納入環境因素之國家、地區及企業效率與生產力

National, Regional and Business Efficiency and Productivity with Environmental Factors

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中文摘要

經濟發展與環境保護必須要相互配合、與時俱進，以達永續發展的目的。本篇論文將以效率與生產力的觀點，探討在加入環境影響因素後，對於國家、地區、與企業整體性的績效評估。對於國家與地區的整體績效評估，本文採實證研究進行；對於企業的整體績效，本文則提供一個概念性的架構，以利實際推廣。

在實證研究的部分，本文先以國家為比較基準，使用Malmquist生產力指數，探討東亞十國經濟/環境的整體生產力，為因應京都議定書正式生效對各國可能產生的衝擊，文中環境變數採各國二氧化碳的排放量來進行分析。其後，本文以中國大陸三十一個行政區為例，探討一國中各地區之經濟/環境的整體效率與生產力，環境變數採亞洲褐雲的排放物來進行分析，實證結果發現在考慮環境因素後，經濟迅速發展的東部沿海地區較內陸地區整體績效為高。

最後，本文提供一個概念性的架構，以效率的觀點，將環境因素納入企業整體績效評估架構之中，透過這個新架構，企業、投資人、與社會大眾可以容易地瞭解企業的運作，並對企業本身營運的能力、財務健全性與對環境的友善程度做一個整體的評價，各種不同性質的團體亦可經由這個一貫的架構，互相溝通並研擬決策。

關鍵詞：效率、生產力、二氧化碳、亞洲褐雲、績效評估架構、績效評估指標

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Abstract

Economics and ecology should be mutually reinforcing to attain sustainable development in modern society. From the perspective of efficiency and productivity, this dissertation studies the performances for multiple organization levels from nation, region, to business taking environmental factors into consideration. Both empirical studies and a conceptual framework for evaluating integrated development for multiple levels of the above entities are presented.

Firstly, this dissertation starts investigating the economic-environmental performance from a nation's level. Productivity growth of ten Asian countries are analyzed by examining their outputs from economic performance and environmental impact standpoint. Taking CO_2 emissions into analysis, productivity growth of these nations are calculated using the Malmquist index.

Secondly, this study focuses on a region's level. This part analyzes the regional development of China by examining economic performance as well as environmental emissions which cause Asian Brown Clouds. Technical efficiency and productivity changes of thirty-one regions in China are computed. The fast-developing east (coastal) regions experience higher technical efficiency and productivity growth than the inland central and west regions economically and environmentally.

Finally, a new conceptual framework for evaluating corporate integrated development through the perspective of efficiency is introduced. Under the proposed framework, businesses, investors, and society can conveniently understand and evaluate corporate holistic performance including its operational competence, financial health, and environmental friendliness. Decisions of different levels and groups can be made with programmed consideration on this proposed analytical ground.

Keywords: Efficiency, Productivity, CO_2 Emissions, Asian Brown Clouds, Conceptual Framework, Performance Indicators

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Chapter 1 Introduction

1.1 Research Background

Environmental ethics is generally defined as the ethical relationship between human beings and the environment in which we live. There are numerous ethical decisions that human beings make with respect to the environment. For example: From a nation's level, should our country sign the Kyoto Protocol to make efforts on CO_2 reduction? From a region's level, should we allow continuing to clear cut the forests for the sake of region's GDP growth? From a business level, should our company make gasoline powered vehicles to deplete fossil fuel resources, and ignore the new-tech vehicles which can create less emission? Environmental ethics is a new field of moral philosophy, primarily because of the recent emergence of awareness (domestically and internationally) and inter-field research regarding humanity's impacts upon nature and the future.

Economics and ecology should be mutually reinforcing to attain sustainable development in modern society. With the increasing awareness of environmental problems and the demand placed by industrial activities on environmental quality, the control of pollution has become more important for nations, regions, as well as individual companies than ever. Increasingly protective environmental legislation and international agreements with an emphasis on conservation and sustainability of our resources are being introduced in most parts of the world. With this trend of global consciousness and behavior to achieve a cleaner earth, the pressure on each level of organization to improve their ways creating wealth is tightened accordingly. As a result, as a member of global village, we must rethink to change our ways of living completely if the global economy is to become sustainable.

1.2 Research Objective

The object of this thesis is to study the performances for multiple organization levels from nation, region, to business taking environmental factors into consideration, with efficiency perspective. In the following article, both empirical studies as well as a conceptual framework for evaluating integrated development for a nation, a region and a company are presented. A perspective of efficiency looking at an entity's work value created in terms of input-output is introduced and applied.

This dissertation starts by the basic concept of estimation methodology used for the following empirical studies in chapter three and four. Data envelopment analysis (DEA) approach and Malmquist productivity index will be introduced to measure technical efficiency and productivity changes for each decision making unit, say for example a country or a region. Alternatives to cope with undesirable outputs are also listed.

The third part of this dissertation investigating the economic-environmental performance from a nation's level. In the first part of this dissertation, productivity growth of ten Asian countries, namely, China, Japan, the NIEs, and the ASEAN-4, are analyzed by examining their outputs from economic performance and environmental impact standpoint. Productivity growth and its components are calculated using the Malmquist index without/with CO_2 emissions. Considering CO_2 emissions, a cross-country comparison analysis is also made accordingly.

The forth part of this dissertation is from a region's level. Taking China for example, this country has seen the fruit of its rapid economic growth over the past two decades, but severe environmental problems have accompanied this, such as the looming danger of Asian Brown Clouds. This part analyzes the regional development of China by examining economic performance as well as environmental emissions. Technical efficiency and productivity changes of thirty-one regions in China during the period 1997-2001 are computed. This part also tests if the fast-developing east (coastal) regions experience higher technical efficiency and productivity growth than the inland central and west regions when both economic growth and environmental factors are concerned.

Ultimately, the economic growth of a nation and its regions are powered from its private sector, say the business operating within. Environmental destructions thus occur with these economic activities to influence our living habitat. In the forth part, a new conceptual framework for evaluating corporate integrated development through the perspective of efficiency is introduced. Under the proposed framework, businesses, investors, and society can conveniently understand and evaluate corporate holistic performance including its operational competence, financial health, and environmental friendliness. Therefore, decisions of different levels and groups can be made with programmed consideration on this pure analytical ground.

1.3 Organization of the Dissertation

This dissertation is organized in the following manner as Figure 1.1 shows: Chapter 1 presents the motives and objectives of the study. Chapter 2 gives a brief introduction of estimation methodology. Chapter 3 is an empirical analysis taking ten Asian economies as example to investigate the relationship of economic performance and environmental impact. Chapter 4 narrows our scope to the regional performance to a specific country, China. Chapter 5 provides fresh insight on introducing a new framework for the evaluation of corporate integrated development and illustrating its application. Chapter 6 concludes this dissertation.

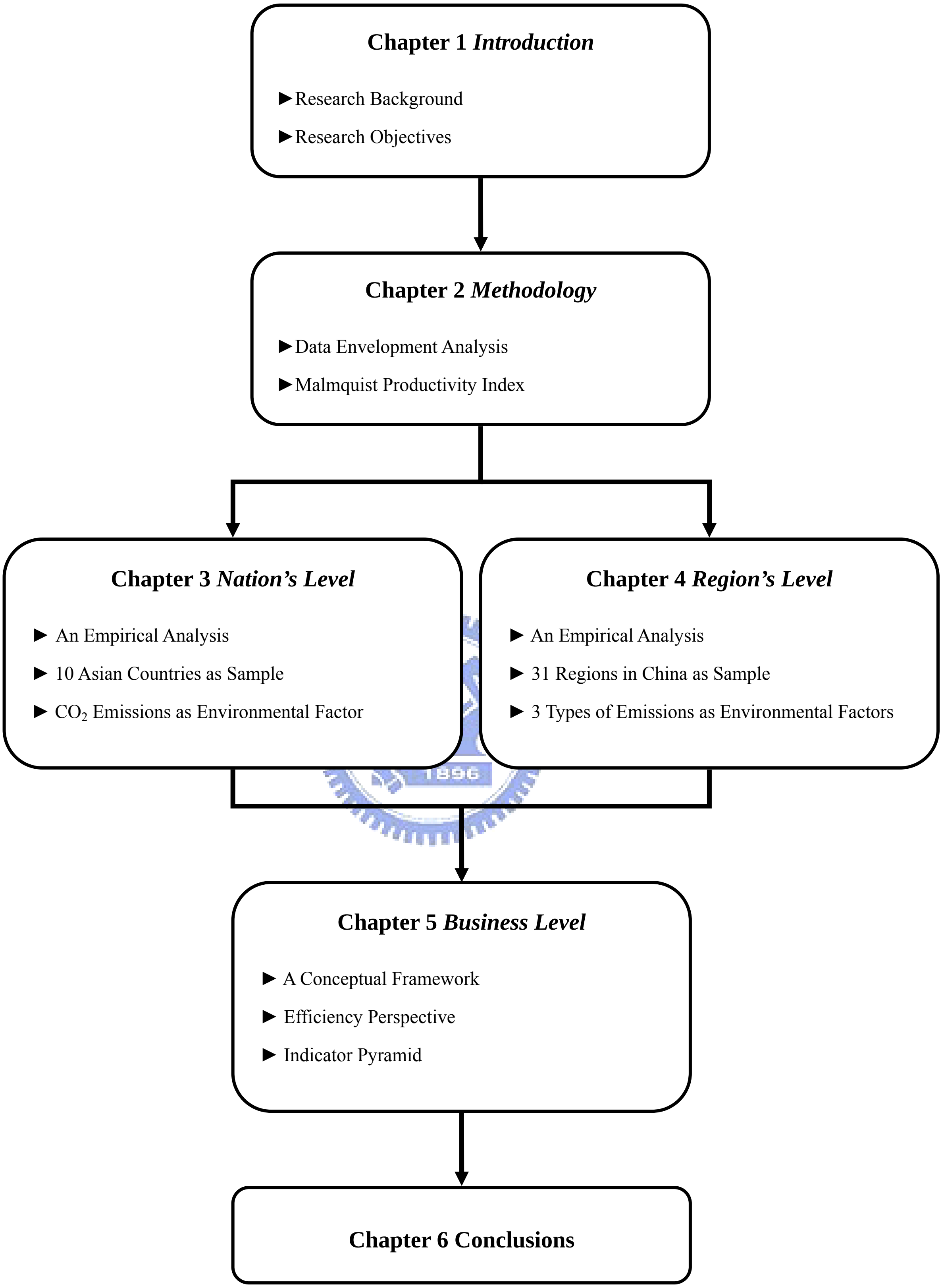


Figure 1.1 Research Flow Chart

Chapter 2 Methodology

In this chapter the data envelopment analysis (DEA) approach and Malmquist productivity index will be introduced to measure technical efficiency and productivity changes of decision making unit for the following empirical analysis.

2.1 Data Envelopment Analysis (DEA) Approach

DEA is known as a mathematical programming method for assessing the comparative efficiencies of a DMU[1] (in this case, a region is counted as a DMU). DEA is a non-parametric method that allows for efficient measurement, without specifying either the production functional form or weights on different inputs and outputs. This methodology defines a non-parametric best practice frontier that can be used as a reference for efficiency measures. Comprehensive reviews of the development of efficiency measurement can be found in Lovell (1993). Assume that there are M inputs and N outputs for each of the K DMUs. For the pth DMU, its multiple inputs and outputs are presented by the column vectors x_i and y_j, respectively. The technical efficiency score (η_p) of DMU p can be found by solving the following linear programming problem:

$$\max \quad \eta_p \qquad (1)$$

$$\text{s.t.} \quad x_{ip} - \sum_{r=1}^{K} x_{ir}\lambda_r \geq 0 \qquad \text{for } i = 1,2, \ldots, M,$$

$$-y_{jp}\eta_p + \sum_{r=1}^{K} y_{jr}\lambda_r \geq 0 \qquad \text{for } j = 1,2, \ldots, N,$$

$$\lambda_r \geq 0 \quad \text{for } r = 1,2, \ldots, p, \ldots, K,$$

[1] DMU is the abbreviation for a 'decision-making unit.'

where η_p is the efficiency score; x_i is the ith input; y_j is the jth output of the production; and λ_r is the weight of each observation. The above procedure constructs a piecewise linear approximation to the frontier by minimizing the quantities of the M inputs required to meet the output levels of the DMU p. The weight λ_r serves to form a convex combination of observed inputs and outputs. The efficiency score η_p measures the maximal radial expansion of the outputs given the level of inputs. It is an output-orientated measurement of efficiency.

Procedure (1) is also known as the CCR model, named after its authors, Charnes, Cooper, and Rhodes (1978), and it assumes that all production units are operating at their optimal scale of production. Banker, Charnes, and Cooper (1984) suggest an extension of the CRS model to account for variable returns to scale (VRS) situations. This model is called the BCC model, named after its authors. It can be obtained by adding one more constraint $\sum_{r=1}^{K} \lambda_r = 1$ on process (1). This constraint essentially ensures that an inefficient DMU is only 'benchmarked' against DMUs of similar size. Under the assumption of constant returns to scale (CRS), the results from these two approaches are identical, whereas under variable returns to scale (VRS), the results could be different.

2.2 Malmquist Productivity Index

Productivity changes can be measured by the Malmquist productivity index, which takes panel data into account. This index was introduced by Caves et al. (1982) who name it the Malmquist productivity index. Sten Malmquist is the first person to construct quantity indices as ratios of distance functions. This method is applied by Färe et al. (1994) to analyze productivity growth of OECD countries, by considering labor and capital as inputs and GDP as an output. Chang and Luh (2000) adopt the same method to analyze productivity growth of ten Asian economies. There may be several reasons for the popularity of the Malmquist productivity index. First, the index does not require information on cost or revenue shares to aggregate inputs and outputs, which means it is less data demanding. Second, compared with other productivity indices, the Malmquist index has the advantage of computational ease. And finally, further decomposition of total productivity can be achieved. The Malmquist index could generate output, such as efficiency change and technical change, which could assist in explaining the differences of growth pattern for different countries.

The efficiency measured from the above procedure is static in nature, as the performance of a production unit is evaluated in reference to the best practice in a given year. The shift of the frontier over time cannot be obtained from DEA. To account for dynamic shifts in the frontier, we use the Malmquist productivity index (MALM) developed by Färe et al. (1994). This method is also capable of decomposing the productivity change into efficiency and technical changes, which are components of productivity change.

For each time period $t = 1,\ldots, T$, the Malmquist index is based on a distance function, which takes the form

$$D^t(X^t, Y^t) = \min\{\ \delta : (X^t, Y^t/\delta) \in S^t\ \}, \tag{2}$$

where δ determines the maximal feasible proportional expansion of output vector Y^t for a given input vector X^t under production technology S^t at time period t. If and only if the input output combination (X^t, Y^t) belongs to the technology set S^t, the distance function has a value less than or equal to one; that is, $D^t(X^t, Y^t) \leq 1$. If $D^t(X^t, Y^t) = 1$, then the production is on the boundary of technology and the production is technically efficient.

Caves et al. (1982) originally define the Malmquist index of productivity change between time period s (base year) and time period t (final year), relative to the technology level at time period s:

$$M^{s}=\frac{D^{s}(X^{t},Y^{t})}{D^{s}(X^{s},Y^{s})}. \tag{3}$$

It provides a measurement of productivity change by comparing data (combination of input and output) of time period t with data of time period s using technology at time s as a reference. Similarly, the Malmquist index of productivity change relative to technology at time t can be defined as

$$M^{t}=\frac{D^{t}(X^{t},Y^{t})}{D^{t}(X^{s},Y^{s})}. \tag{4}$$

Allowing for technical inefficiency, Färe et al. (1994) extend the above models and propose an output-oriented Malmquist index of productivity change from time period s to period t as a geometric mean of the two Malmquist productivity indices of (3) and (4). A CRS technology is assumed to measure the productivity change, and the MALM is expressed as

$$\mathrm{MALM}=\left[\frac{D^{s}_{\mathrm{CRS}}(X^{t},Y^{t})}{D^{s}_{\mathrm{CRS}}(X^{s},Y^{s})}\frac{D^{t}_{\mathrm{CRS}}(X^{t},Y^{t})}{D^{t}_{\mathrm{CRS}}(X^{s},Y^{s})}\right]^{\frac{1}{2}}. \tag{5}$$

Note that if $X^{s}=X^{t}$ and $Y^{s}=Y^{t}$ (for example, there has been no change in inputs and outputs between the periods), then the productivity index signals no change when revealing $\mathrm{MALM}(\cdot)=1$. Equation (5) of productivity change can be rearranged by decomposing into two components, the efficiency change (EFFCH) and the technical change (TECHCH), which take the following forms:

$$\text{Efficiency change (EFFCH)} = \frac{D^t_{\text{CRS}}(X^t, Y^t)}{D^s_{\text{CRS}}(X^s, Y^s)}. \quad (6)$$

$$\text{Technical change (TECHCH)} = \left[\frac{D^s_{\text{CRS}}(X^t, Y^t)}{D^t_{\text{CRS}}(X^t, Y^t)} \frac{D^s_{\text{CRS}}(X^s, Y^s)}{D^t_{\text{CRS}}(X^s, Y^s)} \right]^{\frac{1}{2}}. \quad (7)$$

The term EFFCH measures the changes in relative position of a production unit to the production frontier between time period *s* and *t* under CRS technology. Term TECHCH measures the shift in the frontier observed from the production unit's input mix over the period.[2] How much closer a region gets to the 'regions' frontier' is called 'catching up', and is measured by EFFCH. How much the 'regions' frontier' shifts at each region's observed input mix is called 'innovation', shown by TECHCH. Improvements in productivity yield Malmquist indices and any components in the Malmquist index greater than unity. On the other hand, deterioration in performance over time is associated with a Malmquist index and any other components less than unity.

2.3 Coping with Undesirable Outputs

The growth of a nation's (or a region's) output depends on capital formation as well as efficiency and productivity improvement. Labor and capital are two major inputs in production. When measuring a nation's (or a region's) overall output, gross domestic product (GDP) is commonly used. For a nation/region, while GDP (income) is desirable, emissions (pollutions) are undesirable. The change of income and pollutions are two-way relations: First, the increasing of income deteriorates the environmental condition directly because pollutions are generally byproducts of a production process and are costly to dispose. In reverse, the growth of income is accompanied by public increasing demand for better

[2] In summary, the MALM is in the form: $\text{MALM} = \text{EFFCH} \times \text{TECHCH}$.

environmental quality through driving forces such as the control measures, technological progress and the structural change of consumption. Desirable GDP and undesirable pollutions should be both taken into account in order to correct a nation's output. This concept is called 'green GDP.' Green GDP is derived from the GDP through a deduction of negative environmental and social impacts.

Data envelopment analysis (DEA) measures the relative efficiency of decision making units (DMUs) with multiple performance factors which are grouped into outputs and inputs. Once the efficient frontier is determined, inefficient DMUs can improve their performance to reach the efficient frontier by either increasing their current output levels or decreasing their current input levels. In conducting efficiency analysis, it is often assumed that all outputs are 'good.' However, such an assumption is not always justified, because outputs may be 'bad.' For example, if inefficiency exists in production processes where final products are manufactured with a production of wastes and pollutants, the outputs of wastes and pollutants are undesirable (bad) and should be reduced to improve the performance.

There are various alternatives for dealing with undesirable outputs in the DEA framework. The first is simply to ignore the undesirable outputs. The second is either to treat the undesirable outputs in terms of non-linear DEA model or to treat the undesirable ones as outputs and adjust the distance measurement in order to restrict the expansion of the undesirable outputs (Färe et al., 1989). The third is either to treat the undesirable output as inputs or to apply a monotone decreasing transformation (e.g. $1/y^b$, y^b represents the undesirable output proposed by Lovell et al., 1995).

In this study, we treat pollutions as negative externalities which directly reduce output and productivity of capital and labor (López, 1994; Smulders, 1999; de Bruyn, 2000). In other words, the emission proxies used in our analysis are acted as by-product outputs or cost of loss, e.g. the health problem caused, the corrosion of industrial equipment due to polluted air, and other related social expenses. In the following analytical process, we will cope those undesirable outputs by two alternatives: taking their reciprocals (applied in chapter 3) as well as taking them as input (applied in chapter 4). In other words, CO_2 emissions are taken their reciprocals to measure a country's productivity change. Soot, dust, and sulfur dioxide, the main components of Asian Brown Clouds, are considered as input terms to evaluate macroeconomic performance in terms of the regions in China with BCC and Malmquist models.

Chapter 3 The Asian Growth Experience

3.1 The Economic Growth and CO_2 Emissions in Asia

A country's macroeconomic policies generally have two objectives: creation of wealth and good living condition for its citizens. Gross domestic product (GDP) is commonly used in assessing a country's wealth. However, it does not constitute a measure of welfare say for example without dealing with environmental issues adequately. There is necessity to calculate environmental degradation as a correction factor into our regular definition of economic growth (van Dieren, 1995). For the last three decades, Asia has emerged as one of the most important economic regions of the world. Since 1960, the economy of China, Hong Kong, Indonesia, South Korea, Malaysia, Singapore, Taiwan and Thailand together have grown more than twice as fast as the rest of Asia (Angel and Cylke, 2002). As Asia's economic activities began to shift toward industry and manufacturing, there has been a dramatic increase in pollution in the region (World Bank, 1998). For instance, fast-developing Asia is now one of the major contributors to the global increase in carbon emissions (Hoffert et al., 1998; Siddiqi, 2000). In fact, the highest percentage rises came from the Asia-Pacific region, including India, China and the newly industrializing 'tiger' economies (Masood, 1997). Because emissions of carbon dioxide are generally acknowledged as a cause of 'global warming,' the United Nation has been trying to negotiate a global agreement to tackle carbon dioxide emissions. The Kyoto protocol in 1997 was an international milestone of this effort.

The conflict between economic priorities and environmental interests, for a long time, is at the national level since 1960s. However, as Mol (2003) states, there is an increasing clash of economic and environmental institutions, regimes and arrangements at international level in recent decades. Studies for economic versus environmental issues is now in a transnational arena. For OECD members, the objective to pursue a balance between pro-development and pro-environment has received considerable attention. Lovell et al. (1995) study the macroeconomic performance of 19 OECD countries by extended data envelopment analysis (DEA) approach, namely Global Efficiency Measure (GEM) for single period analysis. Japan is the only Asian country included in their sample. The study takes four services, real GDP per capita, a low rate of inflation, a low rate of unemployment, and a favorable trade balance as four outputs. When two environmental disamenities (carbon and nitrogen emissions) are included into the service list, the rankings change, while the relative scores of the European countries decline. According to the experience of the OECD countries, environmental indicators do seem to have crucial effects on a nation's relative performance.

The aim of this chapter is to measure the macroeconomic performance of Asian countries by moderating unwanted externalities of economic growth using panel data over the period 1987-1996. In this study, performance is defined in light of a country's ability to provide its citizens with both wealth and less polluted environments. We examine the overall performance of ten Asian economies including China, Japan, the East Asian Newly Industrialized Economies (the NIEs, including Hong Kong, Korea, Singapore, and Taiwan), and four countries of the Association of South East Asian Nations (the ASEAN-4, including Indonesia, Malaysia, Philippines and Thailand) by comparing their productivity change. Based on the economic theory of production, productivity is generally defined in terms of the efficiency with which inputs (such as capital and labor) are transformed into outputs (such as gross domestic product, GDP) in the production process. The environmental disamenities are added and the analysis is repeated to see if the performance rankings change. The CO_2 emissions are included as proxy of environmental impact.

3.2 Data of Asian Countries

The ten selected Asian countries are all APEC members, thus, we establish a data set of 19 Pacific Rim countries: Australia, Canada, Chile, China, Columbia, Hong Kong, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, the Philippines, Singapore, Taiwan, Thailand, and the United States during the period form 1987 to 1996. We then construct a world frontier based on the data from our country sample. Each country is compared to that frontier. In the analysis without environmental impacts, there are two inputs and one output. We take capital formation and labor force as two inputs and GDP per capita as the only output for a specific country. The data of our multiple comparisons are from Penn World Table Version 6.1 provided by Center for International Comparisons at the University of Pennsylvania (CICUP, 2002). Although capital formation and labor force are not directly available from the data set, simple calculation can be applied. The capital formation is retrieved from the product of real GDP per capita and investment share of real GDP per capita, while the labor force is calculated by dividing real GDP per capita with real GDP per worker. In addition to those two inputs and one output, Table 3.1 transformed CO_2 emissions are added into the model. The data of per capita CO_2 emissions (metric tons of carbon) is from Carbon Dioxide Information Analysis Center (Marland et al., 2003). The data after 1996 are not included due to the lack of data for certain countries.

Macroeconomic performance is evaluated in terms of the ability of a country to maximize the desirable output GDP while minimizing the CO_2 emissions. The value of monetary inputs and outputs such as GDP per capita and capital formation are in 1996 international prices. Summary statistics of these inputs and outputs are shown in Table 3.1. The software Deap 2.1 (Coelli, 1996) is applied to solve the linear programming problems.

Table 3.1 Summary Statistics of Inputs and Outputs

Country		Output data		Input data	
		GDP	CO_2	Capital	Labor
East Asian economies					
China	Mean	2014.40	0.63	423.77	0.6022
	Std. dev.	603.46	0.07	155.19	0.0047
Japan	Mean	20248.31	2.35	6802.04	0.6325
	Std. dev.	2920.71	0.16	901.47	0.0017
NIEs					
Hong Kong	Mean	20858.23	1.36	5299.07	0.5834
	Std. dev.	3995.09	0.12	1537.09	0.0661
Korea	Mean	10300.18	1.77	4033.09	0.4154
	Std. dev.	2634.26	0.41	1254.83	0.0020
Singapore	Mean	17454.96	3.73	7446.65	0.5241
	Std. dev.	4731.45	0.57	1969.56	0.0443
Taiwan	Mean	11246.89	1.86	2287.07	0.4369
	Std. dev.	2726.79	0.34	699.03	0.0019
ASEAN-4					
Indonesia	Mean	2811.29	0.26	554.93	0.3915
	Std. dev.	670.49	0.06	185.22	0.0025
Malaysia	Mean	6357.23	1.07	1803.68	0.3727
	Std. dev.	1669.54	0.34	804.68	0.0281
Philippines	Mean	2663.87	0.21	402.95	0.3823
	Std. dev.	263.94	0.03	69.87	0.0149
Thailand	Mean	4908.42	0.58	1931.65	0.5286
	Std. dev.	1420.45	0.21	714.98	0.0026
Other APEC economies					
Industrialized					
Australia	Mean	18754.64	4.27	4434.83	0.4825
	Std. dev.	2468.40	0.22	598.39	0.0080
Canada	Mean	20082.99	4.13	5034.40	0.5042
	Std. dev.	1804.36	0.10	366.15	0.0045
New Zealand	Mean	14790.74	2.01	3116.88	0.4596
	Std. dev.	1710.69	0.08	609.79	0.0104
USA	Mean	24241.51	5.30	4942.76	0.4975
	Std. dev.	3166.75	0.12	737.36	0.0072
Developing					
Chile	Mean	6388.21	0.72	1283.88	0.3737
	Std. dev.	1640.98	0.13	516.38	0.0107
Columbia	Mean	4541.05	0.46	574.91	0.3895
	Std. dev.	639.61	0.03	181.77	0.0618
Mexico	Mean	6683.87	1.04	1194.36	0.3410
	Std. dev.	690.97	0.08	257.46	0.0027
Papua N. Guinea	Mean	3093.02	0.17	314.04	0.4728
	Std. dev.	621.56	0.01	61.01	0.0016
Peru	Mean	3718.03	0.29	676.00	0.3700
	Std. dev.	468.83	0.03	169.66	0.0521

3.3 Results of Productivity Change

Using the method in section 2.1, the average cumulative changes of ten Asian economies' productivity without/with CO_2 emissions are shown in Figure 3.1, with the year 1987 as the reference year. The overall productivity growth without/with emissions are rising. The trends go up steadily from 1990 to the end of the sample period. The productivity growth with CO_2 emissions is below that without CO_2 emissions every year except in 1989. It is to be noted that the gap between these two trends seems to be widening each year. In 1996, the difference almost mounts to six percent. This phenomenon is a contrast with the productivity patterns of the industrialized APEC countries in our sample. Figure 3.2 shows the average cumulative productivity without/with CO_2 emissions changes of Australia, Canada, New Zealand and the USA. The two lines of industrialized APEC countries are almost identical, indicating a relatively stable performance without/with including environmental factors comparing with the East Asian experience. Therefore, the productivity of fast developing Asian economies is not as high as reported after considering other non-economic variables. This result is consistent with the estimation that the rapid growth of Asian economies might take a toll on the environment.

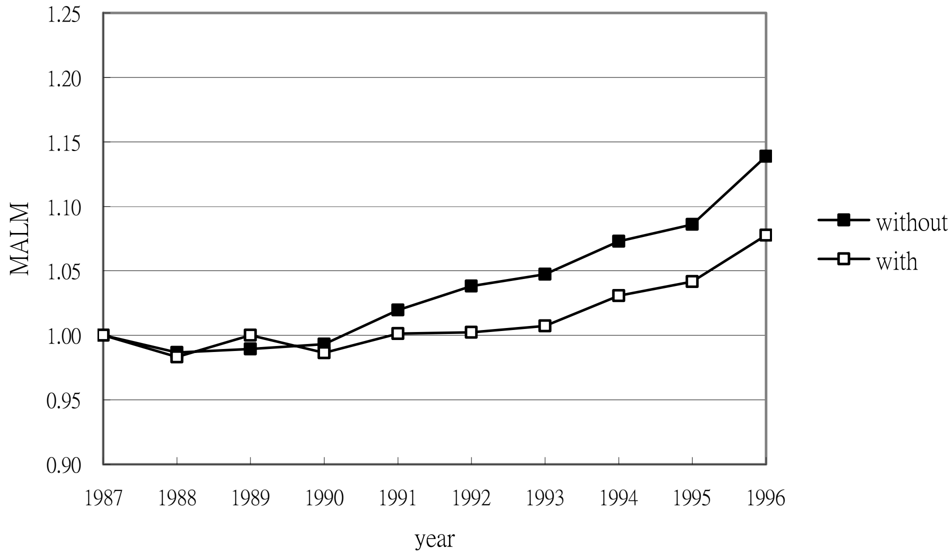


Figure 3.1 Cumulative Change in the MALM without/with CO_2 Emissions for Ten Asian Countries

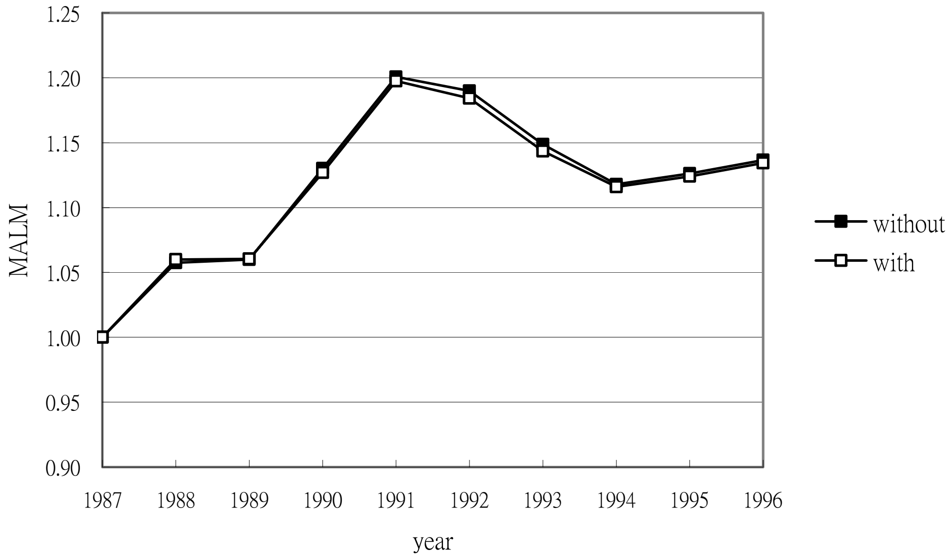


Figure 3.2 Cumulative Change in the MALM without/with CO_2 Emissions for Industrialized APEC Countries

Further comparisons taking into account CO_2 emissions among countries are displayed in Tables 3.2. On the left half side of Table 3.2, the average Malmquist index without CO_2 emissions of the total sample is 1.007, with 7 Asian countries' indices exceeding unity implying that they have positive production growth. Singapore has the highest productivity growth, followed by China, Japan and the NIEs. The productivity growth of ASEAN-4, except Thailand, shows deterioration. We then repeat the computation again by adding transformed CO_2 emissions as environmental proxies. On the right half side of Table 3.2 is the average Malmquist index with CO_2 emissions with total sample mean of 1.004. Not only the average Malmquist index is lower than that without CO_2 emissions, so are efficiency change and technical change indices. Among the East Asian economies, while the Malmquist indices of China, Japan and the NIEs still perform positive, that of all ASEAN-4 countries declines. Singapore is the best performer without or with the environmental factors. Between our experiments without/with CO_2 emissions, it is clear from Table 3.3 that the ranking based on the 10-year average growth performance remain average unchanged, except Indonesia and Thailand, whose ranking regress rather significant compared with other countries' after taking environmental factors into account. Among the ten Asian economies, those countries with per capita GDP exceeding 10,000 US dollars, such as Singapore, Japan and Hong Kong, generally rank higher no matter whether environmental factor is considered or not.

Lovell et al. (1995) shows that the inclusion of two environmental indicators drastically changes the ranking, reflecting that the environment is a decisive variable when assessing a country's relative performance for OECD countries. Whether environmental factors are unimportant to a comparison of Asian economies because of average unchanged productivity ranking deserves further study. The 'Environmental Kuznets Curve' provides a way to explain this phenomenon. The countries with lower per capita GDP are on the increasing stage of per output pollution. On the contrary, countries with higher per capita GDP report a decrease in the per output pollution. It could therefore be stated that better environmental performance has been accompanied with economic achievement for richer countries.

Table 3.2 Decomposition of Malmquist Productivity Index without/with CO_2 Emissions

	Average annual changes without CO_2			Average annual changes with CO_2		
Country	Malmquist index (MALM)	Efficiency change (EFFCH)	Technical change (TECHCH)	Malmquist index (MALM)	Efficiency change (EFFCH)	Technical change (TECHCH)
East Asian economies						
China	1.006	1.020	0.987	1.000	1.020	0.981
Japan	1.037	1.004	1.033	1.043	1.008	1.035
NIEs						
Hong Kong	1.034	1.015	1.019	1.052	1.025	1.026
Korea	1.031	1.005	1.026	1.036	1.011	1.025
Singapore	1.075	1.031	1.042	1.068	1.028	1.039
Taiwan	1.002	1.007	0.995	1.002	1.007	0.995
ASEAN-4						
Indonesia	0.998	1.011	0.987	0.973	0.993	0.979
Malaysia	0.980	0.985	0.995	0.984	0.986	0.998
Philippines	0.980	1.001	0.980	0.949	0.981	0.968
Thailand	1.005	1.007	0.998	0.983	0.987	0.996
Other APEC economies						
Industrialized						
Australia	1.019	1.007	1.012	1.019	1.007	1.012
Canada	1.019	1.006	1.013	1.018	1.005	1.013
New Zealand	0.997	0.997	1.000	0.997	0.997	1.000
USA	1.022	1.000	1.022	1.022	1.000	1.022
Developing						
Chile	0.992	0.996	0.996	0.993	0.994	0.999
Columbia	0.989	1.000	0.989	0.985	1.000	0.985
Mexico	0.991	1.000	0.991	0.992	1.000	0.992
Papua N. Guinea	0.984	1.000	0.984	0.979	1.000	0.979
Peru	0.979	0.995	0.984	0.983	0.981	1.002
Mean	1.007	1.005	1.003	1.004	1.001	1.002

Note: All Malmquist index averages are geometric means.

Table 3.3 Ranking Change of the Malmquist Index without/with CO_2 Emissions

Country	Without CO_2 emissions	With CO_2 emissions	Ranking change
East Asian economies			
China	8	9	-1
Japan	2	3	-1
NIEs			
Hong Kong	3	2	+1
Korea	4	4	0
Singapore	1	1	0
Taiwan	10	8	+2
ASEAN-4			
Indonesia	11	18	-7
Malaysia	17	14	+3
Philippines	18	19	-1
Thailand	9	15	-6
Other APEC economies			
Industrialized			
Australia	6	6	0
Canada	7	7	0
New Zealand	12	10	+2
USA	5	5	0
Developing			
Chile	13	11	+2
Columbia	15	13	+2
Mexico	14	12	+2
Papua N. Guinea	16	17	-1
Peru	19	16	+3

3.4 Results of Cross-Country Comparison

What causes some countries to perform better economically and environmentally than the other countries is an issue to be studied. Without/with considering CO_2 emissions, a cross-country comparison is made for further exploration. The ten Asian economies are studied into groups. The NIEs and the ASEAN-4 are grouped for the countries' geographical and economical proximity. China and Japan are singled out individually. In other words, the following analysis is made based on China, Japan, the NIEs and the ASEAN-4 respectively. The industrialized APEC countries, including Australia, Canada, New Zealand and the USA, are incorporated as a comparison basis to Asian economies.

Figure 3.3 shows the cumulative changes in productivity and its components for China. Without/with CO_2 emissions, the productivity growths (MALM) show similar patterns: increases from 1987 to 1990, decline from 1990 to 1993, and increase again after 1993. However, the changes of the MALM with CO_2 emissions are more undesirable, i.e., the increase is slower and decrease faster than which only considered the GDP after 1990. Considering CO_2 emissions, it was observed that the two components of MALM, EFFCH and TECHCH, fluctuate erratically. While the EFFCH rises from 1987 to 1988, it decreases from 1988 to 1994 then reverses from 1994 to 1996, the TECHCH moves almost to the same extent but in a reverse direction. The TECHCH with CO_2 emissions is always less than that without CO_2 emissions, indicating that technical change may be overestimated when considering only economic aspects. The EFFCH shows little different between the two plots. No matter whether the environment is taken account or not, the result suggests that China experiences either technical regress or efficiency loss, and hence deterioration in productivity during our sample period. In other words, lacking of catching-up and innovation capacities in turns encumbers the productivity growth for China. Furthermore, there exists an overestimation for China's technical change when environmental factors are considered.

As for Japan (see Figure 3.4) the MALM index increases rapidly from 1987 to 1991 and extends steadily from 1991 to 1996 without/with CO_2 emissions. Before 1991, both EFFCH and TECHCH contribute to the growth of productivity. After 1991, the advance in technical change dominates the stability of efficient change leading to positive growth in productivity. It is worth noticing that the cumulative MALM with CO_2 emissions is even higher than that without CO_2 emissions in every year. The difference after considering emissions comes from the better cumulative EFFCH growth indicating Japan's better capacity for allocating its input resources compared with other economies. In other words, Japan performs rather well in catching-up to the frontier due to fewer emissions.

The MALM index of the NIEs (see Figure 3.5) increases by about 40 percent over the years from 1987 to 1996 without/with CO_2 emissions, indicating a rapid productivity growth, especially after 1992. Before 1992, the MALM is dominated by the TECHCH, indicating that the productivity growth is mainly due to improvements in technology. After 1992, the rapid growth of MALM is due to the steady increase of TECHCH and the speedy increase of EFFCH. This implies that the average efficiency of the NIEs countries catches up with the world frontier after 1992. Like Japan, the cumulative MALM with CO_2 emissions is even higher than that without CO_2 emissions in every year after 1990. The difference after considering emissions also comes from the higher cumulative EFFCH growth. In general, after considering environmental factors, the general productivity growth of the NIEs performs even better due to the efficiency progress.

The cumulative changes in productivity and its components for ASEAN-4 are shown in Figure 3.6. Without CO_2 emissions, the productivity of ASEAN-4 countries decreases from 1987 to 1990, and remains rather inactive afterwards. The productivity trend with CO_2 emissions shows a similar tendency but in a less active manner, implying an overestimation of the ASEAN-4's productivity when neglecting the environmental impact. The TECHCH fluctuates less with CO_2 emissions than without, and so does the EFFCH. When taking environment variable into account, the MALM is affected by the deterioration of both EFFCH and TECHCH throughout the sample period, indicating the lack of catching-up as well as innovation affects the growth of productivity.

Incorporating the industrialized APEC countries (see Figure 3.7), without/with taking account CO_2 emissions, the patterns of MALM and its components show almost no difference. It could be concluded that the industrialized APEC countries are relatively more economic-environmental balanced than Asian economies. In summary, Japan and the NIEs perform even better after considering CO_2 emissions because of their higher productivity growth during the time of our sample period. Emissions can be dealt as undesirable outputs that imply inefficiency. From the experience of Japan and the NIEs, the better productivity growth is because of greater EFFCH defined as their ability to well allocate resources with fewer emissions. On the other hand, the productivity of China and the ASEAN-4 are overestimated when only focusing on GDP from our results. Taking environment into consideration, the productivity growth gets worse because of the fluctuating EFFCH or TECHCH in turns in China. As for the ASEAN-4, the productivity deteriorates due to inactive EFFCH and TECHCH. The Environmental Kuznets Curve hypothesis is mirrored in our cross-country comparison for the productivities of those economies with higher GDP per capita. They perform better both economically and environmentally. Furthermore, the conclusions of this section can serve as encouragement to forge a greater link between the economy and environment.

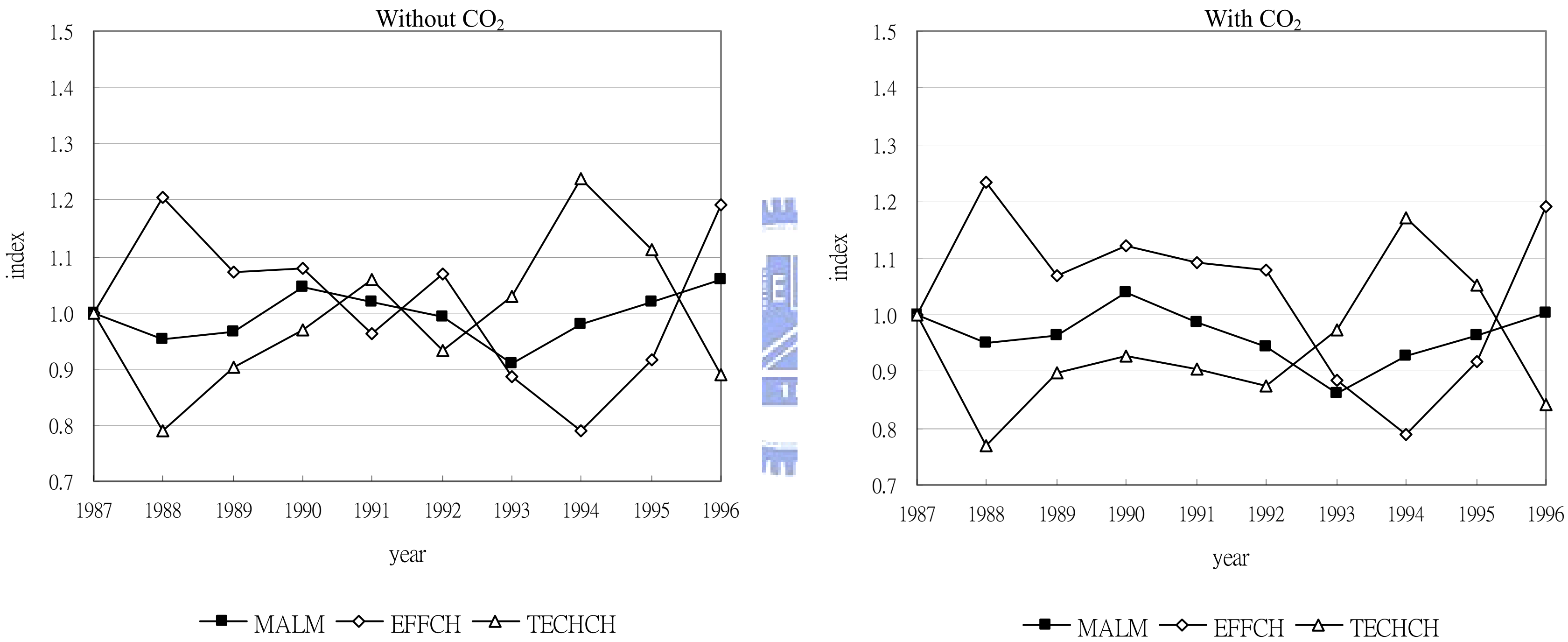


Figure 3.3 Cumulative Change in the MALM and Its Component for China

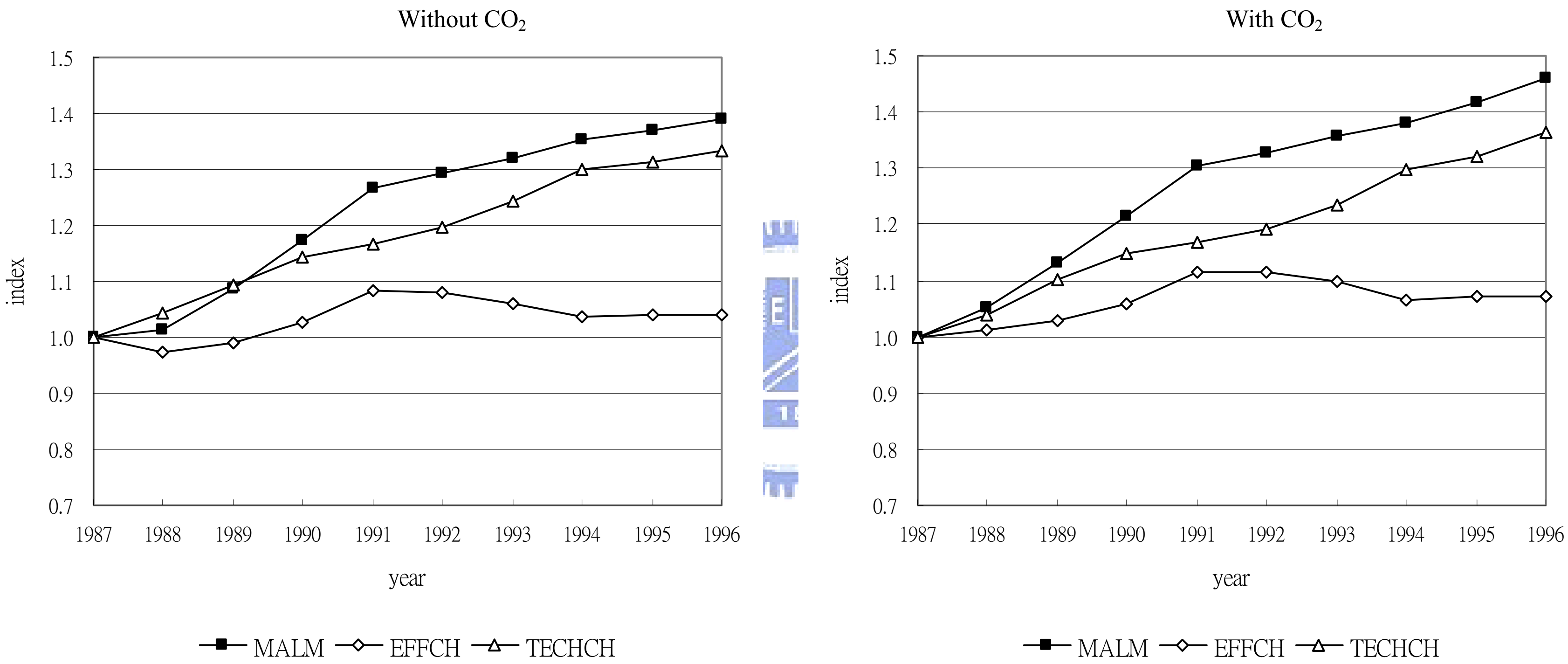


Figure 3.4 Cumulative Change in the MALM and Its Component for Japan

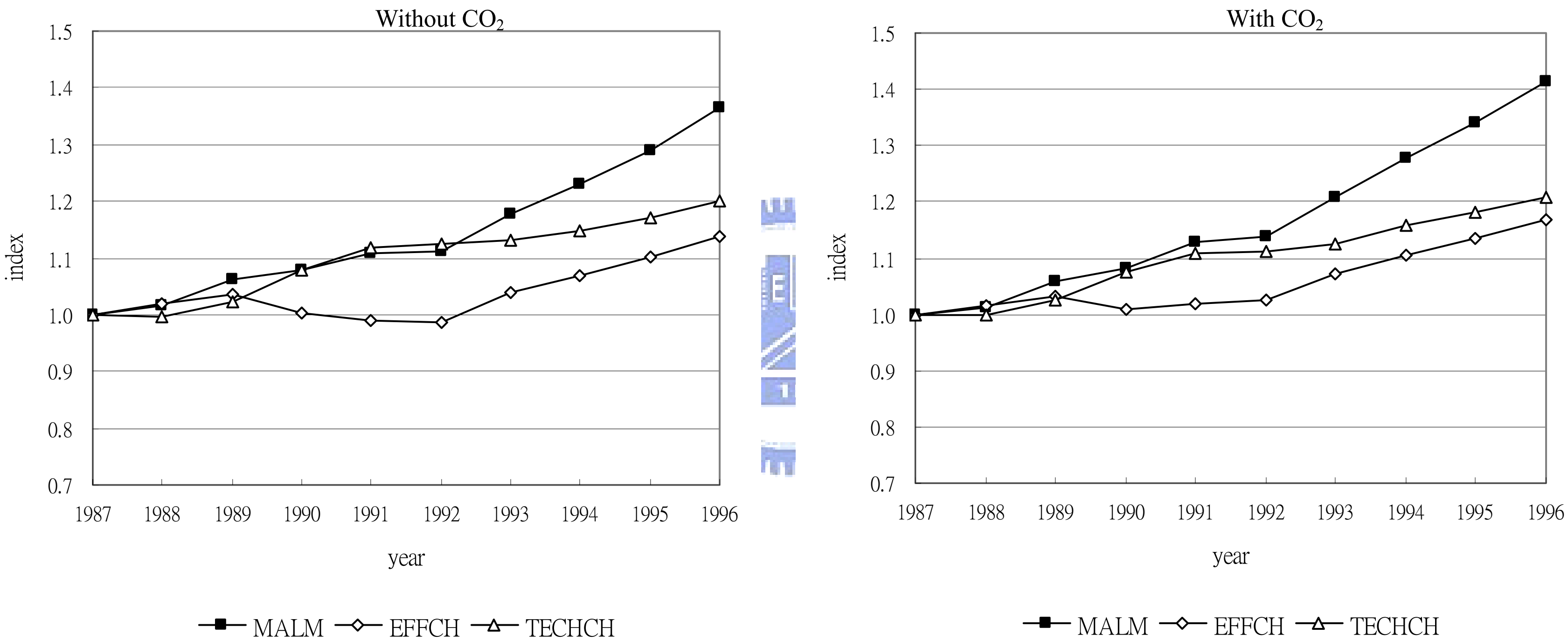


Figure 3.5 Cumulative Change in the MALM and Its Component for NIEs

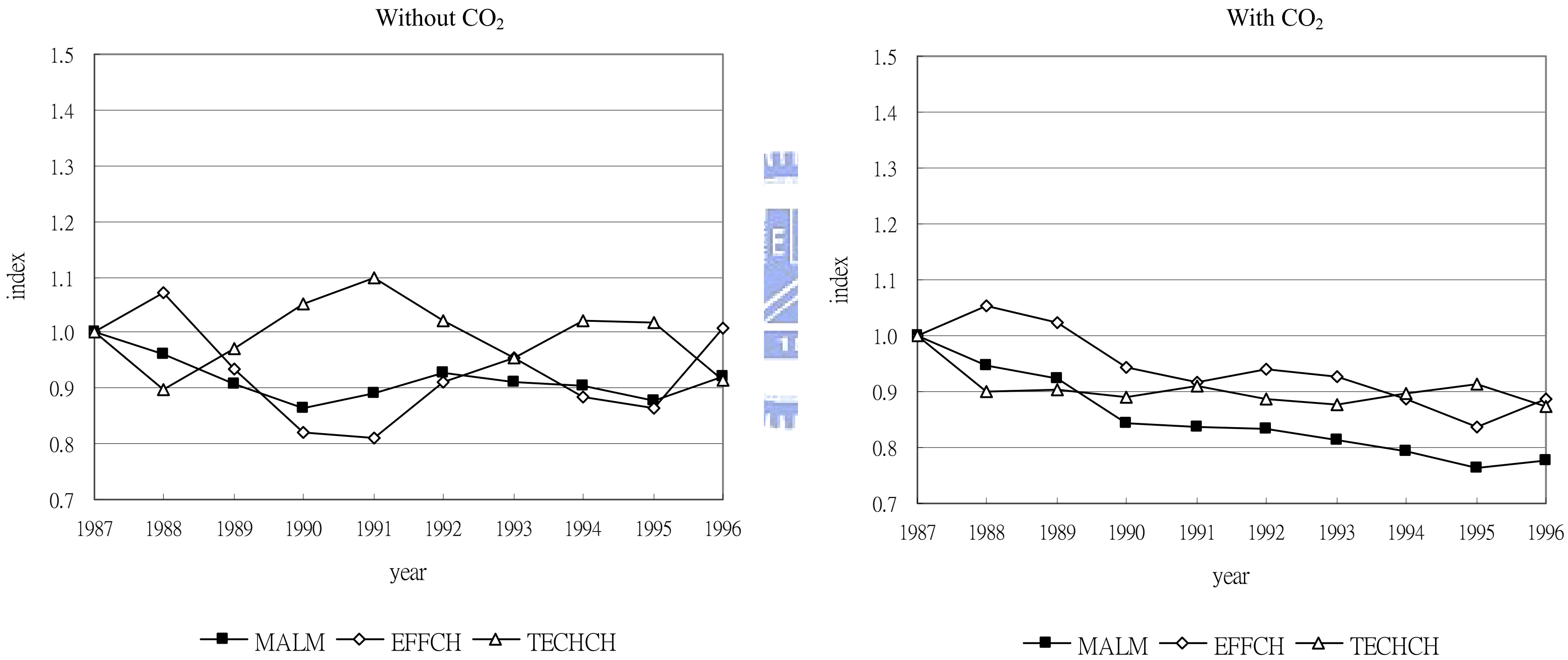


Figure 3.6 Cumulative Change in the MALM and Its Component for ASEAN-4

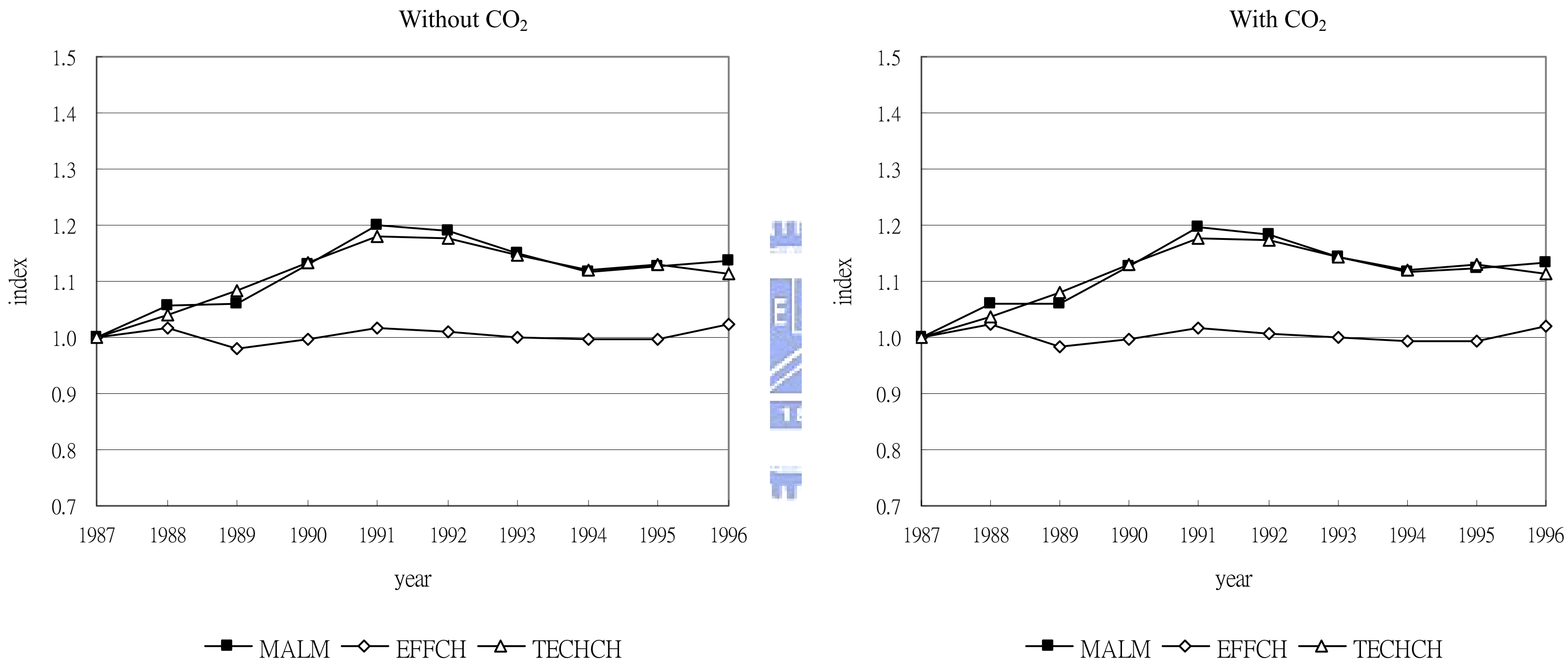


Figure 3.7 Cumulative Change in the MALM and Its Component for Industrialized APEC Countries

3.5 Sub-Conclusions

A country's development performance could be biased when neglecting a number of important respects such as environmental factors. Since late last century, Asia has emerged as one of the most important economic regions of the world. However, there is wide debate over Asia's rapid development and sacrifice of its environment. Incorporating environmental consideration into economic orientation opens up a new way of pursuing sustainable development for Asian economies. In this study, performance is defined in terms of a country's ability to maximize its citizen's wealth as well as to protect the environment through fewer emissions. The macroeconomic performances of ten Asian economies over the period 1987-1996 are studied. Nineteen APEC member economies are included so as to construct a benchmark frontier. The relative productivity change and its decomposition, including efficiency change (which is defined as catching-up) and technical change (which is defined as innovation), of these ten Asian countries are studied. The analysis is repeated again by incorporating CO_2 emissions.

The empirical results could be summarized as follows: (i) Overall, the productivity growth without/with incorporating CO_2 emissions shows similar tendency for ten Asian economies. However, the productivity growth trend with CO_2 emissions is below that without CO_2 emissions. The gap between these two trends widens from 1990 to the end of the sample period. Taking the other industrialized APEC economies as a contrast, a relatively unchanged growth trend is shown after including environmental factors. (ii) Between our analyses without/with CO_2 emissions, the ranking of growth performance remain generally unchanged except in Indonesia and Thailand, who regress rather significant after taking into account environmental factors. (iii) Those Asian countries with higher per capita GDP also tend to rank higher no matter whether the environment is considered or not. (iv) A cross-country comparison is made by scrutinizing the growth pattern varies among countries. Taking CO_2 emissions into account, Japan and the NIEs experience even better growth productivity due to higher efficiency progress. (v) For China, either technical regress or efficiency loss leads to deterioration in productivity. For the ASEAN-4, the productivity decline/stagnation is due to the inactive efficient and technical change. The Environmental Kuznets Curve hypothesis can be verified by lesser emissions having been induced with economic achievement for richer countries. The notion that Asia's rapid growth has been at the expense of its environment needs to be re-analyzed, because from our research this only stands for those economies with lower GDP per capita. In order to promote economic growth and environmental friendliness for Asian countries, especially China and ASEAN-4, the priority should lie in their catching-up capabilities, such as better resource-allocation, and greater innovation related to advanced technologies on the road to sustainable development.

In the long term, growth without environmental protection could lead a country's industry to be less competitive under the rising pressure from environmental protection requirement from the world trading partners. From our results of Asian growth experience, the overall performances of Japan and the NIEs tend to rank higher both economically and environmentally. This implies that these countries have the potential to have a higher standard both on productivity and environmental quality. During our sample period, China and the ASEAN-4 comparably lagged behind on both efficiency and technical change aspects, implicating that the objective of maximizing wealth while protecting environment needs more efforts and research.

Chapter 4 The Unbalanced Regional Productivities in China

4.1 Asian Brown Clouds

A three-kilometer thick cloud of toxic pollution looming over Asia, known as 'Asian Brown Clouds', caught global concern at the 2002 World Summit on Sustainable Development in South Africa. This thick layer of haze that hangs over a wide expanse of territory covering south to east Asia (South Asia, India, Pakistan, Southeast Asia, and China) is a direct result of damaging development trends (CNN News, 2002), for which the whole world now has to work together so as to help reverse it. Asian Brown Clouds are made of soot, ash, dust, and airborne chemicals, which are all products of man-made pollutions. This toxic haze could kill hundreds of thousands of people prematurely and cause deadly flooding and drought. Scientists warn the impact could be global since winds can push pollutants halfway around the world, including to Europe and even the Americas in a week, according to *Concept Paper on Asian Brown Clouds* (2001). Therefore, Asian Brown Clouds are not only an important subject for China and its people, but also for all the people of the world.

Ever since China adopted the policy of economic reform and opened up to the outside world in the late 1970s, it has experienced double-digit growth. Although China has experienced rapid economic growth for more than a decade, its environment is rapidly deteriorating. Soot, dust, and sulfur dioxide, the main components of Asian Brown Clouds, are the major pollutants being emitted. Only recently has the Chinese government taken action to cope with these environmental problems, especially on air and water pollution (World Bank, 2001). Although the dust emission has declined, sulfur dioxide and soot emissions have been climbing in recent years (Liu, 2001), and these problems can be attributed to old-fashioned and inefficient technology, as well as highly polluting engines and fuels (Ramanathan and Crutzen, 2001).

There are numerous theoretical and empirical studies considering the relationship between economic development and environmental quality --- the famous Environmental Kuznets Curve (EKC) postulates an inverted-U relationship between economic growth and pollution. It suggests that environmental degradation should increase at low incomes, reach a peak (turning point), and eventually decrease at high income. EKC implies that persistent economic growth can be accompanied by reductions of environmental degradation in the long run (Neumayer, 1999). The other optimistic view, the Porter hypothesis, states that reducing environmental impacts of production will improve productivity, hence simultaneously benefiting economic growth and the environment (Porter and van der Linde, 1995). Furthermore, more profitable firms are more likely to adopt clear technologies (Dasgupta et al., 2002). This arouses our curiosity: Do China's fast-developing east regions both economically and environmentally perform better than the less-developing inland ones? Do their rankings in regional productivities drastically change after taking into account environmental factors? After its entrance into the World Trade Organization (WTO) in 2001, problems of rising regional economic disparities and environmental protection have become more imminent to China.

Incorporating the economy and the environment together, the concept of sustainable development has become a key element of policies not only at national levels, but also at regional levels (Gibbs, 1998). One can recall the old radical green slogan "think globally, act locally." In other words, development towards sustainability can be introduced by starting from areas on a local or regional level (Wallner et al., 1996; Dryzek, 1997). This type of sub-national scale can be emphasized as a key site for the integration of economic and environment policy (Gibbs, 2000). This would seem to be of particular importance to various regions in China, in light of their geographical and economic diversity.

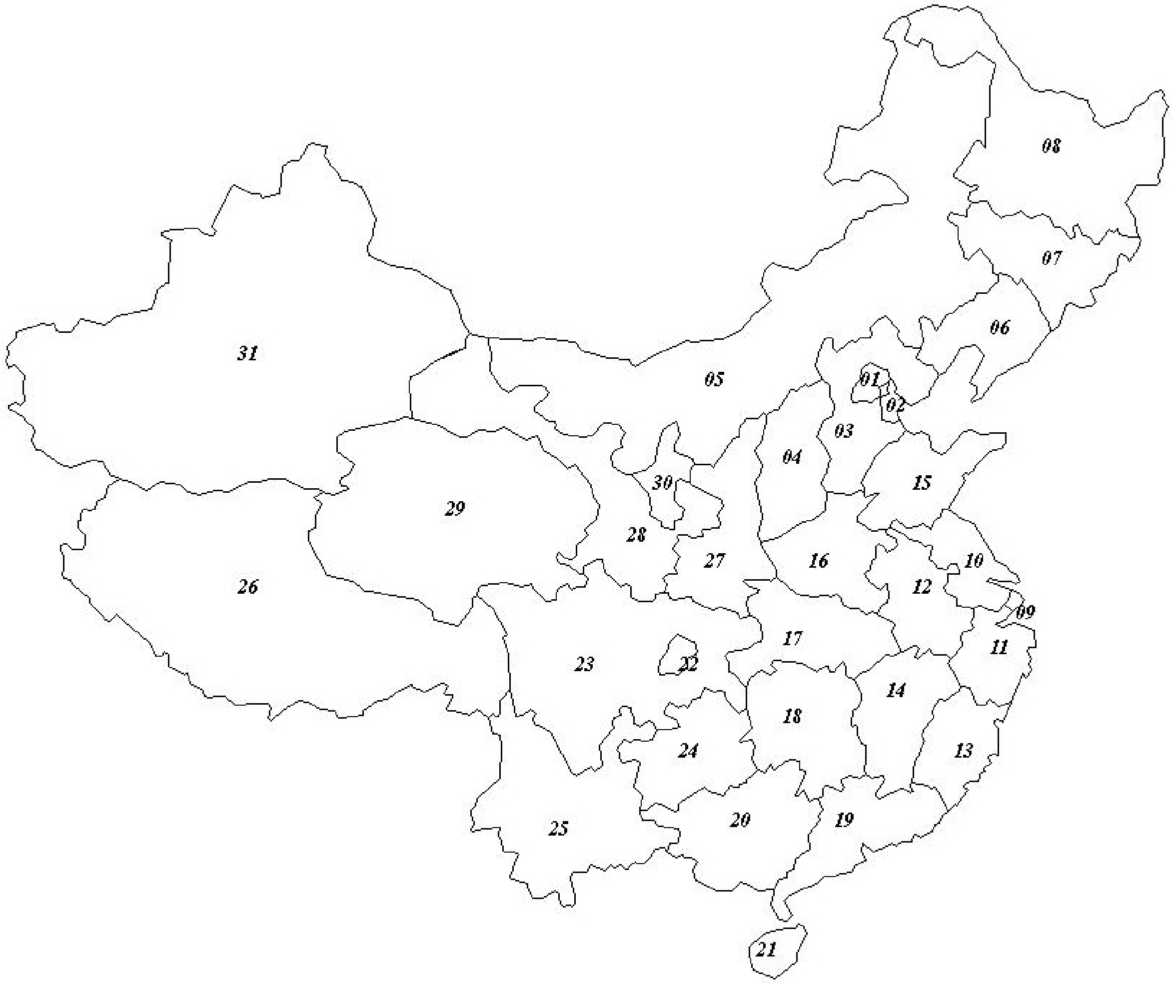
4.2 Regional Economic Disparities in China

From the perspective of China's development and political factors, its provinces, autonomous regions, and municipalities are usually divided into three major areas: the east, central, and west. The east area stretches from the province of Liaoning to Guangxi, including Shandong, Hebei, Jiangsu, Zhejiang, Fujian, Guandong, and Hainan, and the municipalities of Beijing, Tianjin, and Shanghai. Among the three major areas, the east area has experienced the most rapid economic growth. In the early 1980s, the Chinese government established and opened up four special economic zones and fourteen coastal cities to foreign investment and trade. Since then, the special economic zones and the coastal open areas have enjoyed considerable autonomy, special tax treatment, and preferential resource allocations (Litwack and Qian, 1998). They have attracted the most foreign capital, technology, as well as managerial know-how. Rapid economic growth has made this area a magnet for attracting investment and migrant workers. The central area consists of Heilongjiang, Jilin, Inner Mongolia, Henan, Shanxi, Anhui, Hubei, Hunan, and Jiangxi. This area has a large population and a home base of farming. Foreign investment in this area is not as much as in the east coastal regions, and existing equipment relatively lags behind. The west area covers more than half of China, including the provinces of Gansu, Guizhou, Ningxia, Qinghai, Shaanxi, Tibet, Yunnan, Xinjiang, Sichuan, and the municipality of Chongqing. Compared to other two, this area generally has a low population density and is the least developed.

The high economic inequality which can be mainly attributed to the growing inland-coastal disparity (Chang, 2002; Yang, 2002) in China has caught considerable attention and research recently. For instance, the rich coastal provinces perform better with respect to per capita production and consumption than the inland ones during the reform period (Kanbur and Zhang, 1999; Yao and Zhang, 2001). The total factor productivity of the coastal provinces is roughly twice as high as that of the non-coastal provinces (Fleisher and Chen, 1997). General explanations for these disparity issues are from the advantageous geographic factors which will reduce transportation cost and the government's preferable policies for the coastal areas (Yang, 2002).

The locations of the provinces and municipalities and the average per capita nominal GDP of each region in China are shown in Figure 4.1. There is an apparently economic disparity between the coastal and inland areas. Regional economic disparities are because of a greater access to world markets, better infrastructure, a higher-educated labor force, and the government's preferential policies on foreign investment for the east area (World Bank, 1997). Figure 4.2 presents the industry composition[3] (primary, secondary, and tertiary industry[4]) of these three areas in 1997. Compared to the inland central and west areas, the east area has higher proportions of secondary and tertiary industries and a far lower proportion of primary industry.

[3] This is a percentage of an industry's output value of GDP. Figures are from the authors' computation. The percentage compositions of other years are quite similar.
[4] Primary industries include agriculture (farming, forestry, animal husbandry, and fishery). Secondary industries include mining and quarry, manufacturing, production and supply of electricity, water and gas, and construction. Tertiary industries include all other industries not included in the primary or secondary industry.



East Area		*Central Area*		*West Area*	
01 Beijing	20,609	***04*** Shanxi	5,020	***22*** Chongqing	4,955
02 Tianjin	16,545	***05*** Inner Mongolia	5,489	***23*** Sichuan	4,571
03 Hebei	7,112	***07*** Jilin	6,450	***24*** Guizhou	2,518
06 Liaoning	10,242	***08*** Heilongjiang	8,072	***25*** Yunnan	4,470
09 Shanghai	31,347	***12*** Anhui	4,752	***26*** Tibet	4,208
10 Jiangsu	10,945	***14*** Jiangxi	4,674	***27*** Shaanxi	4,243
11 Zhejiang	12,383	***16*** Henan	5,081	***28*** Gansu	3,652
13 Fujian	10,877	***17*** Hubei	6,743	***29*** Qinghai	4,783
15 Shandong	8,881	***18*** Hunan	5,279	***30*** Ningxia	4,589
19 Guangdong	11,983			***31*** Xinjiang	6,795
20 Guangxi	4,313				
21 Hainan	6,426				

Figure 4.1 Regions of China and Average Per Capita Nominal GDP 1997-2001 (RMB)

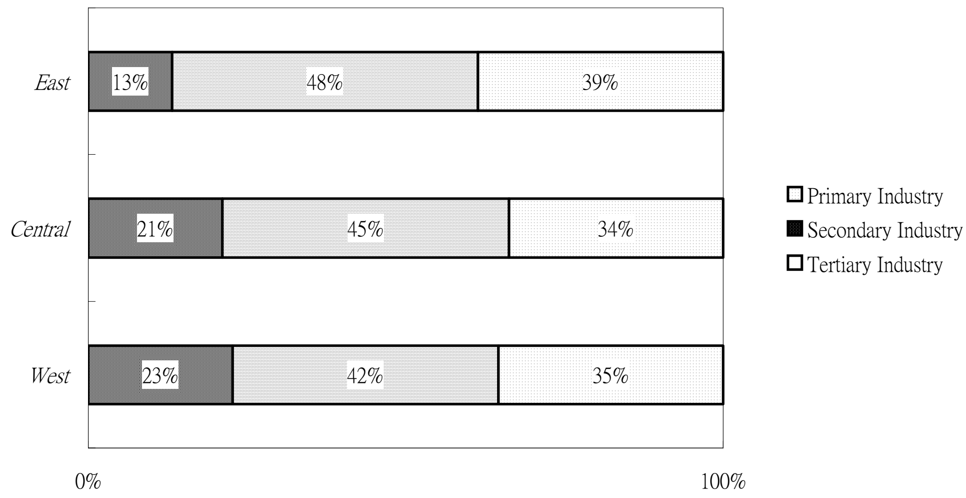


Figure 4.2 The Industry Composition Among Areas (% of GDP in 1997)

4.3 Data Selection for China's Regions

From *China Statistical Yearbook*, we establish a data set for 31 regions in China (27 provinces and 4 municipalities) during 1997[5] to 2001. In the analysis without environmental impacts, there are two inputs and one output. The two inputs are capital stock[6] and number of employed persons. The one output is GDP of a specific region. These are aggregated input and output proxies. The analysis of environmental impact involves five inputs and one output. In addition to those two inputs and one output, three inputs of emissions, which are treated as cost of production, are added: volumes of sulfur dioxide emission, industrial soot emission, and industrial dust emission. These are China's three most serious emissions and constitute the major components of Asian Brown Clouds.

Macroeconomic performance is evaluated in terms of the ability of a region to maximize the one desirable output GDP and to minimize the three environmental disamenities. The

[5] Complete panel data of these variables started from 1997.

[6] The data of capital stock cannot be directly obtained from *China Statistical Year Book*. In this study, every regional capital stock in a specific year is calculated by the authors according to the following formula: capital stock in the previous year + capital formation in the current year – capital depreciation in the current year. All the nominal values are deflated in 1997 prices before summations and deductions. We find the initial capital stock (capital stock data in 1996) from a research of Li (2003).

value of monetary inputs and outputs such as GDP and capital are in 1997 prices. Summary statistics of these inputs and output ordered by year and area are shown in Tables 4.1 and 4.2, respectively. We use freeware Deap 2.1, kindly provided by Coelli (1996), to solve the linear programming problems.

Table 4.1 Summary Statistics of Inputs and Outputs by Year

		1997	1998	1999	2000	2001
Inputs						
Capital Stock	Mean	8 405.88	9 147.91	9 383.09	10 514.87	11 205.46
(100 million RMB)	Std. Dev.	7 383.04	7 776.63	8 172.75	8 595.15	9 022.18
Number of Employed Persons	Mean	2 053.76	2 046.01	2 015.92	2 128.35	2 019.70
(10,000 persons)	Std. Dev.	1 408.80	1 363.67	1 412.84	1 425.89	1 443.79
Volume of Sulfur Dioxide	Mean	439 558	513 878	470 998	511 640	484 979
Emissions (ton)	Std. Dev.	327 707	403 600	342 767	368 056	356 231
Volume of Industrial Soot	Mean	220 844	379 163	307 559	312 784	274 867
Emission (ton)	Std. Dev.	152 050	344 907	218 799	224 387	221 522
Volume of Industrial Dust	Mean	176 901	426 510	379 129	315 022	266 548
Emission (ton)	Std. Dev.	112 955	324 119	301 655	246 890	219 508
Outputs						
Gross Domestic Product	Mean	2 482.45	2 468.56	2 48.57	2 502.62	2 570.18
(100 million RMB)	Std. Dev.	1 915.91	1 922.50	1 920.20	1 997.68	2 061.67

Note:

(1) The monetary values are in 1997 prices.

(2) Data source: *China Statistical Yearbook*, 1998-2002

Table 4.2 Summary Statistics of Inputs and Outputs by Area

		Area of China		
		East	*Cent*	*West*
Inputs				
Capital Stock	Mean	15 867.37	9 691.53	4 486.96
(100 million RMB)	Std. Dev.	9 803.23	2 836.78	2 920.03
Number of Employed Persons	Mean	2 242.71	2 422.49	1 492.03
(10,000 persons)	Std. Dev.	1 423.50	1 335.82	1 252.69
Volume of Sulfur Dioxide	Mean	603 158	470 748	353 590
Emissions (ton)	Std. Dev.	448 745	236 683	269 773
Volume of Industrial Soot	Mean	290 239	393 908	224 231
Emission (ton)	Std. Dev.	231 634	222 962	249 638
Volume of Industrial Dust	Mean	356 233	382 006	198 463
Emission (ton)	Std. Dev.	297 724	261 551	174 525
Outputs				
Gross Domestic Product	Mean	4 426.05	2 742.67	1 242.27
(100 million RMB)	Std. Dev.	2 692.76	1 179.67	1 053.79

Note:

(1) The monetary values are in 1997 prices.

(2) Data source: *China Statistical Yearbook*, 1996-2002

4.4 Results of Efficiency Frontier

The efficiency frontier consists of the most efficient regions for each particular year. Regions on the frontier are assigned an efficiency score of one. Regions with scores approximating to one are those who are closer to the frontier. Compositions of efficiency frontiers without and with environmental factors during 1997 to 2001 are shown in Table 4.3.

Generally speaking, about one-sixth of the regions in the sample are on the frontier at least once for the time period from 1997 to 2001 when environmental factors are not considered. With environmental factors, about one-third of the regions are on the frontier. With or without environmental factors, Shanghai (09), Hunan (18), Guangdong (19), and Tibet (26) are on the frontier every year. Fujian (13) is on the frontier in some years without environmental factors and is on the frontier for every year with environmental factors. Heilongjiang (08), Jiangsu (10), and Hainan (21) behave most efficiently after taking the environmental factors into account. Two municipalities, Beijing (01) and Tianjin (02), are on the frontier for some years with environmental factors. Most of these best performers are in the highly developing areas of China.

Composition of the efficiency frontier sorted by areas of China is in Table 4.4. The east coastal regions are on average in a better position no matter with or without environmental factors. Taking into account environmental factors makes the number of regions on the frontier increase. The total amount of regions gained on the frontier mainly results from the east area. The efficiency frontier derived from technical efficiency is a relative concept. We cannot conclude that those east coastal regions in the frontier have absolutely good environmental conditions. However, these provinces perform better than their inland peers when both economic and environmental factors are concerned.

Table 4.3 Technical Efficiency Score of Region for Variable Returns to Scale

ID	Region	Area	1997		1998		1999		2000		2001	
			w/o[a]	*w/*[b]	*w/o*	*w/*	*w/o*	*w/*	*w/o*	*w/*	*w/o*	*w/*
01	Beijing	E	0.816	0.861	0.825	0.956	0.802	0.916	0.806	1.000	0.840	1.000
02	Tianjin	E	0.906	1.000	0.964	1.000	0.931	1.000	0.947	0.947	0.972	0.972
03	Hebei	E	1.000	1.000	0.992	0.992	0.958	0.958	0.910	0.910	0.891	0.891
04	Shanxi	C	0.563	0.563	0.559	0.559	0.560	0.560	0.558	0.558	0.555	0.555
05	Inner Mongolia	C	0.598	0.598	0.653	0.705	0.674	0.704	0.672	0.672	0.677	0.677
06	Liaoning	E	0.690	0.690	0.736	0.736	0.739	0.739	0.732	0.732	0.725	0.725
07	Jilin	C	0.648	0.757	0.710	0.832	0.753	0.846	0.761	0.782	0.786	0.799
08	Heilongjiang	C	0.851	0.962	0.797	1.000	0.823	1.000	0.857	1.000	0.871	1.000
09	Shanghai	E	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	Jiangsu	E	0.920	1.000	0.926	1.000	0.936	1.000	0.935	1.000	0.955	1.000
11	Zhejiang	E	0.847	0.919	0.834	0.834	0.831	0.831	0.821	0.877	0.831	0.911
12	Anhui	C	0.785	0.814	0.800	0.821	0.791	0.837	0.746	0.813	0.756	0.810
13	Fujian	E	1.000	1.000	1.000	1.000	1.000	1.000	0.965	1.000	0.947	1.000
14	Jiangxi	C	0.673	0.746	0.750	0.767	0.771	0.790	0.729	0.753	0.761	0.773
15	Shandong	E	0.909	0.909	0.904	0.904	0.905	0.944	0.884	0.884	0.886	0.886
16	Henan	C	0.781	0.784	0.786	0.786	0.769	0.769	0.755	0.757	0.755	0.756
17	Hubei	C	0.814	0.828	0.830	0.835	0.816	0.837	0.796	0.801	0.788	0.800
18	Hunan	C	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
19	Guangdong	E	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
20	Guangxi	E	1.000	1.000	1.000	1.000	0.953	0.959	0.896	0.896	0.902	0.902
21	Hainan	E	0.791	1.000	0.928	1.000	0.785	1.000	0.633	1.000	0.719	1.000
22	Chongqing	W	0.411	0.428	0.417	0.565	0.416	0.562	0.420	0.423	0.430	0.430
23	Sichuan	W	0.834	0.855	0.876	0.890	0.855	0.876	0.828	0.839	0.845	0.849
24	Guizhou	W	0.707	0.730	0.780	0.780	0.765	0.765	0.722	0.722	0.702	0.702
25	Yunnan	W	0.776	0.992	0.859	0.983	0.830	0.913	0.789	0.891	0.767	0.829
26	Tibet	W	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
27	Shaanxi	W	0.435	0.435	0.459	0.462	0.494	0.495	0.503	0.503	0.514	0.514
28	Gansu	W	0.507	0.555	0.583	0.639	0.596	0.632	0.578	0.593	0.589	0.599
29	Qinghai	W	0.933	0.944	1.000	1.000	0.818	0.818	0.782	0.797	0.738	0.747
30	Ningxia	W	0.774	0.774	0.841	0.920	0.716	0.716	0.678	0.678	0.646	0.646
31	Xinjiang	W	0.777	0.777	0.789	0.801	0.752	0.767	0.787	0.787	0.775	0.775
Numbers of regions on the frontier			7	9	7	11	5	9	4	9	4	9

Note:

(1) [a] Technical efficiency of the region during the period 1997-2001 without environmental factors.

(2) [b] Technical efficiency of the region during the period 1997-2001 with environmental factors.

(3) E is the abbreviation for east area, C is the abbreviation for central area, and W is the abbreviation for west area.

Table 4.4 Composition of the Efficiency Frontier for Variable Returns to Scale

		Without environmental factors					*With environmental factors*				
		1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
Area of China	*East*	5	4	3	2	2	7	7	6	6	6
	Central	1	1	1	1	1	1	2	2	2	2
	West	1	2	1	1	1	1	2	1	1	1
	Total	7	7	5	4	4	9	11	9	9	9

Note: The numbers in this table are the number of regions on the frontier

4.5 Results of Productivity Change

In the above analysis, the efficiency frontier for each year is constructed from the efficient regions of the given year. This is a kind of static analysis that disregards movements of the frontier, and regions on the frontier have the same efficiency score of one. Geometric means of the Malmquist productivity change summary indices and the components of growth for each sample region are listed below.

Malmquist indices comparison among regions without/with environmental factors is displayed in Table 4.5. On the left side of Table 4.5, the Malmquist indices and its components without environmental factors are listed. The average Malmquist index is 0.955, with 4 regions' indices exceeding unity, implying that they have positive production growth. The east regions generally perform better than inland ones. The sources of productivity growth for those east regions are technical change rather than efficiency change. Most west regions and some central ones lie in the rear of the list. This result is consistent with the developing disparity in China (World Bank 2001) whereby the east areas have better economic conditions.

After incorporating the case of the three undesirable and costly emissions as inputs, regional performance rankings on average do not change: The Malmquist indices and its components with environmental factors are listed on the right side of Table 4.5. The average

Malmquist index is 0.957, with 6 regions showing a positive productivity growth. The overall rankings of Malmquist indices change slightly with and without environmental factors. Productivities of three big cities, Shanghai (09), Beijing (01) and Tianjin (02), improve for a large extent when environmental factors are considered. The regions which improve their rank of position for more than 5 positions are: Hainan (21) in the east; Heilongjiang (8) in the central. The regions which regress more than 5 places are: Jiangsu (10) and Zhejiang (11) in the east; Jiangxi (14) and Hubei (17) in the central.

In order to examine whether an association exits between the two rank lists without/with environmental factors, the test of Spearman rank correlation coefficient is used for this purpose. It is a nonparametric rank correlation procedure for making inferences about the association between two rank series. The Spearman correlation coefficient for the Malmquist indices is 0.9108 with 1% significant level which strongly reject null hypothesis that there is no association between the two rank lists. Therefore, it can be generally concluded that those regions with higher productivity while GDP is solely concerned still rank superior when both GDP as well as environmental factors are considered.

In Lovell et al. (1995) on OECD countries, the inclusion of two environmental indicators did change the ranking, reflecting that the environment is a decisive variable when assessing a nation's relative performance. However, this is not to say that environmental factors are not of importance to Chinese regional comparison, because of this unchanged productivity ranking. It is rather a warning of the extreme developing disparity in China, whereby the non-coastal areas are frail in economic growth as well as in environmental protection. We call this phenomenon the 'double deterioration' of regional development in China.

Table 4.5 Decomposition of the Malmquist Index without/with Environmental Factors

ID	Region	Area	*Without Environmental factors*				*With Environmental factors*			
			Malmquist index (MALM)	Efficiency change (EFFCH)	Technical change (TECHCH)	Rank	Malmquist index (MALM)	Efficiency change (EFFCH)	Technical change (TECHCH)	Rank
01	Beijing	E	0.999	1.008	0.991	5	1.123	1.043	1.077	3
02	Tianjin	E	1.009	1.019	0.990	4	1.022	1.011	1.011	4
03	Hebei	E	0.899	0.975	0.922	30	0.888	0.975	0.911	30
04	Shanxi	C	0.917	0.986	0.930	26	0.907	0.986	0.920	22
05	Inner Mongolia	C	0.958	1.025	0.935	15	0.973	1.025	0.950	11
06	Liaoning	E	1.021	1.030	0.991	2	1.020	1.030	0.989	6
07	Jilin	C	0.986	1.041	0.947	9	0.982	1.030	0.953	10
08	Heilongjiang	C	0.950	0.996	0.954	18	0.983	1.028	0.955	9
09	Shanghai	E	1.021	1.000	1.021	2	1.146	1.000	1.146	1
10	Jiangsu	E	0.993	1.004	0.989	7	0.963	0.967	0.995	12
11	Zhejiang	E	0.983	0.995	0.988	10	0.920	0.984	0.934	19
12	Anhui	C	0.915	0.995	0.919	27	0.899	0.992	0.906	27
13	Fujian	E	0.933	0.979	0.953	21	0.926	1.000	0.926	18
14	Jiangxi	C	0.936	1.016	0.921	20	0.903	1.005	0.899	25
15	Shandong	E	0.940	1.006	0.935	19	0.913	0.982	0.930	21
16	Hennan	C	0.928	1.009	0.920	23	0.914	1.009	0.906	20
17	Hubei	C	0.920	0.997	0.923	24	0.892	0.988	0.903	29
18	Hunan	C	0.919	1.005	0.914	25	0.907	1.000	0.907	22
19	Guangdong	E	0.970	1.000	0.970	11	0.959	1.000	0.959	13
20	Guangxi	E	0.875	0.963	0.909	31	0.873	0.963	0.906	31
21	Hainan	E	0.960	0.985	0.974	14	1.022	1.014	1.007	4
22	Chongqing	W	0.968	1.002	0.966	12	0.949	1.002	0.947	15
23	Sichuan	W	0.929	1.014	0.917	22	0.906	1.001	0.906	24
24	Guizhou	W	0.913	1.005	0.908	28	0.903	1.002	0.901	25
25	Yunnan	W	0.909	0.989	0.919	29	0.897	0.966	0.929	28
26	Tibet	W	1.034	1.075	0.962	1	1.136	1.000	1.136	2
27	Shaanxi	W	0.952	1.032	0.922	16	0.940	1.032	0.911	17
28	Gansu	W	0.952	1.034	0.921	16	0.944	1.023	0.923	16
29	Qinghai	W	0.997	1.012	0.985	6	0.985	1.052	0.936	8
30	Ningxia	W	0.967	0.994	0.973	13	0.959	0.994	0.965	13
31	Xinjiang	W	0.987	0.998	0.989	8	0.989	0.998	0.991	7
	mean		0.955	1.006	0.950		0.957	1.003	0.954	

Note:

(1) All Malmquist index averages are geometric means.

(2) E is the abbreviation for east area, C is the abbreviation for central area, and W is the abbreviation for west area.

(3) The Spearman rank correlation coefficient for the Malmquist indices is 0.9108 with p-value less than 0.01.

The double deterioration in China can also be clearly observed through the regional indices changes without/with environmental factors summarized in Figure 4.3. Figure 4.3 presents the decomposition of the Malmquist index by area. There appears to be an obvious difference between the east and the inland-central-west areas: The productivity growth (MALM) of the east area dominates those of the central and west areas without/with environmental factors. With respect to technical changes (TECHCH), the east area still leads the central and west areas without/with environmental factors. For efficiency changes (EFFCH) without environmental factors, the east area performs worse than the central and west ones. However, this gap gets narrowed after taking environmental factors.

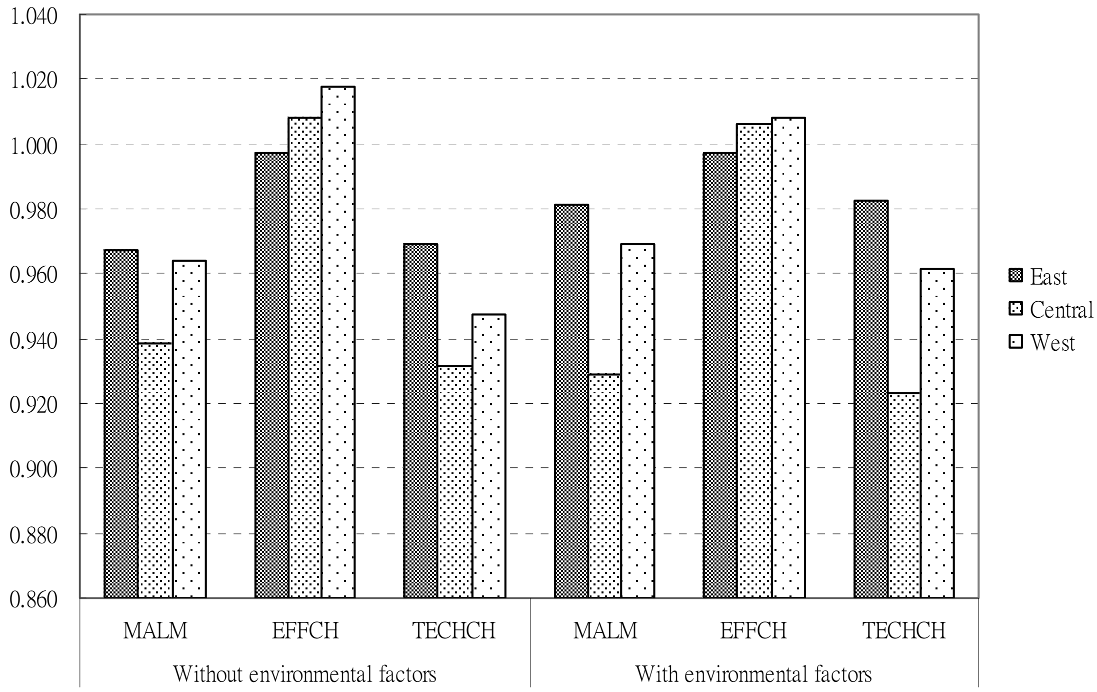


Figure 4.3 Decomposition of Malmquist Index without/with Environmental Factors by Area

One may wonder whether or not the industry composition creates the disparities since the pollution emitted is mainly from the secondary industry. Recall Figure 4.2, which presents the industry composition of the three areas in section 4.2: The percentage of secondary industry in the east area is higher than that of the other two areas. A postulate that an area with a higher percentage of secondary industry performs even worse under environmental concerns is definitely not supported. A possible explanation is that the secondary industry in the inland area is pollution-intensive, such as basic metals and chemicals. Their production equipment and environmental control skills are less developed, hence inducing higher pollution. 'Double deterioration' is a consequence of inefficient funds to replace dirty equipment and fuel for the poor regions.

4.6 Sub-Conclusions

Two decades of rapid economic growth have brought about a steady deterioration to the environment in China. Air pollution alone contributes to the premature death of more than a quarter of a million people each year (World Bank, 1997). With the threat of Asian Brown Clouds, this problem is starting to prompt global attention. In this chapter we have provided an evaluation of the performance of those regions responsible for the conduct of economic development and environmental problems in China.

The empirical results can be summarized as follows: First, the fast developing east coastal regions experience comparatively higher technical efficiency and productivity growth than the other inland regions when GDP is solely considered as a region's output. Second, in static analysis, taking into account environmental factors makes the number of regions on the frontier increase. The total amount of regions gained on the frontier mainly results from the progress of east area. Third, in dynamic analysis, the ranking lists without/with environmental factors change just slightly. This result is statistically significant which provide evidence that these two rank series without/with environmental factors are highly related. The possible interpretation for this phenomenon is that for those regions with inferior productivity suffer from costly environmental problems at the same time. In this study, it is called as a 'double deterioration' in China. Fourth, in the comparison of the Malmquist index and its components, the east area performs better than the inland central and west ones after the adjustment adding into environmental factors. The above phenomenon should be attributed to highly-polluting production processes rather than the industrial composition.

Receiving $45 billion in 1998, China was the largest FDI (Foreign Direct Investment) host country among the developing Asian economies (United Nations, 1999). However, per capita FDI in the west area is only eight percent of that in the east (Hu, 2001). Traditional rules, such as 'economy first, environment later' or 'the coastal first, the inland later,' still dominate the national development policy. Furthermore, China open up for all industries without discrimination after it entered the WTO in 2001. People in China, especially in the areas with lower income, may welcome dirtier industries so as to increase their income. China hence faces a dilemma of economic growth versus environmental protection.

Our empirical findings are consistent with EKC theory: while the poorer inland areas are on the increasing stage of per output pollution, the richer east is on the decreasing stage of per output pollution. Better environmental performance has been accompanied with economic achievement for the fast-developing area. On the other side, double deterioration of the inland area is indeed a warning for China to pursue balanced regional development. The inland regions may produce and mine using a lower grade of equipment that is highly polluting, and they still cannot afford better equipment to treat the pollutants. According to EKC theory, with persistent economic growth, the environment of the inland China will sooner or later improve. However, before this turning point occurs, they are now suffering from a double deterioration of economic performance and environment.

The following principles may serve as some inspirations to speed up the development of the inland China: The first is to diminish transportation expenses in these areas. Most west regions are relatively disadvantageous in not only having a longer distance to market, but also higher transportation costs, which are also obstacles to import the latest pollution abatement technologies and information. The second is to ask for domestic and international assistance in financing, local environmental policy reforms, and education. In the long term, growth without environmental protection could lead the industry to be less competitive under pressure from a world that needs to adhere to environmental protection. Our warning of a ‘double deterioration’ may be beneficial in promoting sustainable development of China’s economy as well as that of the global village.

Chapter 5 A Framework for Corporate Evaluation

5.1 Conflict between Business Profitability and Social Welfare

Nowadays in the beginning of twenty-first century, although we are proud of our advanced technology and modern commerce, the conflict between business profitability and social welfare, a hangover from the last century, has not improved and, in some aspects, is even worse. Our reporting systems for companies' activities are not transparent enough for outsiders to monitor the companies and make their investment decisions accordingly. In the future, the lack of transparency will impede us from reengineering enterprises, which may result in making forecasts that are far too optimistic. Besides, the near-sighted attitude that ecological-innovation is an expense which erodes profit gaining will block the progress. Therefore, we need to make more effort to improve the information transparency through a holistic view in order to enhance the link between economic development and environment sustainability. With many international organizations now adopting foresighted environmental, economic, and social information programs, it seems that the time to implement a long term, holistic approach to corporate-level issues of integrated development is fast approaching.

WBCSD proposed the concept of "eco-efficiency," which unites economic and environmental issues. The eco-efficiency formula are represented by dividing product or service value over environmental influence (value per environmental influence). The International Standards Organization (ISO) recommended that an International Standard on Environmental Performance Evaluation (ISO14031) be used to evaluate a corporation's effect on the environment. ISO 14031 can identify relevant trends in a corporation's activity and thus can provide the management with reliable and verifiable information regarding the company's environmental impact.

It is often assumed that environmental and economic considerations cannot be accommodated in a profit driven company's planning. This is because environmental expenditure is often treated as a corporate expenditure. Therefore, this socially aware consideration is usually ignored. To our belief, this kind of emission is actually inefficient, and an improvement in environmental issue leads to a general upgrade in efficiency. Based on eco-efficiency and ISO14031, this chapter aims to establish an evaluation for environmental protection and corporate profitability from the angle of efficiency. However, we realize that any evaluation system will only be effective if the information provided is user-friendly. Here, users are defined as not only internal business managers, but also investors, insurers, consumers, and other interest groups. This chapter will provide fresh insight on introducing a new framework for the evaluation of corporate integrated development and illustrating its application.

5.2 The Communication Challenge

It is undeniable that in the short run, there is a deep-rooted trade-off between the environment and economy for most enterprises. On one side of the trade-off is the demand of environmental soundness arising from stringent regulation, while on the other, we see industry fighting for competitiveness and desperately pursuing a "cheap at all costs" policy. With the argument framed this way, progress on environmental quality is like an arm-wrestling match. One side pushes for tougher standards; the other tries to roll them back (Porter and Linde, 1995). This kind of conflict is caused by various information barriers including personnel, agent isolation, cost, geographical, dissemination and technical language (Alabaster and Hawthorne, 1999). The communication barriers among different groups are the major causes of conflict between duty and desire.

The possible sources of biases, include the availability of information, selective perception and concrete information (Warner, 1997), which clogs communication, are further discussed below:

Availability of Information

People tend to pay attention to information that is readily available. Some stakeholders, including banks or communities, are very concerned that industry may be harmful to the environment. They make plans and decisions based mostly upon government. However, this well-published or frequently occurring data gathered according to a government's specific purpose may not be enough or suitable for their particular needs.

Selective Perception

People tend to face problems from the perception of their specific group or cultural affinity. The information is then interpreted through tinted glasses it is distorted. This functionally biased perception results in communication inefficiency. In Figure 5.1, it can be observed that different groups weight more on the information of their specific function and interest. While individual companies pay more attention to their machines' or employees' work performance, investors tend to focus on business financial performance. Social groups emphasize the living environment, thus a company's environmental performance is the most important aspects to them. More or less, the groups seem to be in opposition, showing little or no interest in information which does not come under their sphere of interest. For instance, the financial sector has been very slow to come to terms with the concept of corporate operational and environmental performance, due to the traditional resistance towards environmental matters and the inability of understanding the relationship between financial earnings and the environment (Cooper, 1999). As to community, the insistence for holy environmentalism often disregards the reality of peoples' needs for economic prosperity.

Furthermore, the goals and rewards of particular groups cause them to perceive and interpret information in ways that suit and reinforce their functional thoughts.

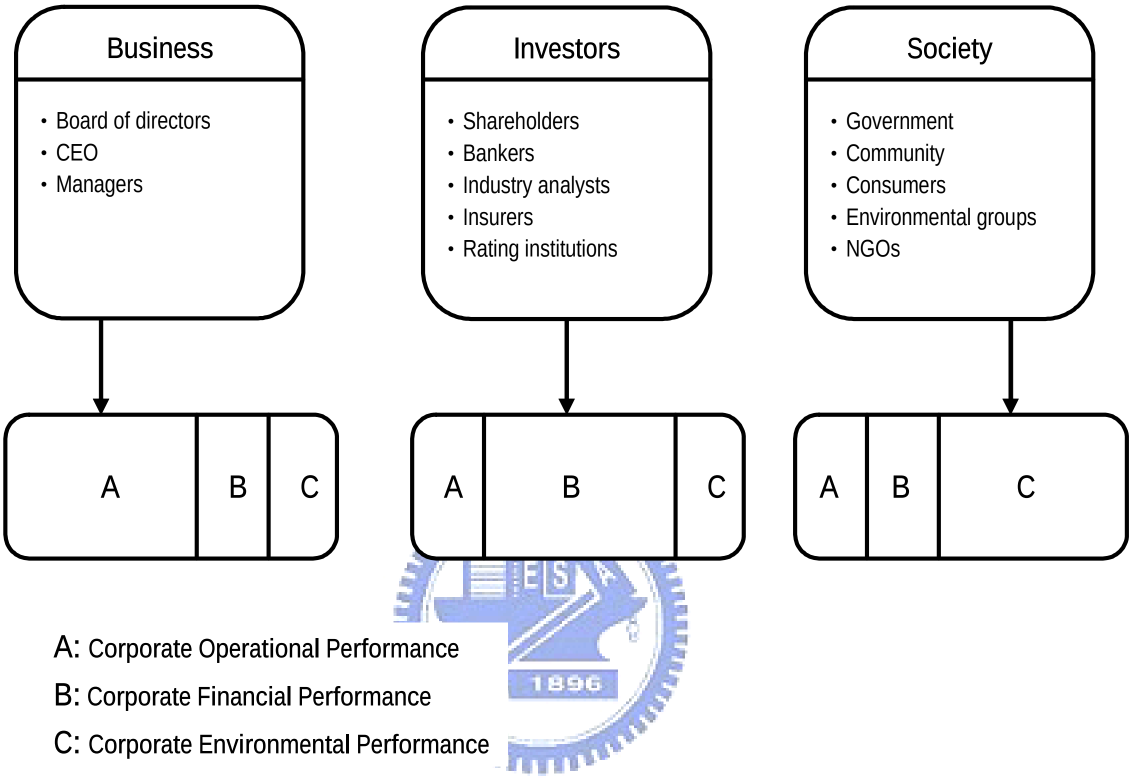


Figure 5.1 Bias in Information Use Caused by Selective Perception.

Concrete Information

A decision, which is supported by verifiable and logical information, is more effective than a decision supported by ambiguous and subjective information. Although the disclosure of corporate environmental reports (CERs) is widely advocated, most reports do not fulfill the needs of corporate integrated information to their stakeholders. Environmental information is plentiful, but is not easily accessed nor readily sought. And when it is, it is often nebulous, scattered, overly technical and biased (Jeffers, 1995). As long as the need for objective, clear and verifiable information is not satisfied, the gap between economy and ecology will become deeper and communication problems will deteriorate.

Corporate integrated development is a view constituting a firm's holistic performance of operational competence, financial health, and environmental friendliness. The aforementioned information gaps and communication problems could only be resolved through a holistic approach. The three main groups should search for a common ground, namely the "one-stop" reporting system. Information should be put into a format that investors, society, and firms can access to evaluate corporate operational, financial and environmental performance more accurately and more efficiently. Through an integrated evaluation approach, there is great potential for investors and communities to influence the way business operates. Moreover, the changing investment patterns and the reasonable negotiation approaches can be a facilitator for the evolution of a sustainable business cycle.

5.3 Evaluation Framework

While many stakeholders see environmental reporting as increasingly important for investment, consumption and other related decisions, the information provided in annual reports falls short of their expectations (Fayers, 1999). For that reason, until there is wide availability of transparent, objective and comparable information presented in an integrated manner, the problem of information asymmetry will continue to exist and the contradiction will remain.

A document that features economic, social and environmental information but does not take any inter-relationships into account is not considered to be integrated (Shearlock, James and Phillips, 2000). Therefore, information should be collected in a systematic way. Properly designed evaluation standards can help policy-makers set industrial upgrading laws, prompt industry restructuring, and trigger the business leaders' logic of process regeneration and product innovation that reduce the total cost and enhance the total value. The appropriate dimensions in terms of managerial and potential application to assess corporate total performance are discussed in this section.

Four Types of Capital

Since the advent of the industry revolution, capital for manufacturing such as financial resources, factories, and equipments has become the major input in industrial production. Natural capital, on the other side, is considered as only a marginal input and has largely been ignored. For a long time, natural capital is thought to be irrelevant to an enterprise's business planning, even though natural capital cannot be produced solely by human activities.

According to Natural Capitalism (Hawken and Lovins, 2000) the traditional definition of capital is accumulated wealth in the form of investments, factories, and equipment. An economy requires four types of capital, namely, human capital, financial capital, manufactured capital and natural capital, to function efficiently. Human capital is usually expressed in the form of labor and intelligence, culture, and organization. Financial capital consists of cash, investments, and monetary instruments. Manufactured capital includes infrastructure, machines, tools, and factories. Natural capital is made of our resources, living systems, and ecosystem services. These four types of capital are not mutually exclusive. Our industries use human, financial, manufactured and transferred natural capital to create the goods that are in common daily use.

Efficiency

We believe that integrated development for business is not a fixed goal, but a process. Therefore, strategies of corporate integrated development initiatives questions not based on morality but on efficiency. Efficiency deals with measuring the performance of firms, which convert inputs into outputs. In managerial application, a firm's micro-level data is used for making performance comparisons at higher levels of aggregation.

The concept of efficiency opens up a new way of looking at the company's work value created in terms of input-output. Through the perspective of efficiency, companies must pursue their manufacturing reengineering in a resource efficient manner that will benefit not only themselves but also all society. Efficient allocation of capital that reflects all input factors should be a major concern of stakeholders for both their present demand and future interest.

Framework

To higher-level managers, investors, and society, the evaluation of a facility's environmental protection activities is emphasized on its total environmental impact, rather than the measurement of certain chemical output. To the same way, evaluation of a company's overall development should be concerned with the total performance to make good use of every type of resource, including materials, facilities, and financial assets, rather than certain material consumption or a certain accounting expense. Decisions must be made on pragmatic considerations as well as on pure analytical grounds.

Evaluation for overall development requires the integration of a firm's three basic abilities: operational, financial and environmental management competence, as shown in Figure 5.2. However, the level of competence cannot be easily observed. Its ambiguous nature must be clarified to enhance our understanding of corporate behavior. Through a systematic view, the procedure of input-process-output-feedback, our problems can be resolved. The four types of resources: human, financial, manufactured and natural capitals that we have discussed in the last section are the corporate inputs. Through business activities, both desirable outputs and undesirable outputs are produced. Desirable outputs could be roughly categorized into real goods such as products and services, and financial gains, like earnings before interest and expense (EBIT). Undesirable outputs are usually pollutions as emissions, wastes and noise. Feedback can be obtained from many output/input ratios. These ratios are the interpretation of firms' three categorized performances: operational, financial and environmental performances that are accessible to all interest groups.

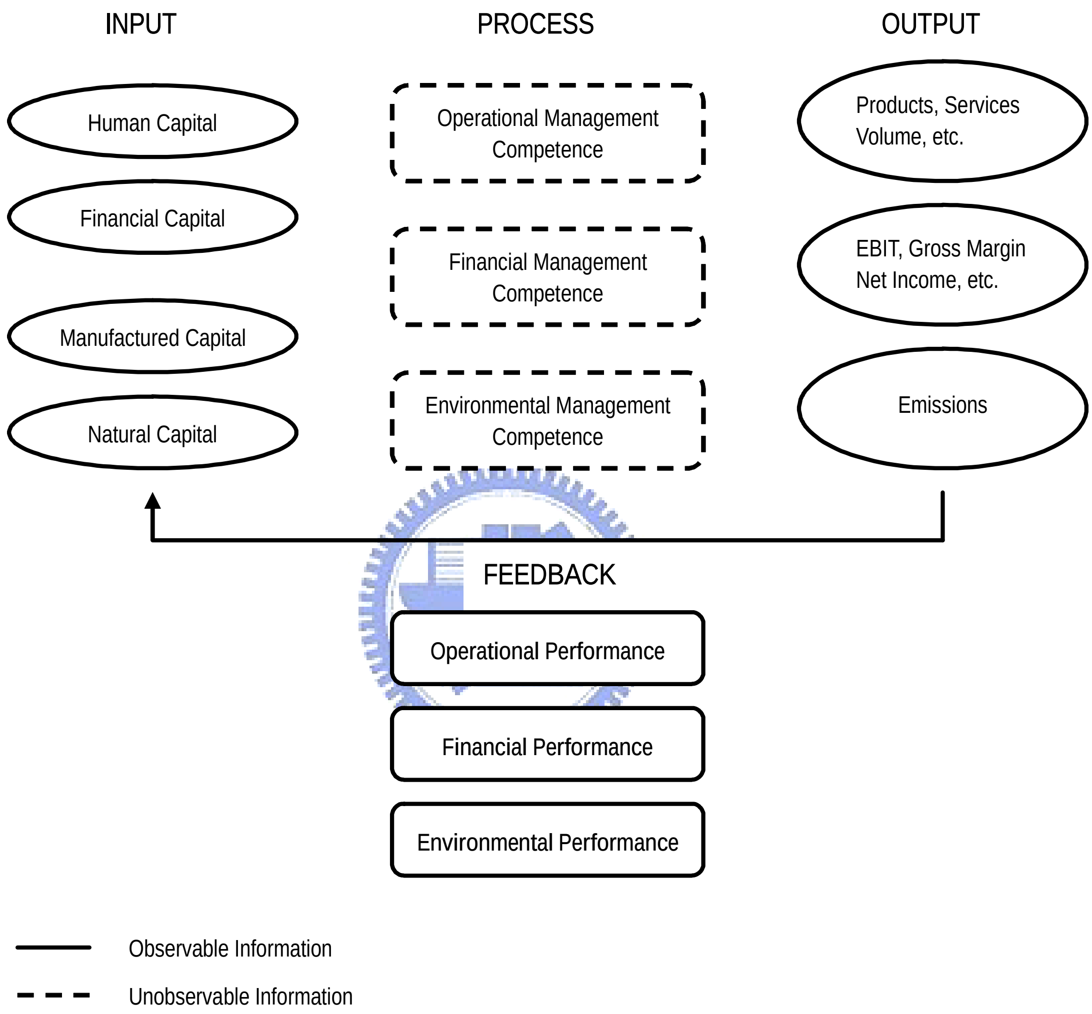


Figure 5.2 The Framework for Evaluation of Corporate Integrated Development

With this framework, we would be in a better position to understand the complex links between firms' operational, financial, and environmental performance. Relevant policies could then be adopted accordingly. However, it is worth noticing that these efficiency measures can provide a misleading indication of overall productivity when considered in isolation. Banks, shareholders, fund managers, and rating agencies need to take the firms' other performances into investment consideration, so that financial capital allocations can be properly allocated without accounting for the loss of natural and human capital. These institutions hopefully would have a financial system with all values in place, and where nothing is marginalized or externalized. Until now, social or biological values have not fit into today's accounting procedures yet. Information disclosure in the manner of this suggested framework could be provided for references of green accounting and environmental tax reform. This framework is also helpful to the business itself. Companies will look for a balance between revenue and responsibility. They will avoid the disasters caused by narrowly focused eco-efficiency for environment by overwhelming resource savings and by manufacturing larger inappropriate products produced by the incorrect process.

Companies that are moving toward advanced efficiency use of their resources will also discover an unexpected consequence to their allocations. They save energy and money, create competitive advantage, help restore the environment, and they will gain the reputation of 'being a good citizen' into the bargain. To the public, this means that they not only maintain a balance between workers and resource-fed machines, but also create a renewed sense of purpose and mission that is good for our younger generation.

5.4 Indicator Example

Companies, investors and society will require integrated information on a wide range of indicators to monitor and evaluate a firm's performance. Having discussed the framework of corporate integrated development, we will give some indicator examples. Financial analysis rating of a company's performance based on traditional criteria as well as on an environmental impact derived from the eco-efficiency approach pioneered by the WBCSD is used. A more detailed input and output data for future indicators are summarized in Table 5.1 and Table 5.2. The indicator examples for each category are given below:

Operational performance is taken from classical microeconomics concerning total factor productivity. Productivity of labor and manufacturing capital are usually discussed. Examples for operational performance are as follows.

Output value created per employee (Output value/Number of employees)

Output value created per machine (Output value/Number of machines)

Financial performance is extracted from financial ratios in annual financial statements. Commonly used financial ratios can be categorized into five kinds: leverage ratios, liquidity ratios, efficiency ratios, profitability ratios and market-value ratios. Appropriate ratios related to the purport of this study are presented below.

Asset Turnover (Sales/Total assets)

Net profit margin (Earnings before interest and tax/Sales)

Return on assets (Net income/Total assets)

Return on equity (Net income/Total equity)

Environmental performance can be divided into two types. One is corporate ability to efficiently transform natural resources into desirable outputs, and the other is corporate environmental preventive behavior to effectively cope with their undesirable outputs. Some indicator examples from WBCSD's pioneer researches include.

Material consumption efficiency (Tons of material/Units of sales)

Energy intensity (Giga-joules/Units of sales)

GHG emissions (Tons of GHG emissions/Units of sales)

Waste water emissions (Tons of waste water/Units of sales)

Indicators, as those discussed, could be employed to assess the condition of a given company to provide an early warning signal of changes in the environment, and to diagnose the cause of a problem. Indicators for business operations, especially, need to capture the complexities of the system, yet remain simple enough to be easily and routinely monitored.

While the interpretation of data is subject to the users' background, the basic constructing principles of an indicator should be established and commonly agreed upon by all information users. Indicators used by different levels of users are quite distinct from information volume and information density as shown in Figure 5.3. For example, a production line manager may focus on very detailed information of processing, whereas a financial department manager may be concerned with the details of expenditure. However, a CEO just needs the summarized information gathered from different department. Therefore, in this pyramid, indicators used in the same levels are for the purpose of communication, whereas indicators provided by the lower levels to the upper ones should be less complex and therefore more easily understandable and in smaller numbers.

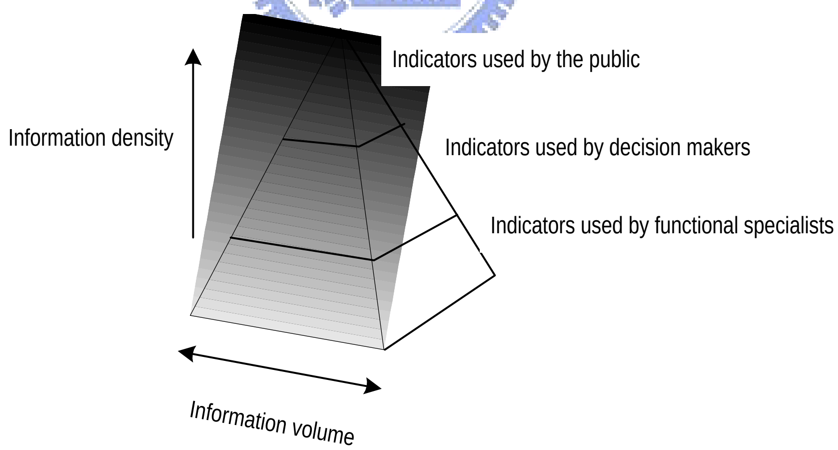


Figure 5.3 Indicator Pyramid

Managerial decisions should be based on broad consensus and support. However, in the real world, decision makers of higher levels in the company often have highly incomplete information, and limited time and scope of attention. In order to provide a sound basis for decision-making, they have to be informed with general, indicative, sensitive, robust and inter-linkage indicators, permitting them to proceed towards total efficiency.

Table 5.1 Indicator Examples of Input Data

Capital type	Indicator example	Unit	Data source
Human capital	• Number of employees	People	Financial reports
	• Number of middle level managers	People	Financial reports
	• Total labor hours	Hours	Financial reports
Manufactured capital	• Numbers of machine	Machine	Industry union, Company
	• Factory space	Meter square	Industry union, Company
Financial capital	• Short-term debt	Dollar	Financial reports
	• Long-term debt	Dollar	Financial reports
	• Insurance expense	Dollar	Financial reports
	• Equity of common shareholders	Dollar	Financial reports
Natural capital	Energy consumption		
	• Electricity	Giga-joules	Industry union
	• Coal	Giga-joules	Industry union
	• Natural gas	Giga-joules	Industry union
	• Fuel oil	Giga-joules	Industry union
	Materials consumption		
	• Raw materials	Tons	Industry union
	• Other process materials	Tons	Industry union
	• Pre- or semi-manufactured parts	Tons	Industry union
	Natural resources consumption		
	• Water	Tons	Industry union
	• Wood	Tons	Industry union
	• Mineral	Tons	Industry union
	• Land use	Hectares	Industry union

Source: Some indicator examples are adapted from *Measuring eco-efficiency: A guide to reporting company performance*, WBCSD.

Table 5.2 Indicator Examples of Output Data

Output type	Indicator example	Unit	Data source
Desirable outputs			
Product & service	• Volume	Units sold or kilogram	Industry union, Company
	• Output value	Dollar	Financial reports
Financial output	• EBIT	Dollar	Financial reports
	• Gross margin	Dollar	Financial reports
	• EPS		Financial reports
Undesirable outputs			
Emissions	GHG emissions	Tons of CO_2 equivalents	
	• CO_2, PFC_S, NF_3, CF_4, C_2F_6, SF_3,C_3F_8		
	ODS emissions	Tons of CFC_{11} equivalents	
	• CFC_S, $HCFC_S$		
	VOC	Kilogram	
	• THC		EPA reports
	Acidification emissions	Kilogram	&
	• NO_X, SO_X, HF, HCL, H_2SO_4		Waste disposal reports
	Waste water		&
	• Waste water emission	Tons	Estimation or calculation
	• pH-value		
	• COD	Tons	
	• BOD	Kilogram	
	Priority heavy metals (PHM)	Tons of Cu equivalents	
	• As, Cd, Cr, Cu, Pb, Hg, Ni, Zn		
Others	Wastes	Tons	
	Noise	Decibel	

Source: Some indicator examples are adapted from *Measuring eco-efficiency: A guide to reporting company performance,* WBCSD.

5.5 Applications

The introduced evaluation framework for corporate integrated development can be beneficial for our society in the following ways:

To End Conflict

For a long time, the environmental debate has been conducted in an endless cycle. Scientists find another negative human activity that may be harmful to the environment. The business refutes the impact, the community contends for living rights, and the media reports both sides. The issue eventually joins the end of a growing list of unresolved problems, and our society becomes paralyzed. The point is not that one side is right and the other side is wrong, but that both sides are not well informed. It is suggested that the reporting system be constructed with the information available in a clear and understandable way. This means, communication barriers need to be removed and the relationship between business and the environment to be strengthened.

To Improve Transparency

The development of an integrated development system will also contribute to greater corporate transparency and the subsequent re-allocation of capital. This system will enable an organization to monitor and measure its environmental performance in addition to its operational and financial performance. More and more companies will find it increasingly easier to communicate the results to stakeholders. Moreover, reporting is more than records of events that have just happened, it can be a yardstick for future actions. It is the question about what information should be reported and analyzed in order to get the company to enhance its performance according to the indicator pyramid. With the proper indicators, all interest groups can determine the extent of corporate development and put pressure on corporations to improve their holistic performance.

In addition, the Internet provides opportunities for the accessing information and joining in the decision-making process. Corporate performance could be shown, either voluntarily or through legislation, as on-line information. The Internet service can help accelerate the transparency of corporate, both from the environmental and financial aspects.

To Predict Industry Restructure

Through the proposed framework, one can easily identify whether an industry is labor or energy intensive. For the newly industrialized countries, the indicators provided can help the government to set a correct industrial policy. For example, when and to what extent to provide subsidies or tax incentives to certain industry. Also, those industries with poor environmental records will naturally be eliminated from the pressure of information disclosure. Changed investment patterns can make a significant contribution towards achieving a sustainable economy from financial prospects. Companies that value the sustainability concepts and are proactive to allocate capitals efficiently will be competitive and give greater priority to public awareness and stricter environmental protection laws in the next decade.

To Advance Ecological-Innovation

Ecological innovation includes the development and implementation of new products, new markets and new systems (Blattel-Mink, 1998). In the past, ecological-innovation is thought to be costly in monetary terms rather than its internal and external created utilities. However, there is evidence that a normative conflict of objectives between economy and ecology does not exist in ecologically innovative companies (Blattel-Mink, 1998) that combine innovations in business practice and in public policies. Once the evaluation system introduced in this paper is established, companies may be inspired to become ecological-innovative, and those companies which are dynamic and innovative will survive and eventually become the winner if the integration of economy and ecology becomes a key factor of competition.

5.6 Sub-Conclusions

This chapter combines corporate operational, financial, and environmental performance in a systematic way. The results could be used as a base for the development of a comprehensive corporate integrated evaluation system. However, the reason for introducing this framework is not to create more indicators. On the contrary, I plan to use the internationally recognized evaluation systems to establish a level playing field for pro-business and pro-environment interests to play on.

Ultimately, the objective of corporate existence is profitability rather than cost saving. The cost concept should be reviewed by the injection of environmental concern and holistic consideration. The struggle between short-term cost declining and long-term profit rising can be relieved by seeing things from a broader prospective. Before everybody learns to think long-term, some legislation forcing business to disclosure its overall performance cannot be avoided. After all, the old cliché that 'we just have one earth' is so real and urgent it cannot be ignored.

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Chapter 6 Conclusions

Each organization in multiple levels of modern society has moral responsibility to insure that its activities be ecological sustainable. From the perspective of efficiency and productivity, this dissertation studies the performances for multiple organizational levels from nation, region, to business, taking environmental factors into consideration. Both empirical studies and a conceptual framework for evaluating integrated development for the levels of the above entities are presented.

Firstly, this dissertation starts investigating the economic-environmental performance from a nation's level. Productivity growth of ten Asian countries are analyzed by examining their outputs from economic performance and environmental impact standpoint. Taking CO_2 emissions into analysis, productivity growth of these nations are calculated using the Malmquist index.

Secondly, this study focuses on a region's level. This part analyzes the regional development of China by examining economic performance as well as environmental emissions which cause Asian Brown Clouds. Technical efficiency and productivity changes of thirty-one regions in China are computed. The fast-developing east (coastal) regions experience higher technical efficiency and productivity growth than the inland central and west regions economically and environmentally.

Finally, a new conceptual framework for evaluating corporate integrated development through the perspective of efficiency is introduced. Under the proposed framework, businesses, investors, and society can conveniently understand and evaluate corporate holistic performance including its operational competence, financial health, and environmental friendliness. Decisions of different levels and groups can be made with programmed consideration on this proposed analytical ground.

Empirical studies on business level are comparably hard to realize upon to the time point while this dissertation is finished. One of the most important reasons is lack of data in terms of environmental factors in business level. Related environmental databases are still under investigation and construction. Since the issue on the balance between profitability and environmental friendliness is still 'young' in the research field of business and management, related studies are encouraged in due course.

For decades, environmental issues have been swept beneath the carpet in our race to build commercial empires. Traditional business management see environmental issues as a one sided argument promoted by ecologists and environmentalists. However, no one, not even management, can deny that our resources are being exhausted due to ours' inefficient and ignorant use. Although the integrated development for a country, a region, and a company, is generally considered costly and impractical, we believe that a new definition on the wealth of an entity should be evaluated not only by the economic terms, but also by the degree of happiness or comfortable environment which cannot easily be evaluated by currency unit. An integral part of the way our government and business should be done is timely. Charles Handy (1997) stated:

"The great excitement of the future is that we can shape it."

The bridge linking economic prosperity and the environment is to search for a common interest and to build on that common ground. Works for integrated evaluation for a nation's, a region's, and a company's level needs efforts. And this game is worth playing. Through it, a well-informed public and a responsible community can work in partnership to restore and protect our precious natural heritage

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