c/toe	1.065
Other washed coal	Kcal/kg	2000	t-c/toe	1.065
Coke	Kcal/kg	6800	t-c/t	0.868
Coke oven gas	Kcal/cu.m	4150	t-c/toe	0.460
Other gas	Kcal/cu.m	2500	t-c/toe	2.990
Other coking products	Kcal/kg	5000	t-c/t	0.868
<Oil>				
Crude oil	Kcal/kg	10000	t-c/t	0.863
Gasoline	Kcal/kg	10300	t-c/t	0.854
Kerosene	Kcal/kg	10300	t-c/t	0.863
Diesel oil	Kcal/kg	10200	t-c/t	0.869
Fuel oil	Kcal/kg	10000	t-c/t	0.878
PLG	Kcal/kg	12000	t-c/t	0.823
Refinery gas	Kcal/kg	11000	t-c/t	0.800
Other petroleum products	Kcal/kg	10000	t-c/t	0.863
Natural gas	Kcal/cu.m	9310	t-c/toe	0.631

Source: Figures for conversion factors of calories are by the China Energy Statistics Yearbook2000-2002, p.536, and for CO_2 Emission coefficient are by National Institute of Science and Technology Policy (eds.)(1992), p.161.

Table2-11 SO_2 emission coefficients in China

	Raw coal	**Cleaned coal**	**Other washed coal**	**Coke**	**Coke oven gas**	**other gas**	**Other coking products**	**Crude oil**
1 Agriculture	12*S[a]	12.0*S[a]	12.0*S[a]	17.7*S[a]	3.8*S[a]	0.01	17.7*S[a]	20*S[b]
2 Mining	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
3 Food products	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
4 Textile and wearing apparel	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
5 Wooden Produce	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
6 Paper Printing	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
7 Chemical products	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
8 Non-metallic mineral products	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
9 Metal products	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
10 Machinery	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
11 Transport equipment	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
12 Electronic products	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
13 Other manufacturing products	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
14 Electricity&Gas&Water	19.5*S[a]	19.5*S[a]	19.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
15 Construction	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
16 Trade and transport	15.5*S[a]	15.5*S[a]	15.5*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]
17 Services	12*S[a]	12.0*S[a]	12.0*S[a]	17.7*S[a]	38*S[a]	0.01	17.7*S[a]	20*S[b]

Table2-11 SO_2 emission coefficients in China (continued)

	Gasoline oil	Kerosene	Diesel oil	Fuel oil	PLG	Refinery gas	Other petroleum products	Natural gas
1 Agriculture	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
2 Mining	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
3 Food products	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
4 Textile and wearing apparel	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
5 Wooden Produce	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
6 Paper Printing	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
7 Chemical products	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
8 Non-metallic mineral products	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
9 Metal products	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
10 Machinery	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
11 Transport equipment	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
12 Electronic products	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
13 Other manufacturing products	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
14 Electricity&Gas&Water	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
15 Construction	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
16 Trade and transport	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092
17 Services	$20*S^c$	$20*S^d$	$20*S^e$	$20*S^f$	0.0136	0.013	1.0	0.0092

Source: Calculated by the National Institute of Science and Technology Policy (eds.)(1992)

Remark : S^a, S^b, S^c, S^d, S^e, S^f are sulfur content .

Table2-12 The value of contented-sulfur by regions

	S^a	S^b	S^c	S^d	S^e	S^f
Beijing	0.76					
Tianjin	0.86					
Hebei	0.97					
Shanxi	0.99					
Inner Mongolia	1.45					
Liaoning	0.75					
Jilin	0.58					
Heilongjiang	0.63					
Shanghai	1.04					
Jiangsu	1.80					
Zhejiang	1.09					
Anhui	1.03					
Fujian	1.26					
Jiangxi	1.39					
Shandong	1.97					
Henan	1.07	1.50	0.12	0.032	0.40	1.50
Hubei	1.00					
Hunan	0.88					
Guangdong	1.09					
Guangxi	2.22					
Hainan	1.34					
Chongqing	1.34					
Sichuan	3.19					
Guizhou	2.95					
Yunnan	3.09					
Tibet	1.00					
Shaanxi	2.72					
Gansu	0.98					
Qinghai	0.70					
Ningxia	1.95					
Xinjiang	1.00					

Source: Calculated by the National Institute of Science and Technology Policy (eds.)(1992)

Table 2-13 Adjusted efficiency improvement by regions

Region	Adjusted rate of efficiency improvement
Northeast	1.97%
North municipalities	7.65%
North coast	1.48%
Central coast	1.31%
South coast	1.57%
Central region	0.98%
Northwest	1.93%
Southwest	1.64%

Table 2-14 The values of Output, CO_2 and SO_2 emission in 2000

	Output (Million RMB)	CO_2 (Mt-c)	SO_2 (1000ton)	CO_2 coefficient (t-c/Million RMB)	SO_2 coefficient (ton/Million RMB)
Northeast	1,947,259.3	114.0	2,195.3	58.5	1.1
North municipalities	941,944.4	57.0	1,298.8	60.5	1.4
North coast	2,849,491.5	110.4	4,461.7	38.7	1.6
Central coast	4,625,353.3	162.4	5,699.0	35.1	1.2
South coast	2,975,665.5	95.4	2,594.1	32.0	0.9
Central region	3,497,789.9	275.8	9,485.8	78.8	2.7
Northwest	1,122,470.4	70.8	2,994.9	63.1	2.7
Southwest	2,024,448.8	71.0	5,087.2	35.1	2.5
Total	19,984,423.2	956.7	33,816.9	47.9	1.7

Table 2-15 Effects of construction phase of CDM project by regions

case1 Effects of construction phase of CDM in Northeast

	Output	CO_2	SO_2
	Million RMB	Mt-c	1000ton
Northeast	8,326.3	0.49	9.20
North municipalities	106.3	0.01	0.21
North coast	534.9	0.04	1.64
Central coast	433.2	0.02	0.80
South coast	160.3	0.01	0.18
Central region	399.7	0.05	1.50
Northwest	101.3	0.01	0.62
Southwest	78.0	0.01	0.41
Total	10,140.1	0.63	14.56

case2 Effects of construction phase of CDM in North municipalities

	Output	CO_2	SO_2
	Million RMB	Mt-c	1000ton
Northeast	121.3	0.01	0.21
North municipalities	5,045.1	0.30	6.73
North coast	516.3	0.06	2.64
Central coast	162.5	0.01	0.34
South coast	59.7	0.00	0.09
Central region	323.1	0.07	2.46
Northwest	97.3	0.01	0.50
Southwest	39.5	0.00	0.21
Total	6,364.8	0.47	13.18

case3 Effects of construction phase of CDM in North coast

	Output	CO_2	SO_2
	Million RMB	Mt-c	1000ton
Northeast	233.5	0.02	0.43
North municipalities	125.7	0.02	0.39
North coast	8,522.7	0.33	13.23
Central coast	502.5	0.03	1.19
South coast	114.2	0.01	0.15
Central region	545.5	0.07	2.44
Northwest	144.8	0.02	0.68
Southwest	75.9	0.01	0.41
Total	10,264.8	0.50	18.92

case4 Effects of construction phase of CDM in Central coast

	Output	CO_2	SO_2
	Million RMB	Mt-c	1000ton
Northeast	135.5	0.01	0.24
North municipalities	75.7	0.01	0.18
North coast	630.4	0.05	1.87
Central coast	7,207.8	0.25	8.55
South coast	251.3	0.02	0.46
Central region	814.8	0.11	3.70
Northwest	110.6	0.01	0.60
Southwest	142.1	0.01	0.86
Total	9,368.2	0.47	16.46

case5 Effects of construction phase of CDM in South coast

	Output	CO_2	SO_2
	Million RMB	Mt-c	1000ton
Northeast	55.8	0.01	0.09
North municipalities	41.7	0.00	0.09
North coast	272.6	0.02	0.71
Central coast	397.6	0.02	0.80
South coast	4,764.4	0.16	4.40
Central region	498.4	0.07	2.34
Northwest	57.4	0.01	0.29
Southwest	209.6	0.01	1.08
Total	6,297.7	0.30	9.80

case6 Effects of construction phase of CDM in Central region

	Output	CO_2	SO_2
	Million RMB	Mt-c	1000ton
Northeast	117.2	0.01	0.20
North municipalities	74.7	0.01	0.16
North coast	660.1	0.04	1.67
Central coast	618.9	0.03	1.15
South coast	219.8	0.01	0.28
Central region	8,309.5	0.79	27.55
Northwest	249.0	0.03	1.41
Southwest	168.9	0.01	0.95
Total	10,418.0	0.94	33.37

Table 2-15 Effects of contraction phase of CDM project by regions (continued)

case7 Effects of construction phase of CDM in Northwest	Output	CO_2	SO_2
	Million RMB	Mt-c	1000ton
Northeast	200.8	0.02	0.35
North municipalities	134.1	0.01	0.27
North coast	639.4	0.04	1.45
Central coast	490.1	0.03	0.85
South coast	222.3	0.01	0.24
Central region	811.6	0.10	3.19
Northwest	6,706.7	0.40	17.10
Southwest	270.9	0.02	1.49
Total	9,475.7	0.62	24.96

case8 Effects of construction phase of CDM in Southwest	Output	CO_2	SO_2
	Million RMB	Mt-c	1000ton
Northeast	81.0	0.01	0.13
North municipalities	49.3	0.00	0.10
North coast	363.6	0.02	0.85
Central coast	405.5	0.02	0.70
South coast	319.6	0.02	0.42
Central region	575.9	0.07	2.18
Northwest	166.8	0.02	0.81
Southwest	7,793.4	0.31	21.95
Total	9,755.1	0.46	27.15

Table 2-16 Own shares of output inducement by CDM investment

Region name	Own share of output inducement	Region name	Own share of output inducement
Northeast	82.1%	South coast	75.7%
North municipalities	79.3%	Central region	79.8%
North coast	83.0%	Northwest	70.8%
Central coast	76.9%	Southwest	79.9%

Table 2-17 Total effects of construction phase of CDM

	Unit	Northeast	North municipalities	North coast	Central coast	South coast	Central region	Northwest	Southwest
Output	Million RMB	10,140.1	6,364.8	10,264.8	9,368.2	6,297.7	10,418.0	9,475.7	9,755.1
CO_2	Mt-c	0.63	0.47	0.50	0.47	0.30	0.94	0.62	0.46
$S0_2$	1000ton	14.6	13.2	18.9	16.5	9.8	33.4	25.0	27.1

Table 2-18 Total effects of operating phase of CDM

	Unit	Northeast	North municipalities	North coast	Central coast	South coast	Central region	Northwest	Southwest
Output	Million RMB	-22,969.5	-20,344.2	-24,728.1	-42,953.1	-48,587.6	-32,600.2	-12,433.0	-15,956.3
CO_2	Mt-c	-2.7	-3.0	-2.1	-3.9	-4.8	-4.9	-1.3	-1.6
$S0_2$	1000ton	-69.3	-96.3	-89.0	-158.1	-177.5	-181.1	-59.3	-122.2

Table 2-19 Net Effects of CDM

	Unit	Northeast	North municipalities	North coast	Central coast	South coast	Central region	Northwest	Southwest
Output	Million RMB	-12,829.4	-13,979.4	-14,463.3	-33,584.9	-42,289.9	-22,182.2	-2,957.3	-6,201.2
CO_2	Mt-c	-2.1	-2.6	-1.6	-3.5	-4.5	-3.9	-0.7	-1.1
$S0_2$	1000ton	-54.7	-83.2	-70.0	-141.6	-167.7	-147.7	-34.3	-95.1
The share of total CO_2 emission in 2000		0.22%	0.27%	0.17%	0.36%	0.47%	0.41%	0.08%	0.12%
The share of total SO_2 emission in 2000		0.16%	0.25%	0.21%	0.42%	0.50%	0.44%	0.10%	0.28%

Table 2-20 Direct and indirect effects of CO_2 mitigation by CDM

(Unit: Mt-c)

	Northeast	North municipalities	North coast	Central coast	South coast	Central region	Northwest	Southwest
Direct effects	-0.72	-0.79	-0.33	-0.79	-1.08	-0.94	-0.37	-0.42
Indirect effects(Operating effects)	-2.00	-2.24	-1.80	-3.13	-3.75	-3.94	-0.98	-1.19
Indirect effects(Net effects)	-1.37	-1.77	-1.30	-2.67	-3.45	-3.00	-0.36	-0.73

Table 2-21 Results of analysis

Indicators	Rank of regions
Value added division of labor	H>F>C>A>G>D>B>E
Spillover in manufacturing sector	G>E>B>H>F>C>A>D
Total effects of construction of CDM	
Increase amount of output	F>C>A>H>G>D>B>E
Increase amount of CO_2	F>A>G>C>D>B>H>E
Increase amount of SO_2	F>H>G>C>D>A>B>E
Total effects of operating of CDM	
Decrease amount of CO_2	F>E>D>C>B>A>H>G
Decrease amount of SO_2	F>E>D>H>C>B>A>G
Net effects of CDM	
Decrease amount of CO_2	E>F>D>B>A>C>H>G
Decrease amount of SO_2	E>F>D>H>B>C>A>G
Output of per capita	B>D>E>A>C>F>G>H

A	Northeast
B	North municipalities
C	North coast
D	Central coast
E	South coast
F	Central region
G	Northwest
H	Southwest

Table 2-22 Rank of the site location in CDM

Region	Total point	Rank
Northeast	33	8
North municipalities	45	5
North coast	39	6
Central coast	46	4
South coast	65	1
Central region	50	3
Northwest	34	7
Southwest	56	2

Remark: Point total of indices in Table 2-21.
Each region is given a pint of 1 to 8 based on the score in each index.
As to value added, spillover, and output effect, points are give in ascending order, and as to emissions of CO_2 and SO_2, points are given in descending order.