經營學博士 學位論文

A Comparative Study on the Productivity Of Chinese Seaport Cities

中國港灣都市들의 生産性에 대한 比較 研究

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2009年 2月

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ACKNOWLEDGEMENTS

I own a great deal to a number of people for the various kinds of help they have given to me during my school time.

First of all, my heartfelt thanks and appreciation go to my supervisor, Prof. Nah Ho Soo, for his patient tutorship, in-depth comment and invaluable advice in preparing my paper through the beginning to the end. It has been a great privilege and joy to study under his guidance and encouragement. Without his expert comments, suggestions and modifications, my thesis would not have emerged in its present form.

Meanwhile, special thanks will give to my dissertation committee members, Prof. You Il Sun, Prof. Jung Hong Yul, Prof. Shin ChangHoon and Prof. Liu ShinIl, who have give me valuable guidance in this thesis.

And also, many thanks go to the professors who have given me lectures during the master and doctor course. I would like to express my gratitude for their enlightening instruction and warm-hearted assistance.

My Thanks will also give to Mr. Wu Yongli, Vice-mayor of LaiXi, President of Haixin Construction LTD Li Chaoxun, Consulate-General of the People 's Republic of China Consul Zhang Yaqin, Doctor Piao Yongnan of KMU, Friends of Federation of Chinese Students in South Korea and collage mates in KMU for their kind support to my studies.

Last but not least, many thanks go to my families, my parents my borther and sister-in-law for their sympathetic understanding and unfailingly support during my studies and during my preparation of my thesis.

國文 抄錄

中國港灣都市들의 生産性에 대한 比較 硏究

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본 논문에서는 자료포괄분석방법(data envelopment analysis: DEA)을 사용하여 1997 년부터 2007 년 사이의 기간에 대하여 중국의 10 대 항만도시들의 효율성을 측정하고 맘퀴스트 생산성지수를 측정하였다. 항만도시들의 효율성과 효율성의 등위는 규모에 대한 수익불변(CRS)과 규모에 대한 수익 가변(VRS)의 가정하에서 측정되었다. 주요한 연구결과는 다음과 같다.

첫째, 舟山은 가장 효율적인 항만도시로 나타났고 지난 9 년 동안 CRS 와 VRS 의 가정하에서 1 위를 유지하였다.

둘째, 深圳은 신흥개방항만으로서 가장 뚜렷하고 의미있는 효율성의 개선을 나타내었다. 한편 大連은 오래된 항구로서 가장 빠른 상대적 효율성의 하락을 보여주었다.

셋째, 5 대 항만도시는(上海, 寧波, 天津, 廣州, 靑島) 꾸준한 추세를 보여 주었다.

넷째, 맘퀴스트 지수결과에서는 대체적으로 10 개의 항만도시들이 총요소생산성의 증가를 보여 주었는데 연평균 4.3%정도로 나타났다. 기술변화는 총생산성증가에서 중요한 역할을 하고 있음을 확인하였고 특히

투자의 지연효과를 고려한 모형에서 그 효과가 크게 나타났다.

다섯째, 중규모 및 대규모 항만과 비교하여 소규모 항만의 규모효율성은 가장 낮게 나타났으나 증가속도는 가장 빠르게 나타났다.

여섯째, 인구와 도시의 개방도는 항만의 도시생산성에 양의 효과를 보여주었고 항만의 화물취급능력은 음의 효과를 보여 주었다.

미래의 연구에서는 더 많은 자료와 더 나은 자료를 활용하여 중국 항만도시들의 효율성의 특징들을 이해하는데 더 나은 연구결과가 지속적으로 도출될 수 있을 것으로 기대된다.

Abstracts

A Comparative Study on the Productivity Of Chinese Seaport Cities

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By using data envelopment analysis(DEA) this research measures the efficiency of Chinese ten seaport cities and their Malmquist productivity form 1999 to 2007. Seaport cities' efficiency and efficiency rankings are measured under the assumption of constant return to scale(CRS) and various return to scale(VRS). Main finding facts are: 1) Zhoushan is the most efficient seaport city, which kept its first position in both CRS and VRS efficiency ranks in the past nine years. 2) Shenzhen, the newly built coastal open city, enjoyed the most clear and significant efficiency improvement; meanwhile the old seaport city Dalian suffered the most rapid relative efficiency decline. 3) The efficiency of the largest five seaport cities(Shanghai, Ningbo, Tianjin, Guangzhou, Qingdao) kept correspondingly

steadily. As to the Malmquist index results, in general, these ten seaport cities enjoyed increasing of total factor productivity with the average rate of 4.3%. Technical change played the most important role in the productivity increase. 4)The Malmquist index of efficiency has appeared a little higher when measured with views to the investment lagged effect. 5) The scale efficiency of small-sized seaport cities is the lowest, but the increase speed is the fastest, compared with the middle-sized and large-sized seaport cities. 6)The population and the openness of the city have positive effects on the seaport cities' efficiency, while the cargo handling capacity has negative effect.

In future research the more and better data will be expected to improve the understanding of Chinese seaport cities' efficiency characteristics.

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1. Introduction

1.1 Purpose

Sea transportation is one of the most important methods to move products and people in modern times. The concentration of economic activities in cities is the most striking feature of today's economic geography. In particular, in many counties, their dominant cities have developed mostly through ports. The port industry plays a pivotal role in the globalization of the world economy; the development of the port industry brings the development of the port cities. Nowadays Chinese coastal region especially seaport cities are the core of the Chinese economy: 71.2% of population lives in south-east costal area (2005)[1]; 15 coastal open cities produced 21.4% of Chinese GDP (2004)[2]. Chinese coastal region especially seaport cities are the core of the whole Chinese economy and the seaport cities are the representative of the Chinese advanced productivity.

Therefore the study of Chinese seaport cities' economic performance is not only a way to know the economic performance of these cities, but also a pass through to understand the economic situation of the whole China and to forecast the future development of the other cities.

In this paper, ten largest seaport cities' efficiency levels from 1999 to 2007 are estimated. The objectives of this research are to evaluate the efficiency, scale

[1] "A comparative Study of Chinese Eas ten and Western Population and Development" written by Luochun and Lvzhaohe, Yunnan University (2007.4).
[2] Source from: http://news3.xinhuanet.com/zhengfu/2005-04/20/content_2852812.htl, XINHUA NEWS AGENCY

economic (SE), returns to scale (RS), determinants of efficiency of seaport cities and to compare large-sized, middle-sized and small-sized seaport-cities' scale efficiencies.

1.2 The Seaport Cities of Interest

The primary seaport cities of interest include ten seaport cities of China; these data are observed over the time period 1999-2007. The ten cities are classified as three kinds: three large-sized seaport cities, five middle-sized seaport cities and two small-sized seaport cities.

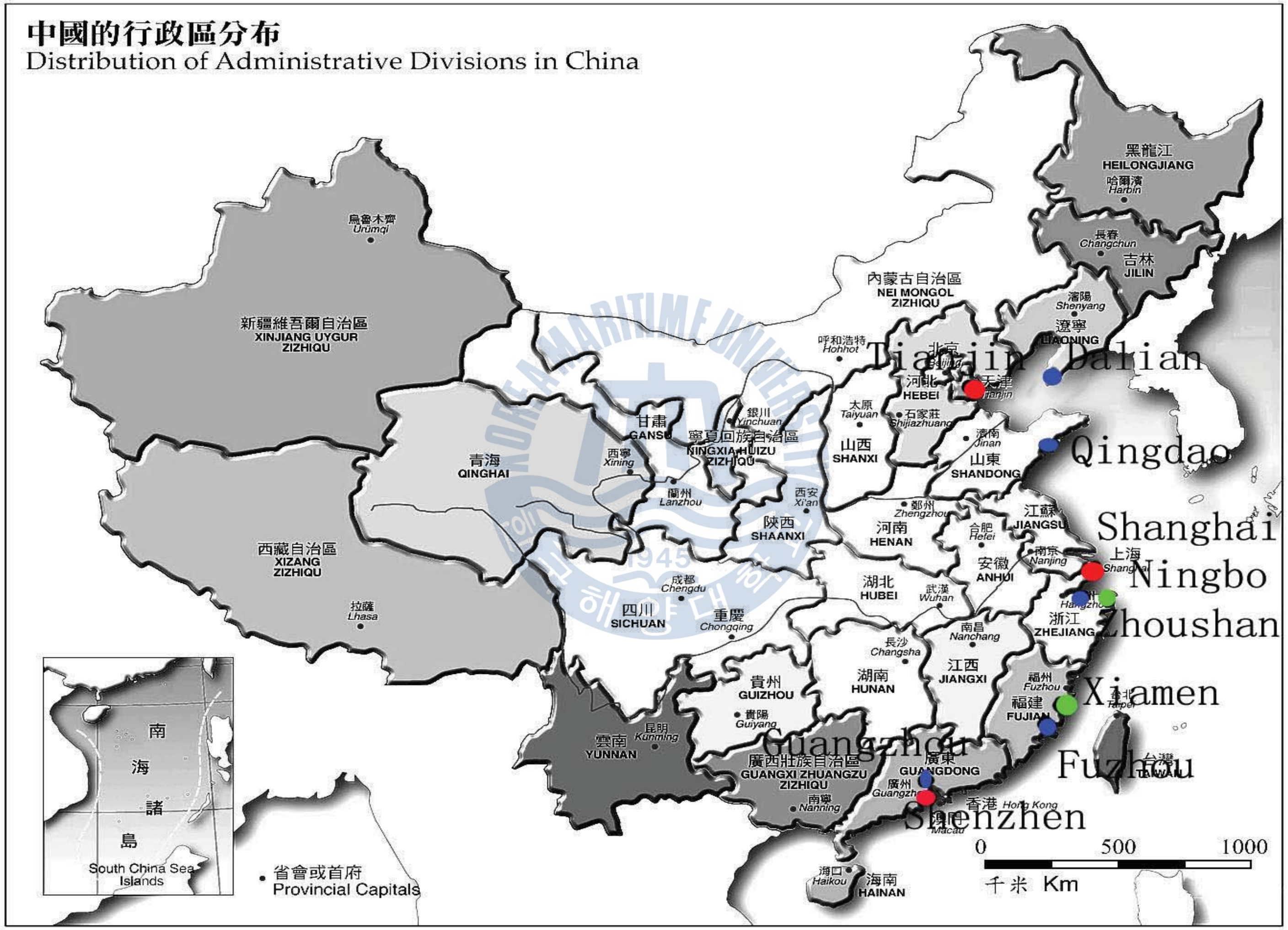
1.3 The Selection of Seaport Cities

In terms of the calculation of total cargo handling ability, we select the largest ten seaport cities[3]: Shanghai, Ningbo, Tianjin, Guangzhou, Qingdao, Qinhuangdao, Dalian, Shenzhen, Zhoushan and Yingkou. According to the total container handling ability the largest ten sea port cities rank is: Shanghai, Shenzhen, Qingdao, Ningbo, Zhoushan, Guangzhou, Tianjin, Xiamen, Dalian, Fuzhou and Zhongshan. In this paper we choose the ten largest cities ranked by the total cargo handling ability, but the data of Qinghuangdao and Yingkou are unavailable, so we take Xiamen and Fuzhou which are on the list of largest ten container sea port cities.

Picture 1 shows the locations of the ten largest seaport cities which are selected to this study by this paper. The large-sized seaport cities are marked with red, the

[3] "China's Top Ten Ports" published by China International Maritime Network & Dalian Maritime University (2007.9).

Picture 1 The distribution of the ten largest seaport cities



middle-sized seaport cities are marked with blue, and the small-sized cities are marked with green.

1.5 Structure

The content of this dissertation is structured as follows. This chapter provides the necessary background information regarding the ten largest Chinese seaport cities. The literature review of section two examines previous studies regarding efficiency measurement and the associated methodologies. Section three develops the separate methodologies employed in this research. Section four provides the data sources. Section five provides the results of the efficiency analysis of the ten seaport cities, while section six makes the summary, limitation, and conclusions.

2. Literature Review

2.1 Data Envelopment Analysis Models

Data Envelopment Analysis(DEA) is a mathematical programming approach developed by Charnes, Cooper, and Rhodes (1978) from the work of Farrell (1957). DEA leads to a fractional programming problem, normally converted to a linear program for ease of solving. Efficiency is often evaluated as in the classical engineering sense of the ratio of outputs to inputs. The DEA measures used in this dissertation are generally unit invariant, because optimality is independent of the input and output measures. A full description of the technique is explained for Chapter 3.

2.2 Previous Studies

DEA and multivariate statistical techniques have been used in combination in various studies. Since the number of efficient DMUs[4] depends on the number of inputs and outputs in the model, it is important to control for the number of inputs plus outputs; Pedraja et al (1999). Adler and Golany (2001) use principal components as inputs and outputs, and thus reduce the data that is fed into the DEA model. A very similar approach is followed by Vargas and Bricker (2000). Multivariate statistical methods and DEA are also used in sequence, to obtain a more complete understanding of the data; examples are Mancebon and Mar Molinero (2000), Bradley et al (2001), and Nath (2001). Zhu (1998) uses PCA[5] as an

[4] DMU stands for “decision making unit”. It is more appropriate term than “firm” when, for example, a bank is studying the performance of its branches or an education district is studying the performance of its schools.
[5] Principal component analysis (PCA) is a vector space transform often used to reduce multidimensional data

alternative to the DEA model, although he is aware of the limitations of the procedure. Premachandra (2001) demonstrates the soundness of Zhu's approach and extends it.

Lewin and Minton (1986) set out in some detail the desirable features of the DEA approach to efficiency measurement. Worthington (2001) provides a very clear explanation of DEA along with a review of those empirical studies that have applied the technique to schools. Most studies, including Engert (1996), Ruggiero (1996), Bates (1997), Chalos (1997), Duncombe, Miner and Ruggiero (1997) and Grosskopf, Hayes, Taylor and Weber (2001), perform their analyses at the level of school district (in the United States) or local education authority (United Kingdom), although Mizala, Romaguera and Farren (2002), Bradley, Johnes and Millington (2001) and Kirjavainen and Loikkanen (1998) use data at school level in Chile, England and Finland, respectively, in the context of situations where individual schools are permitted a good degree of decision making authority. Simar and Wilson (2007, page 32) provide a very long list of studies that have taken a two-stage (DEA and regression) approach to the measurement and subsequent analysis of efficiency in a rank of settings. Unfortunately, almost all of these studies, including those on schools, suffer from a problem that arises because the DEA efficiency estimates are serially correlated. Two papers that did attempt to correct for the serial correlation problem made use of a naïve bootstrap method which is "inconsistent in the context of non-parametric efficiency estimation" (Simar and Wilson 2007, page 33). Oliveira and Santos (2005) appear to be the first to implement some of Simar and Wilson's (2000) suggestions in the context of schooling. However, their data relate to a crosssection sample of only 42

sets to lower dimensions for analysis. Depending on the field of application, it is also named the discrete Karhunen-Loève transform (KLT), the Hotelling transform or proper orthogonal decomposition (POD).

Portugese public schools and they are therefore unable to implement double bootstrapping to correct for bias in the estimates of the efficiency scores.

Zhu's (1998) approach is based on the realisation that a ratio of a single output to a single input can be a feasible solution in the efficiency frontier and that, by studying such ratios, and their linear combinations, it is possible to rank efficient units. This is certainly a new perspective on the ranking of efficient DMUs which has recently been based on the concept of superefficiency introduced by Andersen and Petersen (1993), although other ranking methods have also been proposed; for example, Doyle and Green (1994) proposed a method based on the cross-efficiency matrix; Sinuany-Stern and Friedman (1998) proposed the use of discriminant analysis; and the same authors also put forward a methodology based on canonical correlation analysis; Friedman and Sinuany-Stern (1997). Raveh (2000a) uses the co-plot, a simplified version of Multidimensional Scaling (MDS) methods to rank Greek banks. A description of the co-plot methodology can be found in Raveh (2000b).

Multivariate statistical techniques and DEA can also be used simultaneously as was done by Serrano Cinca et al. (2001). These authors combined MDS and DEA in the context of efficiency in dot.com companies. Data on a set of ratios that combined web metrics –output- and financial information –input- was represented in the form of MDS configurations, on which efficiency ratings were superimposed and used to explore the various strategic objectives of the dot.com companies. Various strategic groups of companies were identified. It was shown that the various strategic groups had different objectives, and that different DEA models were appropriate for each group.

Kneip, Park and Simar (1998) state all required statistical assumptions needed to derive consistency and convergence speeds of Farrell's estimated efficiency scores for the multivariate case with multiple inputs and multiple outputs. The rate of convergence of the efficiency scores is low and depends on the degree of smoothness of the true frontier and the number of inputs and outputs. The greater the number of inputs and outputs, the slower of the convergence rate will be. Also, the efficiency measure is sensitive to sampling variation and is upward biased by construction. Unfortunately, analytical results for the asymptotic distribution and for bias-correction are not available for the multivariate case due to the complexity involved.

3 Methodology

3.1 Data Envelopment Analysis

Data Envelopment Analysis is a flexible, mathematical programming approach for the assessment of efficiency, where efficiency is (in general) defined as a linear combination of the weighted outputs divided by a linear combination of the weighted inputs[6]. DEA models are flexible, albeit primarily deterministic unless some sort of stochastic modifier is used. A detailed development of several DEA models follows.

The piecewise-liner convex hull approach to frontier estimation, proposed by Farrell (1957), was considered by only a handful of authors in the two decades following Farrell's paper. Authors such as Boles (1966) and Afriat (1972) suggested mathematical programming method which could achieve the task, but the method did not receive wide attention until the paper by Charnes, Cooper and Rhodes (1978) which coined the term data envelopment analysis (DEA). There has since been a large number of papers which have extended and applied the DEA methodology.

There are multiple formulations of DEA models. Two of the most frequently used models are the Charnes, Cooper, and Rhodes (1978) model (CCR) and the Banker, Charnes, and Cooper (1984) model (BCC)[7]. The CCR model assumes constant

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6 Stephen M. Miller and Mukti P. Upadhyay *Total Factor Productivity, Human Capital and Outward Orientation: differences by Stage of Development and geographic Regions*, 2002.

7 Patrick L. Brockett, Reuben R. Mcdaniel,Jr, and Barbara wojcik *performance of Army Medical Department Health Delivery Components, 2001-2003: A multi-Model Approach*.2005.

returns to scale, which is arguably less appropriate for evaluation of health care entities, because there should be no assumption of constant returns to scale (Zuckerman et al, 1994). Constant returns to scale implies that if f(x) = y represents the production function, f, which relates output vector y to input vector x, then f(tx) = t(f(x)) = ty, where t is any positive scalar (Cooper, Seiford, and Tone, 1994).

3.2 The Constant Returns to Scale Model(CRS)

We shall begin by defining some notation. Assume there is data on K inputs and M outputs on each of N firms or DMU's as they tend to be called in the DEA literature. For the i-th DMU there are represented by the vectors x_i and y_i, respectively. The K·N input matrix, X, and the M·N output matrix, Y, represent the data of all N DMU's. The purpose of DEA is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier[8]. For the simple example of an industry where one output is produced using two inputs, it can be visualized as a number of intersecting planes forming a tight fitting cover over a scatter of points in three-dimensional space. Given the CRS assumption, this can also be represented by a unit isoquant in input/output space.

The best way to introduce DEA is via the ratio form. For each DMU we would like to obtain a measure of the ratio of all outputs over all inputs, such as $u'y_i/v'x_i$, where u is an M·1 vector of output weights and v is a K·1 vector of input weights. To select optimal weights we specify the mathematical programming problem:

$$\max_{u,v}(u'y_i/v'x_i)$$

[8] Coelli T.J. *A Guid to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program,* 1996.

st $\quad u'y_i/v'x_i < 1, j = 1,2, \dots, N,$

$$u, v \geq 0. \qquad (1)$$

This involves finding values for u and v, such that the efficiency measure of the i-th DMU is maximized, subject to the constraint that all efficiency measures must be less than or equal to one. One problem with this particular ratio formulation is that it has an infinite number of solutions[9]. To avoid one can impose the constrain t$v'x_i = 1$, which provides:

$$\max_{\mu,v}(\mu' y_i),$$

st $\quad v'x_i = 1,$

$$\mu' y_i - v' x_i \leq 0, \text{ j=1,2,...N},$$

$$\mu, v \geq 0, \qquad (2)$$

where the notation change from u and v to μ and v reflects the transformation. This form is known as the multiplier form of the linear programming problem.

Using the duality in linear programming, one can derive an equivalent envelopment form of this problem:

$$\min_{\theta,\lambda}\theta,$$

st $\quad -y_i + Y\lambda \geq 0,$

$$\theta x_i - X\lambda \geq 0,$$

$$\lambda \geq 0, \qquad (3)$$

where θ is a scalar and λ is a N*1 vector of constants. This envelopment form involves fewer constraints than the multiplier (K+M<N+1), and hence is gengrally the preferred form to solve.the value of θ obtained will be the efficiency score for the i-th DMU. It will satisfy $\theta \leq 1$, with a value of I indicating a point on the frontier and hence a technically efficient DMU, according to the Farrell (1957)

9 That is, if $(u^*, v^*)$is a solution, then $(\alpha u^*, \alpha v^*)$is another solution, etc.

definition. Not that the linear programming problem must be solved N times, once for each DMU in the sample. A value of θ is then obtained for each DMU.

The piecewise linear form of the non-parametric frontier in DEA can cause a few difficulties in efficiency measurement. The problem arises because of the sections of the piecewise linear frontier which run parallel to the axes which do not occur in most parametric functions. To illustrate the problem, refer to Figure 5 where the DMU's input combinations C and D are the two efficient DMU's which define the frontier, and DMU's A and B are inefficient DMU's. the Farrell (1957) measure of technical efficiency gives the efficiency of DMU's A and B as OA'/OA and OB'/OB, respectively. However, it is questionable as to whether the point A' is an efficient point since one could reduce the amount of input x_2 used (by the amount CA') and still produce the same output. This is known as input slack in the literature. Once one considers a case involving more inputs and/or multiple outputs, the diagrams are no longer as simple, and the possibility of the related concept of output slack also occurs. Thus it could be argued that both the Farrell measure of technical efficiency (θ) and any non-zero input or output slacks should be reported to provide an accurate indication of technical efficiency of a DMU in a DEA analysis.[10] Note that for the i-th DMU the out slacks will be equal to zero only if $Y\lambda - y_i = 0$, while the input slacks will be equal to zero only if $\theta x_i - X\lambda = 0$ (for the given optimal values of θ and λ).

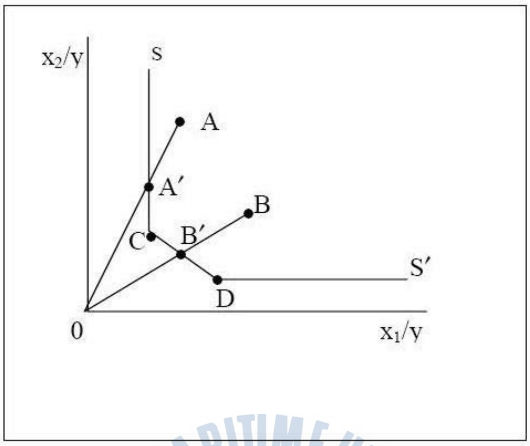
In Figure 1 the input slack associated with the point A' is CA' of input x_2. In cases when there are more inputs and outputs than considered in this simple example,

[10] Koopman's (1995) definition of technical efficiency was stricter than the Farrell (1957) definition. The former is equivalent to stating that a firm is only technically efficient if it operates on the frontier and furthermore that all associated slacks and zero.

the identification of the "nearse" efficient frontier point (such as C), and hence

Figure 1

Efficiency Measurement and Input Slacks



the subsequent calculation of slacks, is not a trivial task. Some authors (see Ali and Seiford 1993) have suggested the solution of a second-stage linear programming problem to move to an efficient frontier point by MAXIMISING the sum of slacks require to move from an inefficient frontier point (such as A' in Figure 1) to an efficient frontier point (such as point C). This second stage linear programming problem may be defined by:

$$\mathrm{Min}_{\lambda,OS,IS} - (M1'OS + K1'IS)$$

$$\text{st} \quad -y_i + Y\lambda - IS = 0$$

$$\theta x_i - X\lambda - IS = 0$$

$$\lambda \geq 0, OS \geq 0, IS \geq 0, \qquad (4)$$

where OS is an M*1 vector of output slacks, IS is a K*1 vector of input slacks, and M1 and K1 are M*1 and K*1 vectors of ones, respectively. Note that in this secondstage linear program, θ is not a variable, its value is taken from the first-stage results. Furthermore, note that this second-stage linear program must also be solved for each of the N DMU's involved.

There are two major problems associated with this second stage LP. The first and most obvious problem is that the sum of slacks is MAXIMISED rather than MINIMISED. Hence it will identify not the NEAREST efficient point but the FURTHEST efficient point. The second major problem associated with the above second-stage approach is that it is not invariant to units of measurement. The alteration of the units of measurement, say for a fertilizer input from kilograms to tones (while leaving other units of measurement unchanged), out result in the identification of different efficient boundary points and hence different slack and lambda measures[11].

Note, however, that these two issues are not a problem in the simple example presented in Figure 1 because there is only one efficient point to choose from on the vertical facet. However, if slack occurs in 2 or more dimensions (which it often does) when the above mentioned problems can come into play.

As a result of this problem, many studies simply solve the first-stage linear program for the value of the Farrell radial technical efficiency measures (θ) for each DMU and ignore the slacks completely, or they report both the radial Farrell technical efficiency score θ and the residual slacks, which may be calculated as $OS = -y_i + Y\lambda$ and $IS = \theta x_i - X\lambda$. However, this approach is not without problems either because these residual slacks may not always provide all (Koopmans) slacks and hence may not always indentify the nearest (Koopmans) efficient point for each DMU.

[11] Chares, Cooper, Rousseau and Semple (1987) suggest a units in variant model where the unit worth of a slaxk is made inversely proportional to the quantity of that input or output used by the I-th firm. This does solve the immediate problem, but does create another, in that there is no obvious reason for the slacks to be weighted in the way.

3.3 The Variable Returns to Scale Model

The CRS assumption is only appropriate when all DMU's are operating at optimal scale (i.e. one corresponding to the flat portion of the LRAC curve). Imperfect competition, constraints on finance, etc. may cause a DMU to be not operating at optimal scale. Banker, Charnes and Cooper (1984) suggested an extension of the CRS DEA model to account for variable returns to scale (VRS) situations. The use of the CRS specification when not all DMU''s are operating at the optimal scale, will result in measure of TE which are confounded by scale Efficiencies (SE). the use of the VRS specification will permit the calculation of TE devoid of these SE effects.

The CRS linear programming problem can be easily modified to account for VRS by adding the convexity constraint: N1'λ=1 to (4) to provide:

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ \text{st} \quad &-y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &N1'\lambda = 1 \\ &\lambda \geq 0, \end{aligned} \qquad (5)$$

where N1 is an N*1 vector of ones. This approach forms a convex hull of interesting planes which envelope the data points more tightly than the CRS conical hull and thus provides technical efficiency sores which are greater than or equal to those obtained using the CRS model. The VRS specification has been the most commonly used specification in the 1990's.

3.4 Input orientated and output orientated measures.

3.4.1 Input orientated measures

Farrell illustrated his ideas using a simple example involving firms which use two inputs (x_1 and x_2) to produce a single output(y), under the assumption of constant returns to scale[12]. Knowledge of the unit isoquant of the fully efficient firm, represented by SS' in Figure 2, permits the measurement of technical efficiency. If a given firm uses quantities of inputs defined by the point P, to produce a unit of output, the technical inefficiency of that firm could be represented by the distance QP, which is the amount by which all inputs could be proportionally reduced without a reduction in output. This is usually express in percentage terms by the ratio QP/0P, which represent the percentage by which all inputs could be reduced. The technical efficiency (TE) of a firm is most commonly measured by the ratio.

$$TE_I = 0Q/0P, \qquad (6)$$

which is equal to one minus QP/0P[13]. It will take a value between zero and one, and hence provides an indicator of the degree of technical inefficiency of the firm. A value of one indicates the firm is fully technically efficient. For example, the point Q is technically efficient because it lies on the efficient isoquant.

If the input price ratio, represented by the line AA' in figure 2, is also known allocative efficiency may also be calculated. The allocative efficiency (AE) of the

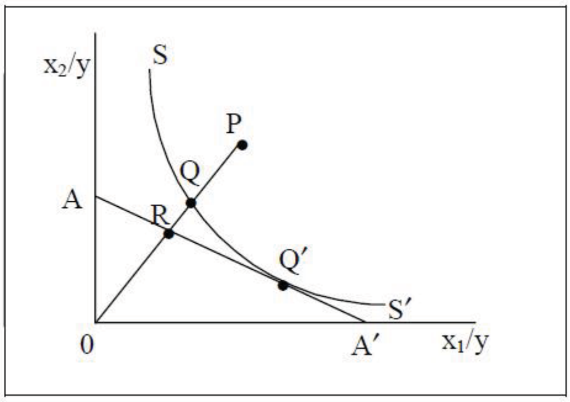
[12] The constant returns to scale assumption allows one to represent the technology using a unit isoquant. Furthermore also discussed the extension of his method so as to accommodate more than two inputs, multiple output, and non-constant returns to scale.

[13] The subscript "I" is used on the TE measure to show that it is an input-orientated measure. Output-orientated measures will be defined shortly.

firm operating at P is defined to be the ratio

Figure 2

Technical and Allocative Efficiencies



$$AE_I = 0R/0Q \quad (7)$$

since the distance RQ represents the reduction in production costs that would occur if production were to occur at the allocatively (and technically) efficient point Q', instead of a at the technically efficient, but allocatively inefficient, point Q'[14].

The total economic efficiency (EE)is defined to be the ratio

$$EE_I = 0R/0P \quad (8)$$

where the distance RP can also be interpreted in terms of a cost reduction. Note that the product of technical and allocative efficiency provides the overall economic efficiency

$$TE_I \times AE_I = (0Q/0P)\times(0R/0Q) = (0R/0P) = EE_I. \quad (9)$$

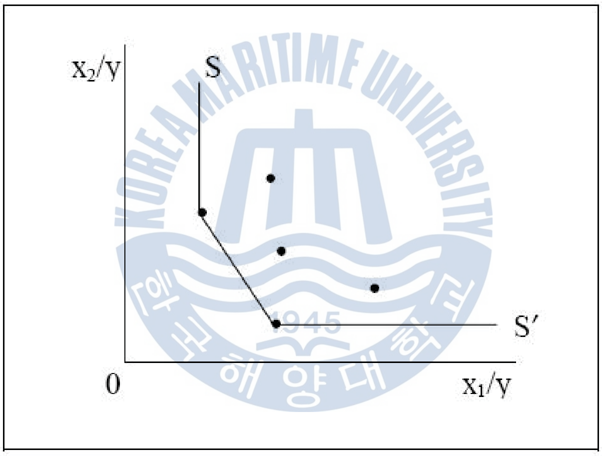
Note that all three measures are hounded by zero and one.

[14] One could illustrate this by drawing two isocost lines through Q and Q'. irrespective of the slope of there two parallel lines (which is determined by the input price ratio) the ratio RQ/0Q would represent the percentage reduction in cost associated with movement from Q to Q'.

Those efficiency measures assume the production function of the fully efficient firm is known. In practice this is not the case, and the efficient isoquant must be estimated form the sample data. Farrel suggested the use of either a non-parametric piecewise-linear convex isoquant constructed such that no observed point should lie to the left of below i, or a parametric function, such as the Cobb-Douglas form, fitted to the data, again such that no observed point should lie to the left or below it.

Figure 3

Piecewise Linear Convex Isoquant



3.4.2 Output-Orientated Measures

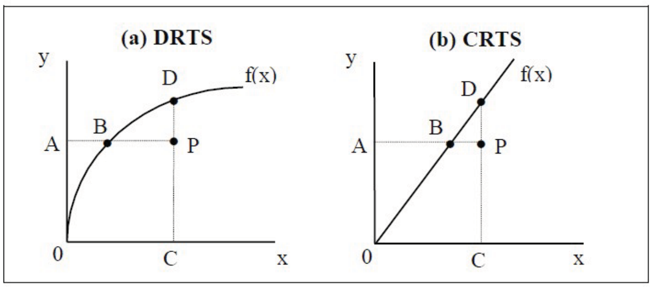
The above input-orientated technical efficiency measure addresses the question: “By how much can input quantities be proportionally reduced without changing the output quantities produced?” One could alternatively ask the question: “By how much can output quantities be proportionally expanded without altering the input quantities used?”. This is an output-orientated measure as opposed to the input-oriented measure discussed above. The difference between the output-and input-orientated measures can be illustrated using a simple example involving one input and one output. This is depicted in Figure 4(a) where we have a decreasing return to scale technology represented by f(x), and an inefficient firm operating at the point P. the Farrell input-orientated measure of TE would be equal to the ratio AB/AP, while the output-orientated measure of the TE would be CP/CD. The output- and input- orientated measures will only provide equivalent measures of technical efficiency when constant returns to scale exist, but will be unequal when increasing or decreasing returns to scale case is depicted in Figure 4(b) where we observe that AB/AP=CP/CD, for any inefficient point P we care to choose.

One can consider output-orientated measures further by considering the case where production involves two outputs (y_1 and y_2) and a single input (x_1). Again, if we assume constant returns to scale, we can represent the technology by a unit production possibility curve in two dimensions. This example is depicted in Figure 5 where the line ZZ_2 is the unit production possibility curve and the point A corresponds to an inefficient firm. Note that inefficient point, A, lies below the curve in this case because ZZ_2 represents the upper bound of production possibilities.

Figure 4

Input- and Output-Orientated Technical Efficiency Measures

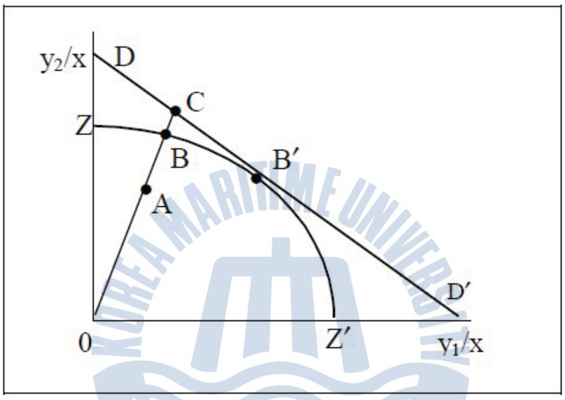
and Returns to Scale



The Farrell output-orientated efficiency measures would be defined as follows. In Figure 5 the distance AB represents technical inefficiency. That is, the amount by which outputs could be increased without requiring extra inputs. Hence a measure of output-orientated technical efficiency is the ratio

Figure 5

Technical and Allocative Efficiencies from an Output Orientation



$$TE_O = 0A/0B. \quad (10)$$

If we have price information then we can draw the isorevenue line DD_2, and define the allocative efficiency to be

$$AE_o = 0B/0C \quad (11)$$

which has a revenue increasing interpretation (similar to the cost reducing interpretation of allocative inefficiency in the input-orientated case). Furthermore, one can define overall economic efficiency as the product of these two measures

$$EE_o = (0A/0C) = (0A/0B)\cdot(0B/0C) = TE_o\cdot AE_o. \quad (12)$$

Again, all of these three measures are bounded by zero and one.

The Farrell input-and output-orientated technical efficiency measures can be shown to be equal to the input and output distance functions discussed in

Shepherd (1970). For more on this see Lovell (1993). This observation becomes important when we discuss the use of DEA methods in calculating Malmquist indices of TFP change.

In the preceding input-orientated models, the method sought to indentify technical inefficiency as a proportional reduction input usage. This corresponds to Farrell's input-based measure technical inefficiency as a proportional increase in output production. The two measures provide the same value under CRS but are unequal when VRS is assumed. Given that linear programming cannot suffer from such statistical problems as simultaneous equation bias, the choice of an appropriate orientation is not as crucial as it is in the econometric estimation case. In many studies the analysts have tended to select input-orientated models because many DMU's have particular orders to fill (e.g. electricity generation) and hence the input quantities appear to be the primary decision variables, although this argument may not be as strong in all industries. In some industries the DMUs may be given a fixed quantity of resources and asked to produce as much output as possible. In this case an output orientation would be more appropriate. Essentially one should select an orientation according to which quantities (inputs or outputs) the managers have most control over. Furthermore, in many instances upon the scores obtained (e.g. see Coelli and Perelman 1996).

The output-orientated models are very similar to their input-orientated counterparts. Consider the example of the following output-orientated VRS model:

$$\max_{\phi,\lambda} \phi,$$

$$\text{st} \quad -\phi y_i + Y\lambda \geq 0,$$

$x_i - X\lambda \geq 0,$

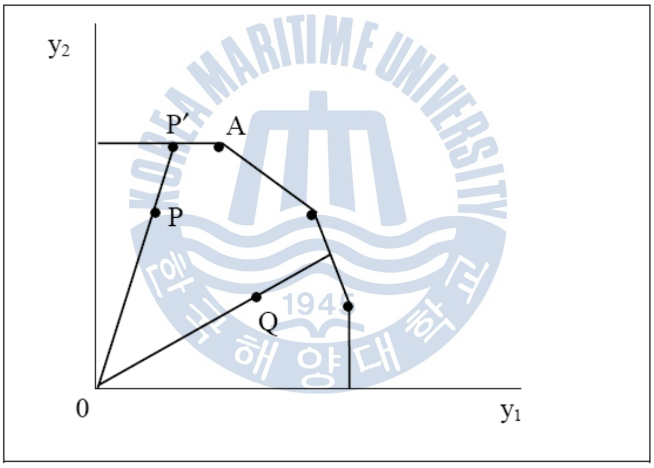
N1'λ=1

$\lambda \geq 0,$ (13)

where $1 \leq \phi < \infty$ and ϕ-1 is the proportional increase in outputs that could be achieved by the i-th DMU, with input quantities held constant[15]. Not that 1/ ϕdefines a TE core which varies between zero and one (and that this is the output-orientated TE score reported by DEAP)

Figure 6

Output-Orientated DEA



A two-output example of an output-orientate DEA could be resented by a piecewise linear production possibility curve, such as that depicted in Figure 6. Note ahta the observations lie below this curve, and that the sections of the curve which are at right angles to the axes will cause output slack to be calculated when a production point is projected onto those parts of the curve by a radial expansion in outputs. For example the point P is projected to the point P' which is on the frontier but not on the efficient frontier, because the production of $y_1$could be

15 An output-oriented CRS model is defined in a similar way, but is not presented here for brevity.

increased by the amount AP' without using any more inputs. That is there is output slack in this case of AP' in output y_1.

Once point that should be stressed is that the output- and input- orientated models will estimate exactly the same frontier and therefore, by definition, identify the same set of DMU's as being efficient. It is only the efficiency measures associated with the inefficient DMU's that may differ between the two methods. The two types of measures were illustrated in Figure 6, where we observed that the two measures would provide equivalent values only under constant returns to scale.

3.5 Scale Efficiencies[16]

Many studies have decomposed the TE scores obtained from a CRS EDA into two components, one due to scale inefficiency and one due to "pure" technical inefficiency. This may be done by conducting both a CRS and a VRS DEA upon the same data. If there is a difference in the two TE scores for a particular DMU, then this indicates that the DMU has scale inefficiency, and that the scale inefficiency can be calculated from the difference between the VRS TE sore and the CRS score.

Figure 7 attempts to illustrate this. In this figure we have a one-input one output example and have drawn the CRS and VRS DEA frontiers. Under CRS the input-orientated technical inefficiency of the point P is the distance PPc, while under VRS the technical inefficiency would only be PPv. The difference between these two, PcPv, is put down to scale inefficiency. One can also express all of this

[16] Coelli T.J. *A Guid to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program,* 1996.

in ratio efficiency measures as:

$$TE_{I,CRS} = AP_C/AP$$

$$TE_{I,VRS} = AP_V/AP$$

$$SE_I = AP_C/AP_V$$

where all of these measures will be bounded by zero and one. We also note that

$$TE_{I,CRS} = TE_{I,VRS} \times SE_I$$

because

$$AP_C/AP = (AP_V/AP) \times (AP_C/AP_V).$$

That is, the CRS technical efficiency measure is decomposed into “pure” technical efficiency and scale efficiency.

One short coming of this measure of scale efficiency is that the value does not indicate whether the DMU is operating in an area of increasing or the decreasing returns to scale. This may be determined by running an addition DEA problem with non-increasing returns to scale (NRS) imposed. This can be done by altering the DEA model by substituting the N1λ=1 restriction with N1’$\lambda \leq 1$, to provide:

$$\min_{\theta,\lambda} \theta$$

$$\text{st} \quad -y_i + Y\lambda \geq 0,$$

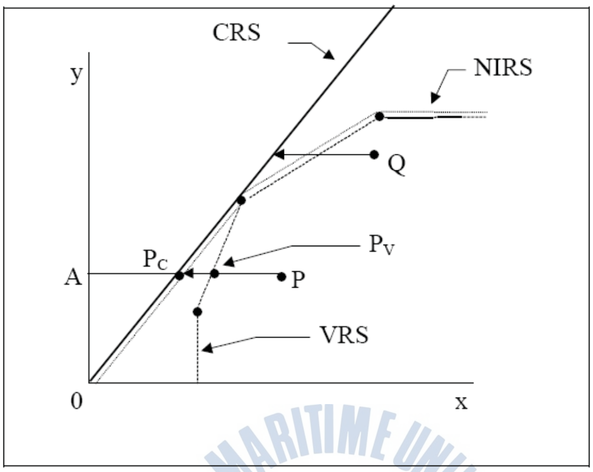
$$\theta x_i - X\lambda \geq 0,$$

$$N1'\lambda \leq 1$$

$$\lambda \geq 0, \qquad (13)$$

Figure 7

Calculation of Scale Economies in DEA



The NIRS DEA frontier is also plotted in Figure 7. The nature of the scale inefficiencies (i.e. due to increasing or decreasing returns to scale) for a particular DMU can be determined by seeing whether the NIRS TE score is equal to the VRS TE score. IF they are unequal (as will be the case for the point P in Figure 7) then increasing returns to scale exist for that DMU. If they are equal (as is the case for point Q in Figure 7) then decreasing returns to scale apply. An example of this approach applied to international airlines is provided in BIE (1994).

3.6 The Malmquist[17] Index

When one has panel data, one may use DEA-like linear programs and a (input- or output-based) Malmquist TFP index to measure productivity change, and to decompose this productivity change, and to decompose this productivity change

[17] Coelli T.J. *A Guid to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program,* 1996.

to technical change and technical efficiency change.

Fare et al (1994) specifies an output-based Manlmquist productivity change index as:

$$M_o(y_{t+1},x_{t+1},y_t x_t)=[\, d_o^t(x_{t+1},y_{t+1})/d_o^t(x_t,y_t) \times d_o^{t+1}(x_{t+1},y_{t+1})/d_o^{t+1}(x_t,y_t)\,]^{1/2}. \quad (16)$$

This represents the productivity of the production point (x_{t+1},y_{t+1}) relative to the production point (x_t,y_t). A value greater than one will indicate positive TFP growth from period t to period t+1. This index is, in fact, the geometric mean of two output-based Malmquist TFP indices. One index uses period t technology and the other period t+1 technology. To calculate quation 16 we must calculate the four component distance functions, which will involve four LP problems (similar to those conducted in calculating Farrell technical efficiency (TE) measures).

We begin by assuming CRS technology (we conduct a further decomposition later to look at a scale efficiency questions). The CRS output-orientated LP used to calculate $d_o^t(x_t,y_t)$ is identical to equation 16, except that the convexity (VRS) restriction has been removed and time subscripts have been included. That is,

$$[d_o^t(x_t,y_t)]^{-1} = \max_{\phi,\lambda}\phi,$$

$$\text{st} \qquad -\phi y_{i,t} + y_t\lambda \geq 0,$$

$$x_{i,t} + X_t\lambda \geq 0,$$

$$\lambda \geq 0, \quad (17)$$

The remaining three LP problems are simple variants of this

$$[d_o^{t+1}(x_{t+1},y_{t+1})]^{-1} = \max_{\phi,\lambda}\phi,$$

$$\text{st} \quad -\phi y_{i,t+1} + y_{t+1}\lambda \geq 0,$$
$$x_{i,t+1} + X_{t+1}\lambda \geq 0,$$
$$\lambda \geq 0, \qquad (18)$$

$$[d_o^t(x_{t+1}, y_{t+1})]^{-1} = \max_{\phi,\lambda} \phi,$$

$$\text{st} \quad -\phi y_{i,t+1} + y_{t+1}\lambda \geq 0,$$
$$x_{i,t+1} + X_t\lambda \geq 0,$$
$$\lambda \geq 0, \qquad (19)$$

$$[d_o^t(x_t, y_t)]^{-1} = \max_{\phi,\lambda} \phi,$$

$$\text{st} \quad -\phi y_{i,t} + y_{t+1}\lambda \geq 0,$$
$$x_{i,t} + X_{t+1}c \geq 0,$$
$$\lambda \geq 0, \qquad (20)$$

Note that in LP's 19 and 20, where production points are compared to technologies from different time periods, the ϕ parameter need not be $\geq$1, as it must be when calculation Farrell efficiencies. The point could lie above the feasible production set. This will most likely occur in LP 19 where a production point from period t+1 is compared to technology in period t. if technical progress has occurred, then a value of $\phi \leq$1 is possible. Note that it could also possibly occur in LP 20 if technical regress has occurred, but this is less likely.

Some points to keep in mind are that ϕ and ϕ's are likely to take different values in the above for LP's. Furthermore, note that the above four LP's must be calculated for each firm in the sample. Thus if we have 20 firms and 2 time periods we must calculate 80 LP's. Note also that as we add extra time periods, we must calculate an extra three LP's for each firm (to construct a chained index). If we have T time periods, we must calculate (3T-2) LP's for each firm in the sample.

Hence, if we have N firms, we will need to calculate N*(3T-2) LP's.

Results on each and every firm for each and every adjacent pair of time periods can be tabulated, and/or summary measures across time and/or space can be presented.

4 Data Sources

4.1 Sources of the data

This paper assumes three inputs: Investment in fixed assets (hundred million CNY), foreign investment(hundred million USD) and the population (10 thousand) which is used as labor pool for the production; two outputs: total retail sales(hundred million CNY) and total industry outputs(hundred million CNY). Price index and cargo handling capacity (10000 tons) are also used to calculate relative price index and the determinants of efficiency of seaport cities.

The following data of year 1999-2007 were taken from the Chinese Statistical Year Book[18], the Development of National Economy Bulletin[19] of each city, the homepage of Bureau of Statistics of each city, and Chinese Port Yearbook, various issues. Two inputs (investment in fixed assets, foreign funds actually used) and three outputs (total industrial output value, total value of retail sales and cargo handling capacity of coastal ports) were chosen to characterize the economy performances of those cities. Note that these input and output measures are of particular importance to the activities of cities under study (see Zhu, 1996b). The raw data are as follows:

Table 1 Data set of Shanghai

Shanghai					
	Population	Investment in Fixed Assets	Foregin Investment	Total Retail Sales	Total Industry Outputs

[18] Published by the National Bureau of Statistics of China
[19] Published by the city government at the end of the each year.

	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	1313.12	1856.72	30.48	1722.33	6213.24
2000	1321.63	1869.67	31.6	1865.28	7022.98
2001	1327.14	1994.73	43.9	2016.37	7806.18
2002	1334.23	2187.06	50.3	2203.89	8730
2003	1342.77	2452.11	58.5	2404.45	11708.49
2004	1352.39	3084.66	65.41	2656.91	14595.29
2005	1360.26	3542.55	68.5	2972.97	16876.78
2006	1368.08	3925.09	71.07	3360.41	19631.23
2007	1378.86	4458.61	79.2	3847.79	23108.63

Table 2 Data set of Ningbo

Ningbo					
	Population	Investment in Fixed Assets	Foreign Investment	Total Retail Sales	Total Industry Outputs
	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	528.41	318.93	5.20	345.76	1062.29
2000	538.94	360.26	6.22	389.29	1427.70
2001	543.37	470.28	8.74	414.20	1629.66
2002	546.19	610.27	12.47	462.87	2000.16
2003	549.07	837.60	17.27	521.50	2630.29
2004	552.69	1095.70	21.03	595.63	3815.04
2005	556.7	1370.40	23.10	759.80	5936.70
2006	560.45	1543.00	24.30	882.50	7510.70
2007	564.6	1597.90	25.10	1035.50	9513.60

Table 3 Data set of Tianjin

Tianjin					
	Population	Investment in Fixed Assets	Foreign Investment	Total Retail Sales	Total Industry Outputs
	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	910.17	567.36	25.32	657.28	682.52

2000	912	608.80	26.60	736.63	785.96
2001	913.98	705.10	32.20	832.70	869.15
2002	919.05	811.26	38.06	941.36	968.44
2003	926	1046.72	16.33	1074.50	1217.88
2004	932.55	1258.98	24.72	1044.78	1549.70
2005	939.31	1516.84	33.29	1190.06	1885.04
2006	948.89	1849.80	43.31	1356.79	2292.73
2007	959.1	2388.63	52.78	1603.74	2668.95

Table 4 Data set of Guangzhou

	Guangzhou				
	Population	Investment in Fixed Assets	Foreign Investment	Total Retail Sales	Total Industry Outputs
	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	685	878.26	31.76	1000.68	2779.37
2000	700.69	923.67	31.15	1121.13	3100.02
2001	712.6	978.21	33.27	1248.28	3393.19
2002	720.62	1009.24	26.53	1370.68	3788.91
2003	725.19	1175.17	30.64	1494.27	4705.91
2004	737.67	1348.93	24.77	1677.77	5766.69
2005	750.53	1519.16	28.41	1898.74	6767.96
2006	760.72	1696.38	30.55	2182.77	8112.40
2007	773.48	1863.34	32.86	2595.00	9870.57

Table 5 Data set of Qingdao

	Qingdao				
	Population	Investment in Fixed Assets	Foreign Investment	Total Retail Sales	Total Industry Outputs
	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	702.97	278.90	9.53	376.28	1682.24
2000	706.65	321.12	12.82	428.29	1940.83
2001	710.49	384.41	15.99	491.17	2239.85
2002	715.65	478.25	23.78	557.44	2579.43
2003	720.68	739.38	41.14	645.51	3119.56

2004	731.12	1025.42	38.17	747.50	3959.08
2005	740.91	1456.58	36.56	865.91	5001.78
2006	749.38	1485.70	31.17	1006.67	6529.27
2007	757.99	1635.40	38.07	1199.18	8314.58

Table 6 Data set of Dalian

	Dalian				
	Population	Investment in Fixed Assets	Foreign Investment	Total Retail Sales	Total Industry Outputs
	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	545.3	222.70	13.20	448.00	1030.50
2000	551.5	268.50	13.06	488.70	1079.80
2001	554.6	305.10	14.50	534.20	1100.30
2002	557.93	367.90	16.03	591.90	1245.00
2003	560.16	506.90	22.11	568.45	1517.00
2004	561.6	716.20	22.30	645.20	1997.20
2005	565.3	1110.50	10.02	732.00	2562.80
2006	572.1	1469.50	22.45	839.30	3621.60
2007	578.2	1930.80	22.80	983.30	4966.40

Table 7 Data set of Shenzhen

	Shenzhen				
	Population	Investment in Fixed Assets	Foreign Investment	Total Retail Sales	Total Industry Outputs
	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	632.56	567.88	27.54	467.45	2025.73
2000	701.24	616.25	29.68	538.17	2517.85
2001	724.57	673.37	36.03	609.26	3090.33
2002	746.62	747.15	49.02	689.59	3571.26
2003	778.27	946.49	50.42	801.77	5073.77
2004	800.80	1090.14	23.50	915.45	6509.27
2005	827.75	1181.51	29.69	1438.29	9473.57
2006	846.43	1273.67	32.69	1671.29	11633.55
2007	861.55	1345.00	36.62	1915.03	13357.25

Table 8 Data set of Zhoushan

Zhoushan					
	Population	Investment in Fixed Assets	Foreign Investment	Total Retail Sales	Total Industry Outputs
	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	98.48	37.92	0.09	54.61	100.45
2000	98.42	42.18	0.11	59.48	127.89
2001	98.26	55.72	0.11	65.40	154.94
2002	97.92	64.54	0.11	74.07	190.13
2003	97.12	98.01	0.18	75.11	240.10
2004	96.91	127.87	0.23	87.52	310.39
2005	96.71	163.83	0.31	100.14	403.64
2006	96.58	218.99	0.50	113.97	505.37
2007	96.69	279.64	0.75	132.37	642.53

Table 9 Data set of Xiamen

Xiamen					
	Population	Investment in Fixed Assets	Foreign Investment	Total Retail Sales	Total Industry Outputs
	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	128.99	192.46	13.42	140.24	698.54
2000	131.27	175.02	10.32	147.66	776.56
2001	134.36	191.89	12.72	159.93	884.32
2002	137.16	211.73	11.90	179.01	1111.50
2003	141.76	245.12	8.09	207.47	1394.17
2004	146.77	304.65	5.70	234.46	1976.03
2005	153.22	401.62	7.07	276.86	2099.03
2006	160.38	662.10	9.55	314.94	2444.75
2007	167.24	972.70	12.72	362.05	2837.09

Table 10 Data set of Fuzhou

Fuzhou

	Population	Investment in Fixed Assets	Foreign Investment	Total Retail Sales	Total Industry Outputs
	10 thousand	hundred million CNY	hundred million USD	hundred million CNY	hundred million CNY
1999	583.13	260.99	9.00	315.23	1051.04
2000	589.23	237.53	8.01	351.77	1123.85
2001	594.14	260.83	10.02	386.29	1162.64
2002	597.54	302.83	12.02	430.69	1342.91
2003	604.86	425.72	13.02	490.98	1627.09
2004	609.39	526.63	13.60	580.38	1992.10
2005	614.83	603.2595	16.00	580.38	2209.99
2006	622.73	732.34	16.21	775.53	2545.96
2007	630.3	1001.45	17.02	940.99	3080.73

4.2 The price index of 1999-2007

The price indexes for each factor were presented here were find in order to calculate the real value of the price data:

Table 11 Three price index[20] of year 1999-2007

	Investment in Fixed Assets Price Index	Ex-Factory Price Indexes of Industrial Products	Retail Price Index preceding year=100
1999	99.6	97.6	97
2000	101.1	102.8	98.5
2001	100.4	98.7	99.2
2002	100.2	97.8	98.7
2003	102.2	102.3	99.9
2004	105.6	106.1	102.8
2005	101.6	104.9	100.8
2006	101.5	103	101
2007	103.9	103.1	103.8

[20] The raw data of each kinds of price index of china was found in the Chinese Statistic Year Book 2007, with the base year 2000=100. And the price index which this paper used was converted to based on the preceding year =100.

4.3 The cargo handling capacity[21] of seaport cities

Table 12 The Cargo handling capacity of seaport cities

10000 tons

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Shanghai	18641	20440	22099	26384	31621	37896	44371	53748	56145
Ningbo	9660	11547	12852	15398	18500	22600	27000	31000	34500
Tianjin	7298	9582	11369	12906	16182	20619	24069	25760	30947
Guangzhou	11336	12455	13539	16772	19200	23887	27283	32816	36864
Qingdao	7282	8661	10423	12252	14135	16303	18678	22400	26500
Dalian	9079	9699	10500	11200	12600	14500	17100	20000	22000
Shenzhen	4663	5697	6643	8767	11220	13537	14951	17598	19994
Zhoushan	2082	3189	3281	4068	5722	7359	9052	11418	12818
Xiamen	1773	1965	2099	2735	3404	4261	6700	7792	8117
Fuzhou	1744	2425	2961	3907	4753	5939	7443	8169	6433

[21] The total handling capacity is measured by the total cargo that the city’s port handled during the year.

5. The Results of Measurement

Based on the data and of each city referring to the according price index, the following can be numerated:

Input 1: Investment in fixed assets by state-owned enterprises (hundred million CNY), where the Chinese monetary unit. (based on fixed prices of the year 2000)
Input 2: Foreign funds actually used (hundred million USD)
Input 3: Labor (10 thousand)

Output 1: Total industrial output value (based on fixed price of the year 2000)(hundred million CNY)
Output 2: Total value of retail sales (based on fixed price of the year 2000) (hundred million CNY)

5.1 **Results of the efficiency of seaport cities**

The results include two parts: the measurements with current investment and the measurements with investment lagged effect [22] applying to both the input-orientated DEA models and output-orientated DEA models. Table 13 and Table 14 show the results of efficiency values of input-orientated DEA models. Table 15 and Table 16 show the results of the output-orientated DEA models. Table 17 and Table 18 show the results of input-orientated DEA models with lagged effect of the investment, Table 19 and Table 20 shows the results of

[22] Investment has some effects on the output contemporaneously or laggedly.

Table 13 Result of the efficiency of seaport cities by input-orientated DEA models

	City	Shanghai	Ningbo	Tianjin	Guangzhou	Qingdao	Dalian	Shenzhen	Zhoushan	Xiamen	Fuzhou	mean
1999	crste	0.709	0.752	0.681	0.814	0.855	1.000	0.545	1.000	0.541	0.726	0.762
	vrste	0.731	0.825	0.712	0.816	0.865	1.000	0.559	1.000	0.881	0.749	0.814
2000	crste	0.742	0.747	0.712	0.852	0.808	0.967	0.565	1.000	0.602	0.874	0.787
	vrste	0.764	0.797	0.753	0.853	0.822	0.974	0.575	1.000	0.901	0.909	0.835
2001	crste	0.720	0.617	0.719	0.893	0.764	0.953	0.589	0.961	0.597	0.832	0.765
	vrste	0.761	0.637	0.754	0.898	0.774	0.955	0.598	0.998	0.902	0.859	0.814
2002	crste	0.718	0.531	0.724	0.940	0.688	0.920	0.604	1.000	0.608	0.790	0.752
	vrste	0.753	0.535	0.753	0.955	0.693	0.923	0.611	1.000	0.925	0.808	0.796
2003	crste	0.702	0.443	0.724	0.886	0.563	0.692	0.574	0.905	0.611	0.698	0.680
	vrste	0.723	0.450	0.759	0.886	0.572	0.704	0.581	1.000	0.953	0.709	0.734
2004	crste	0.667	0.444	0.568	0.876	0.495	0.592	0.653	0.994	0.817	0.697	0.680
	vrste	0.704	0.480	0.576	0.881	0.504	0.604	0.660	1.000	1.000	0.707	0.712
2005	crste	0.759	0.641	0.535	0.881	0.431	0.666	0.850	1.000	0.789	0.617	0.717
	vrste	0.788	0.662	0.538	0.881	0.475	0.811	0.855	1.000	1.000	0.619	0.763
2006	crste	0.871	0.794	0.512	0.913	0.562	0.481	0.942	0.998	0.876	0.701	0.765
	vrste	0.898	0.806	0.515	0.914	0.581	0.509	0.943	1.000	1.000	0.708	0.787
2007	crste	1.000	1.000	0.498	1.000	0.685	0.638	1.000	1.000	1.000	0.663	0.848
	vrste	1.000	1.000	0.522	1.000	0.704	0.646	1.000	1.000	1.000	0.675	0.855
mean	crste	0.765	0.663	0.630	0.895	0.650	0.768	0.702	0.984	0.716	0.733	0.751
	vrste	0.791	0.688	0.654	0.898	0.666	0.792	0.709	1.000	0.951	0.749	0.790

Table 14 Rank of the efficiency of seaport cities by input-orientated DEA models

	City	Shanghai	Ningbo	Tianjin	Guangzhou	Qingdao	Dalian	Shenzhen	Zhoushan	Xiamen	Fuzhou
1999	crste	7	5	8	4	3	1	9	1	10	6
	vrste	8	5	9	6	4	1	10	1	3	7
2000	crste	7	6	8	4	5	2	10	1	9	3
	vrste	8	7	9	5	6	2	10	1	4	3
2001	crste	6	8	7	3	5	2	10	1	9	4
	vrste	6	8	7	4	9	2	10	1	3	5
2002	crste	5	10	6	2	7	3	9	1	8	4
	vrste	6	10	6	2	8	4	9	1	3	5
2003	crste	4	10	3	2	8	6	9	1	7	5
	vrste	5	10	4	3	9	7	8	1	2	6
2004	crste	5	10	8	2	9	7	6	1	3	4
	vrste	5	10	8	3	9	7	6	1	1	4
2005	crste	5	7	9	3	10	6	2	1	4	8
	vrste	6	7	9	3	10	5	4	1	1	8
2006	crste	5	6	9	3	8	10	2	1	4	7
	vrste	5	6	9	4	8	10	3	1	1	7
2007	crste	1	1	10	1	7	9	1	1	1	8
	vrste	1	1	10	1	7	9	1	1	1	8
mean	crste	4	8	10	2	9	3	7	1	6	5
	vrste	5	8	10	3	9	4	6	1	2	7

Table 15 Result of the efficiency of seaport cities by output-orientated DEA models

	City	Shanghai	Ningbo	Tianjin	Guangzhou	Qingdao	Dalian	Shenzhen	Zhoushan	Xiamen	Fuzhou	mean
1999	crste	0.709	0.752	0.681	0.814	0.855	1.000	0.545	1.000	0.541	0.726	0.762
	vrste	0.737	0.831	0.777	0.830	0.869	1.000	0.553	1.000	0.738	0.756	0.809
2000	crste	0.742	0.747	0.712	0.852	0.808	0.967	0.565	1.000	0.602	0.874	0.787
	vrste	0.774	0.804	0.805	0.870	0.814	0.974	0.584	1.000	0.803	0.912	0.834
2001	crste	0.720	0.617	0.719	0.893	0.764	0.953	0.589	0.961	0.597	0.832	0.765
	vrste	0.779	0.644	0.800	0.912	0.765	0.953	0.609	0.962	0.810	0.863	0.810
2002	crste	0.718	0.531	0.724	0.940	0.688	0.920	0.604	1.000	0.608	0.790	0.752
	vrste	0.778	0.542	0.794	0.961	0.716	0.920	0.624	1.000	0.864	0.813	0.801
2003	crste	0.702	0.443	0.724	0.886	0.563	0.692	0.574	0.905	0.611	0.698	0.680
	vrste	0.819	0.446	0.762	0.899	0.578	0.693	0.584	1.000	0.919	0.714	0.741
2004	crste	0.667	0.444	0.568	0.876	0.495	0.592	0.653	0.994	0.817	0.697	0.680
	vrste	0.827	0.451	0.580	0.882	0.498	0.593	0.672	1.000	1.000	0.712	0.722
2005	crste	0.759	0.641	0.535	0.881	0.431	0.666	0.850	1.000	0.789	0.617	0.717
	vrste	0.868	0.643	0.556	0.885	0.434	0.828	0.856	1.000	1.000	0.624	0.769
2006	crste	0.871	0.794	0.512	0.913	0.562	0.481	0.942	0.998	0.876	0.701	0.765
	vrste	0.934	0.794	0.525	0.916	0.564	0.487	0.943	1.000	1.000	0.713	0.788
2007	crste	1.000	1.000	0.498	1.000	0.685	0.638	1.000	1.000	1.000	0.663	0.848
	vrste	1.000	1.000	0.563	1.000	0.689	0.644	1.000	1.000	1.000	0.685	0.858
mean	crste	0.765	0.663	0.630	0.895	0.650	0.768	0.702	0.984	0.716	0.733	0.751
	vrste	0.835	0.684	0.685	0.906	0.659	0.788	0.714	0.996	0.904	0.755	0.792

Table 16 Rank of the efficiency of seaport cities by output-orientated DEA models

	City	Shanghai	Ningbo	Tianjin	Guangzhou	Qingdao	Dalian	Shenzhen	Zhoushan	Xiamen	Fuzhou
1999	crste	7	5	8	4	3	1	9	1	10	6
	vrste	9	4	6	5	3	1	10	1	8	7
2000	crste	7	6	8	4	5	2	10	1	9	3
	vrste	9	7	6	4	5	2	10	1	8	3
2001	crste	6	8	7	3	5	2	10	1	9	4
	vrste	7	9	6	3	8	2	10	1	5	4
2002	crste	7	10	6	2	8	3	9	1	9	5
	vrste	7	10	6	2	8	3	9	1	4	5
2003	crste	3	10	5	2	9	6	8	1	7	4
	vrste	4	10	5	3	9	7	8	1	2	6
2004	crste	5	10	8	2	9	7	6	1	3	4
	vrste	4	10	8	3	9	7	6	1	1	5
2005	crste	5	7	9	2	10	6	3	1	4	8
	vrste	4	7	9	3	10	6	5	1	1	8
2006	crste	5	6	9	3	8	10	2	1	4	7
	vrste	4	6	9	5	8	10	3	1	1	7
2007	crste	1	1	10	1	7	9	1	1	1	8
	vrste	1	1	10	1	7	9	1	1	1	8
mean	crste	4	8	10	2	9	3	7	1	6	5
	vrste	9	7	8	2	10	5	7	1	3	6

Table 17 Result of the efficiency of seaport cities by input-orientated DEA models with investment lagged effect

	City	Shanghai	Ningbo	Tianjin	Guangzhou	Qingdao	Dalian	Shenzhen	Zhoushan	Xiamen	Fuzhou	mean
2000	crste	0.677	0.772	0.691	0.806	0.891	1.000	0.559	1.000	0.511	0.735	0.764
	vrste	0.692	0.819	0.718	0.808	0.895	1.000	0.569	1.000	0.854	0.754	0.811
2001	crste	0.712	0.723	0.732	0.845	0.846	0.970	0.584	1.000	0.590	0.869	0.787
	vrste	0.728	0.755	0.771	0.846	0.857	0.975	0.593	1.000	0.882	0.899	0.831
2002	crste	0.697	0.621	0.732	0.869	0.788	0.961	0.603	1.000	0.606	0.848	0.773
	vrste	0.726	0.635	0.763	0.869	0.796	0.963	0.611	1.000	0.902	0.869	0.813
2003	crste	0.712	0.549	0.749	0.919	0.751	0.809	0.668	1.000	0.648	0.836	0.764
	vrste	0.732	0.553	0.779	0.925	0.755	0.818	0.673	1.000	0.939	0.851	0.803
2004	crste	0.727	0.490	0.650	0.914	0.619	0.733	0.649	0.999	0.772	0.777	0.733
	vrste	0.820	0.511	0.684	0.915	0.626	0.743	0.655	1.000	1.000	0.787	0.774
2005	crste	0.760	0.646	0.583	0.890	0.531	0.608	0.894	1.000	0.839	0.643	0.739
	vrste	0.792	0.664	0.590	0.894	0.539	0.619	0.929	1.000	1.000	0.649	0.768
2006	crste	0.861	0.794	0.550	0.909	0.534	0.723	0.929	1.000	0.895	0.744	0.794
	vrste	0.865	0.805	0.553	0.909	0.559	0.931	0.929	1.000	1.000	0.746	0.830
2007	crste	1.000	1.000	0.559	1.000	0.690	0.608	1.000	1.000	1.000	0.792	0.865
	vrste	1.000	1.000	0.562	1.000	0.700	0.630	1.000	1.000	1.000	0.800	0.869
mean	crste	0.768	0.699	0.656	0.894	0.706	0.802	0.736	1.000	0.733	0.781	0.777
	vrste	0.794	0.718	0.678	0.896	0.716	0.835	0.745	1.000	0.947	0.794	0.812

Table 18 Rank of the efficiency of seaport cities by input-orientated DEA models with investment lagged effect

	City	Shanghai	Ningbo	Tianjin	Guangzhou	Qingdao	Dalian	Shenzhen	Zhoushan	Xiamen	Fuzhou
2000	crste	8	5	7	4	3	1	9	1	10	6
	vrste	9	5	8	6	3	1	10	1	4	7
2001	crste	8	7	6	5	4	2	9	1	10	3
	vrste	9	8	7	6	5	2	10	1	4	3
2002	crste	7	8	5	3	6	2	9	1	10	4
	vrste	8	9	7	4	6	2	10	1	3	4
2003	crste	7	10	6	2	5	4	8	1	9	3
	vrste	8	10	6	3	7	5	9	1	2	4
2004	crste	6	10	7	2	9	5	8	1	4	3
	vrste	4	10	7	3	9	6	8	1	1	3
2005	crste	5	6	9	3	10	8	2	1	4	7
	vrste	5	6	9	4	10	8	3	1	1	7
2006	crste	5	6	8	3	9	8	2	1	4	7
	vrste	6	7	10	5	9	3	4	1	1	8
2007	crste	1	1	10	1	8	9	1	1	1	7
	vrste	1	1	10	1	8	9	1	1	1	7
mean	crste	5	9	10	2	8	3	6	1	7	4
	vrste	5	8	10	3	9	4	7	1	2	5

Table 19 Result of the efficiency of seaport cities by output-orientated DEA models with investment lagged effect

	City	Shanghai	Ningbo	Tianjin	Guangzhou	Qingdao	Dalian	Shenzhen	Zhoushan	Xiamen	Fuzhou	mean
2000	crste	0.677	0.772	0.691	0.806	0.891	1.000	0.559	1.000	0.511	0.735	0.764
	vrste	0.696	0.824	0.775	0.820	0.897	1.000	0.574	1.000	0.705	0.759	0.805
2001	crste	0.712	0.723	0.732	0.845	0.846	0.970	0.584	1.000	0.590	0.869	0.787
	vrste	0.735	0.759	0.814	0.859	0.851	0.975	0.600	1.000	0.766	0.902	0.826
2002	crste	0.697	0.621	0.732	0.869	0.788	0.961	0.603	1.000	0.606	0.848	0.773
	vrste	0.767	0.640	0.802	0.883	0.790	0.961	0.621	1.000	0.811	0.871	0.815
2003	crste	0.712	0.549	0.749	0.919	0.751	0.809	0.668	1.000	0.648	0.836	0.764
	vrste	0.818	0.557	0.811	0.934	0.764	0.810	0.669	1.000	0.887	0.853	0.810
2004	crste	0.727	0.490	0.650	0.914	0.619	0.733	0.649	0.999	0.772	0.777	0.733
	vrste	0.895	0.496	0.694	0.924	0.629	0.735	0.651	1.000	1.000	0.790	0.781
2005	crste	0.760	0.646	0.583	0.890	0.531	0.608	0.894	1.000	0.839	0.643	0.739
	vrste	0.865	0.647	0.593	0.894	0.531	0.609	0.933	1.000	1.000	0.652	0.772
2006	crste	0.861	0.794	0.550	0.909	0.534	0.723	0.929	1.000	0.895	0.744	0.794
	vrste	0.908	0.795	0.567	0.911	0.539	0.940	0.929	1.000	1.000	0.749	0.834
2007	crste	1.000	1.000	0.559	1.000	0.690	0.608	1.000	1.000	1.000	0.792	0.865
	vrste	1.000	1.000	0.598	1.000	0.693	0.615	1.000	1.000	1.000	0.802	0.871
mean	crste	0.768	0.699	0.656	0.894	0.706	0.802	0.736	1.000	0.733	0.781	0.777
	vrste	0.836	0.715	0.707	0.903	0.712	0.831	0.747	1.000	0.896	0.797	0.814

Table 20 Rank of the efficiency of seaport cities by output-orientated DEA models with investment lagged effect

	City	Shanghai	Ningbo	Tianjin	Guangzhou	Qingdao	Dalian	Shenzhen	Zhoushan	Xiamen	Fuzhou
2000	crste	8	5	7	4	3	1	9	1	10	6
	vrste	9	4	6	5	3	1	10	1	8	7
2001	crste	8	7	6	5	4	2	10	1	9	3
	vrste	9	8	6	4	5	2	10	1	7	3
2002	crste	7	8	6	3	5	2	10	1	9	4
	vrste	8	9	6	3	7	2	10	1	5	4
2003	crste	7	10	6	2	5	4	8	1	9	3
	vrste	5	10	6	2	8	7	9	1	3	4
2004	crste	4	8	7	2	9	5	10	1	6	3
	vrste	4	10	7	3	9	6	8	1	1	5
2005	crste	5	6	9	3	10	8	2	1	4	7
	vrste	5	7	9	4	10	8	3	1	1	6
2006	crste	5	6	9	3	10	8	2	1	4	7
	vrste	6	7	9	5	10	3	4	1	1	8
2007	crste	1	1	10	1	8	9	1	1	1	7
	vrste	1	1	10	1	8	9	1	1	1	7
mean	crste	5	9	10	2	8	3	6	1	7	4
	vrste	4	8	10	2	9	5	7	1	3	5

output-orientated DEA models with the lagged effect of investment.

1) Zhoushan is the most efficient seaport city. In the past nine years, this city has shown the first ranking in both constant returns to scale efficiency and variable returns to scale efficiency among the ten largest seaport cities of China.

2) Shenzhen, as the newly-built coastal open city, the improvement of efficiency is clear and significant. According to Table 13 to Table 20, the efficiency value in the past 9 years of Shenzhen increased fast and steady: From the last rank in year 1999 achieved first rank in year 2007; and from CRS 0.545 VRS 0.559 in year 1999 to CRS 1.000 and VRS 1.000.

3) To the contrary, the old north seaport city Dalian has suffered decreasing efficiency in the past years: The efficiency value of CRS and VRS decreased from 1.000 to 0.638 and 0.646, even in the year 2006 reduced to 0.481(CRS) and 0.509(VRS); The efficiency rank of Dalian also decreased form first rank to 10^{th} in year 2006 and 9^{th} in year 2007.

4) Compare the average CRS values and average VRS values of the 9 years of each seaport city, the results are relatively steady, and a little increasing is showed. This means that the efficiency of these seaport cities have enjoyed stability and a small amount of increase.

5) In the year 2007 six seaport cities’ CRS and VRS value achieved 1.000

6) In the past nine years efficiency of the largest five seaport cities(Shanghai Ningbo Tianjin Guangzhou Qingdao)' kept correspondingly steadily, without notable change.

7) The results made by input-orientated DEA and output-orientated DEA are similar with or without considering the investment lagged effect.

5.2 Results about scale economic (SE) and returns to scale (RS)

5.2.1 Results of scale economic and returns to scale of Shanghai

The results of scale economic and returns to scale of Shanghai are showed in Table 21 and Figure 8, and the explanations are as follows:

1) As the "Center of Chinese Economy", Shanghai experiences decrease returns to scale (drs) for eight times during the past nine years and constant returns to scale (crs) for only one times.

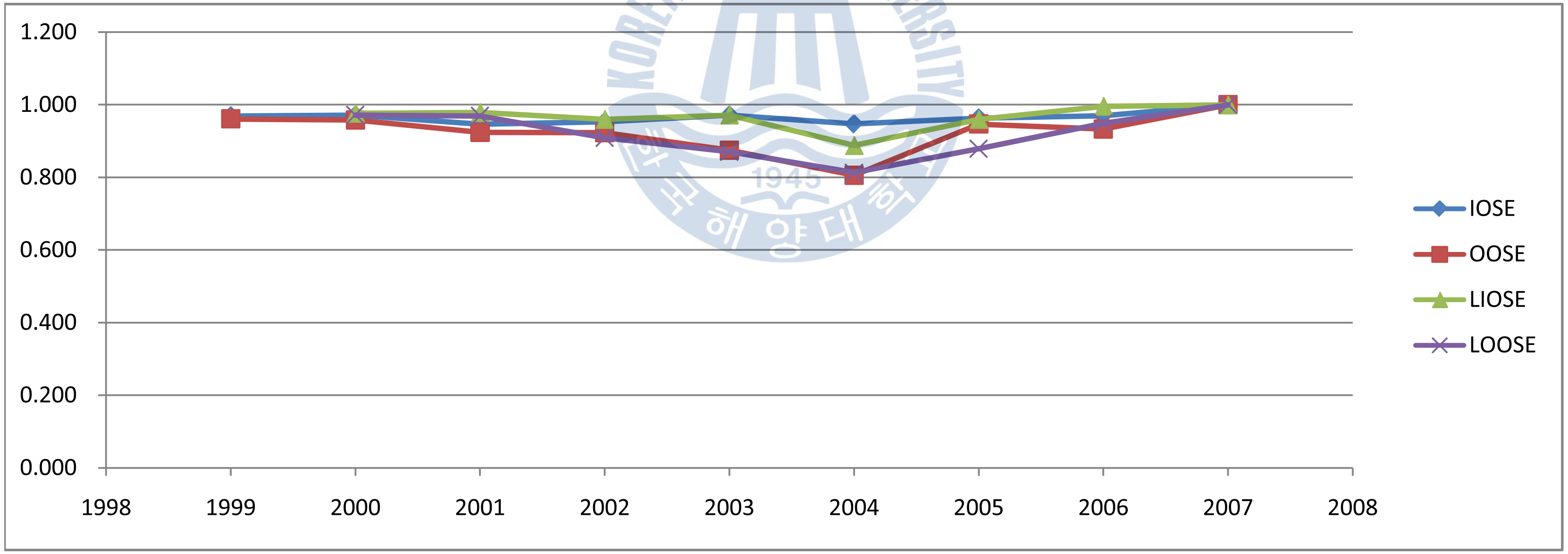
2) The scale economy appears comparatively efficient with the value of about 0.960 and 0.970, and in the year 2007 reached the most efficient.

3) According to Figure 8, there were not much difference between IOSE(input-oriented scale economy) and OOSE(output-oriented scale economy); LIOSE(input-oriented scale economy with investment lagged effect and LOOSE(output-oriented scale economy with investment lagged effect), which means that the investment aspect have effect but not much to do with

Table 21 Scale economic and returns to scale of Shanghai

Shanghai		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	0.969	0.971	0.946	0.953	0.971	0.947	0.963	0.970	1.000
	IORS	drs	drs	drs	drs	drs	drs	drs	drs	crs
Output orientated model	OOSE	0.961	0.958	0.924	0.923	0.875	0.806	0.947	0.933	1.000
	OORS	drs	drs	drs	drs	drs	drs	drs	drs	crs
Input orientated model with investment lagged	LIOSE		0.977	0.979	0.96	0.972	0.888	0.96	0.996	1.000
	LIORS		drs	drs	drs	drs	drs	drs	drs	crs
Output orientated model with investment lagged	LOOSE		0.972	0.969	0.909	0.871	0.813	0.879	0.949	1.000
	LOORS		drs	drs	drs	drs	drs	drs	drs	crs

Figure 8 Scale economic and returns to scale of Shanghai



the economy efficiency.

4) In the year 2007, Shanghai's economy performance reaches the most efficient point and enjoyed constant returns to scale instead of 8 years decreases returns to scale.

5.2.2 Results of scale economic and returns to scale of Ningbo

The results of scale economic and returns to scale of Ningbo are showed in Table 22 and Figure 9, and the explanations are as follows:

1) Ningbo is the second largest seaport city of China. In the first part of last 9 years (1999-2002), Ningbo experienced decreasing returns to scale, but at after year 2002, increasing returns to scale came up in the input-orientated DEA model measurement.

2) As the scale economic, Ningbo appears steadily and comparatively efficient with the value near "1" in the most of the past 9 years. And in the year 2007 all the four models shows it reached the most efficient value, 1.000.

3) The investment lagged effect did not make much difference in Ningbo's economy efficiency as Figure 9 showed.

5.2.3 Results of scale economic and returns to scale of Tianjin

The results of scale economic and returns to scale of Tianjin are showed in Table 23 and Figure 10, and the explanations are as follows:

Table 22 Scale economic and returns to scale of Ningbo

Ningbo		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	0.912	0.937	0.968	0.992	0.984	0.924	0.969	0.985	1.000
	IORS	drs	drs	drs	drs	irs	irs	irs	irs	crs
Output orientated model	OOSE	0.905	0.930	0.957	0.980	0.994	0.984	0.998	1.000	1.000
	OORS	drs	drs	drs	drs	drs	drs	drs	crs	crs
Input orientated model with investment lagged	LIOSE		0.943	0.958	0.978	0.994	0.958	0.974	0.986	1.000
	LIORS		drs	drs	drs	drs	irs	irs	irs	crs
Output orientated model with investment lagged	LOOSE		0.937	0.952	0.971	0.986	0.988	0.999	0.998	1.000
	LOORS		drs	drs	drs	drs	drs	crs	irs	crs

Figure 9 Scale economic and returns to scale of Ningbo

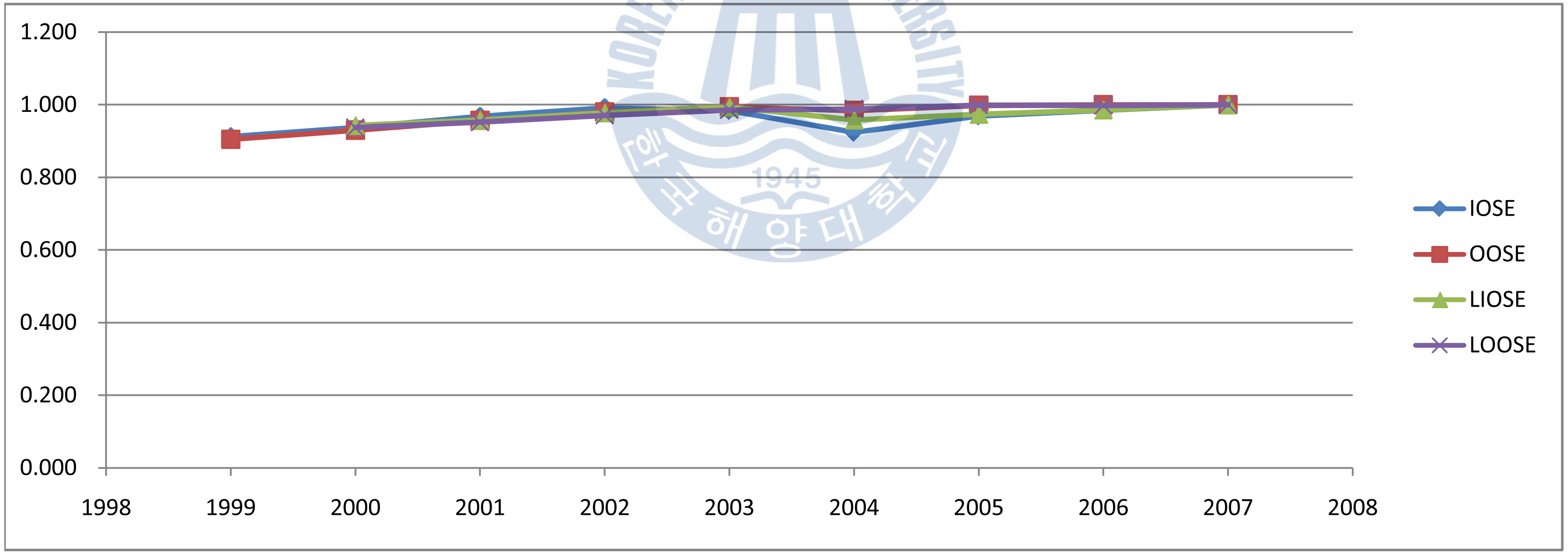
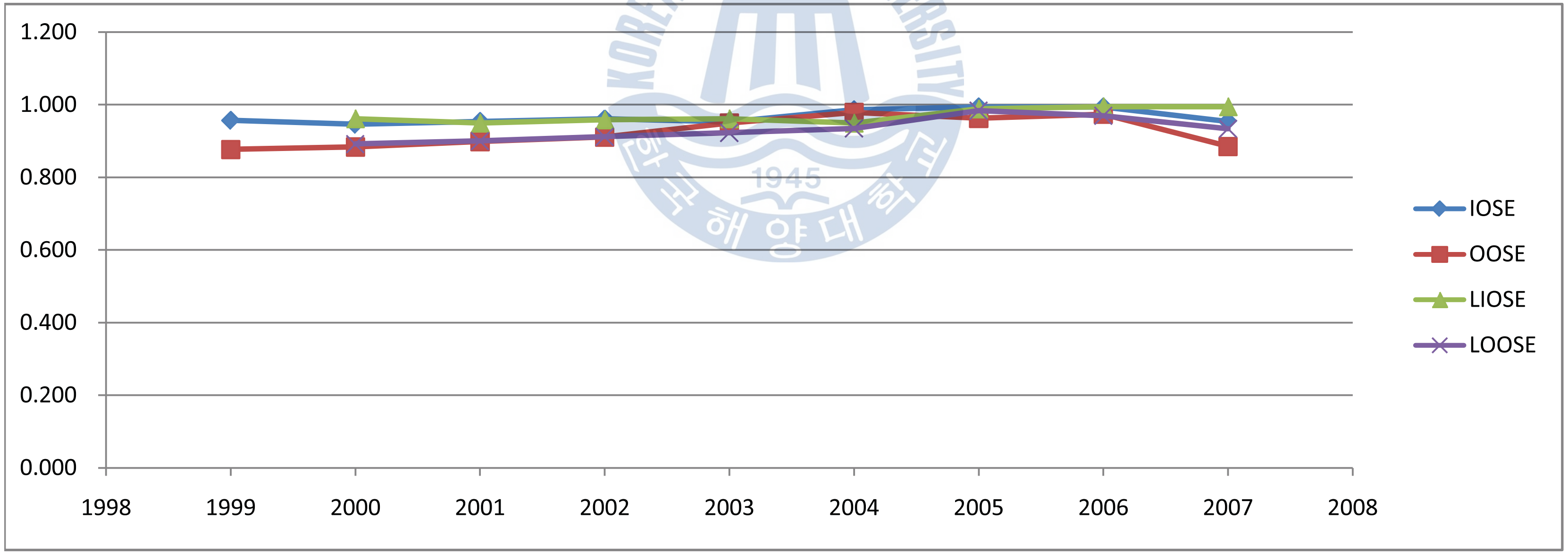


Table 23 Scale economic and returns to scale of Tianjin

Guangzhou		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	0.957	0.946	0.954	0.961	0.953	0.986	0.994	0.994	0.954
	IORS	drs	drs	drs	drs	drs	drs	irs	irs	irs
Output orientated model	OOSE	0.877	0.884	0.899	0.911	0.950	0.979	0.963	0.974	0.885
	OORS	drs	drs	drs	drs	drs	drs	drs	drs	drs
Input orientated model with investment lagged	LIOSE		0.962	0.950	0.959	0.962	0.950	0.989	0.995	0.995
	LIORS		drs	drs	drs	drs	drs	drs	irs	irs
Output orientated model with investment lagged	LOOSE		0.892	0.900	0.912	0.923	0.935	0.984	0.970	0.934
	LOORS		drs	drs	drs	drs	drs	drs	drs	drs

Figure 10 Scale economic and returns to scale of Tianjin



1) In the first part of last nine years, Tianjin has suffered decreasing returns to scale until year 2004, but from the year 2005 the situation started to change.

2) The sale economy values of Tianjin kept raising in the first eight years, which means its scale efficiency improves very clearly and smoothly. But in the year 2007 the scale efficiency got down again.

3) The IOSE and LIOSE, OOSE and LOOSE line of Tianjin are also similar with each other, which shows us the investment and the investment lagged effect worked on but not much.

5.2.4 Results of scale economic and returns to scale of Guangzhou

The results of scale economic and returns to scale of Guangzhou are showed in Table 24 and Figure 11, and the explanations are as follows:

1) Seaport city Guangzhou shows decrease returns to scale in the most of last nine years. This phenomena maybe due to the development of the nearby seaport city Shenzhen. It will be hard for Guangzhou to make lager development.

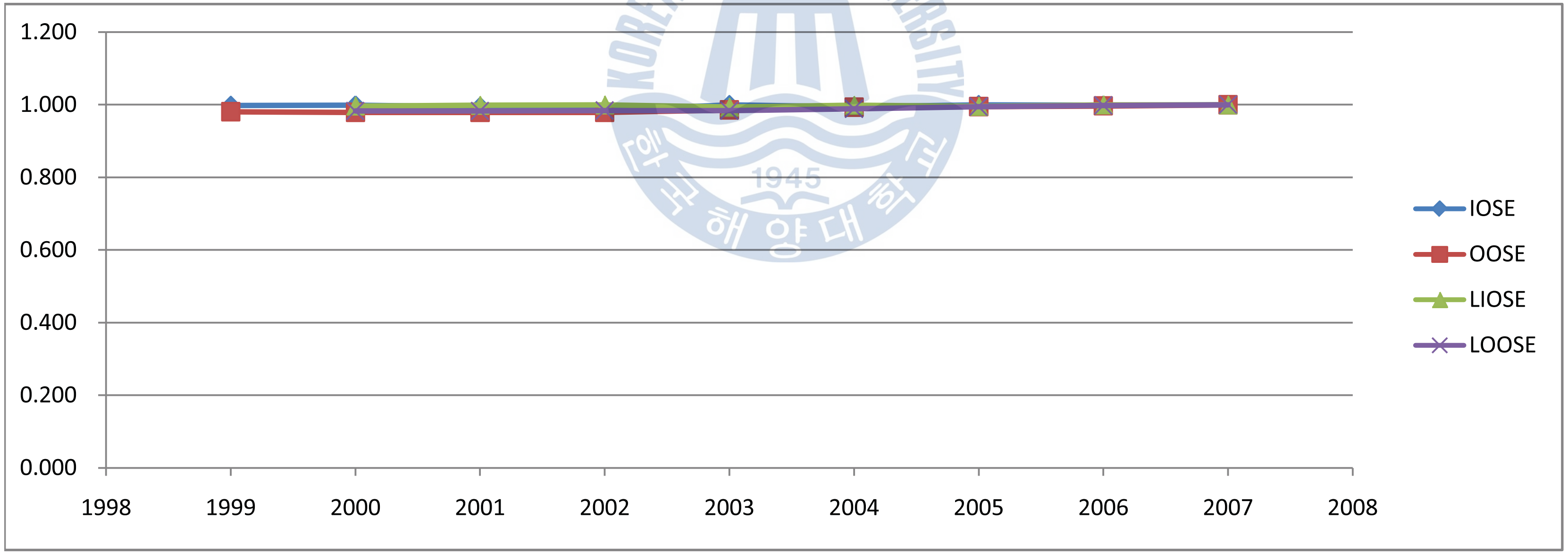
2) Scale economic of Guangzhou performs comparatively efficient, with the SE value near “1” for the most years.

3) In Figure 11, the four lines IOSE, LIOSE, OOSE,LOOSE almost keep in the same, telling us that the investment lag did not affect much about Guangzhou’s efficiency.

Table 24 Scale economic and returns to scale of Guangzhou

Guangzhou		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	0.998	0.999	0.995	0.985	1.000	0.995	1.000	0.999	1.000
	IORS	irs	irs	drs	drs	crs	drs	crs	irs	crs
Output orientated model	OOSE	0.981	0.979	0.979	0.979	0.986	0.993	0.995	0.997	1.000
	OORS	drs	drs	drs	drs	drs	drs	drs	drs	crs
Input orientated model with investment lagged	LIOSE		0.997	0.999	1.000	0.994	0.999	0.996	1.000	1.000
	LIORS		irs	irs	crs	drs	drs	drs	crs	crs
Output orientated model with investment lagged	LOOSE		0.983	0.983	0.984	0.984	0.989	0.995	0.998	1.000
	LOORS		drs	drs	drs	drs	drs	drs	drs	crs

Figure 11 Scale economic and returns to scale of Guangzhou



5.2.5 Results of scale economic and returns to scale of Qingdao

The results of scale economic and returns to scale of Qingdao are showed in Table 25 and Figure 12, and the explanations are as follows:

1) Qingdao performs not steadily, though it enjoyed increase returns to scale in most of the nine years, decrease returns to scale came out for several times.

2) As to the scale economy, Qingdao performed much more steadily than other cities with the value lager than 0.900.

3) The lagged investment effect which are showed in Figure 12 are not clear in Qingdao's results.

5.2.6 Results of scale economic and returns to scale of Dalian

The results of scale economic and returns to scale of Dalian are showed in Table 26 and Figure 13, and the explanations are as follows:

1) Dalian showed increasing return to scale for most of years in the last past 9 years, but also showed decreasing returns to scale for many times.

2) The scale economy of Dalian performed very good with the SE value near "1", except the year 2005.

3) According to the investment lagged effect, the investment lag showed lower

Table 25 Scale economic and returns to scale of Qingdao

Qingdao		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	0.989	0.983	0.987	0.992	0.985	0.982	0.906	0.968	0.973
	IORS	drs	irs	irs	irs	irs	irs	irs	irs	irs
Output orientated model	OOSE	0.985	0.993	0.998	0.960	0.974	0.994	0.993	0.998	0.994
	OORS	drs	irs	irs	drs	drs	drs	irs	drs	irs
Input orientated model with investment lagged	LIOSE		0.995	0.987	0.990	0.994	0.988	0.985	0.956	0.986
	LIORS		drs	irs	irs	irs	irs	irs	irs	irs
Output orientated model with investment lagged	LOOSE		0.993	0.994	0.999	0.982	0.984	1.000	0.990	0.997
	LOORS		drs	irs	irs	drs	drs	crs	irs	irs

Figure 12 Scale economic and returns to scale of Qingdao

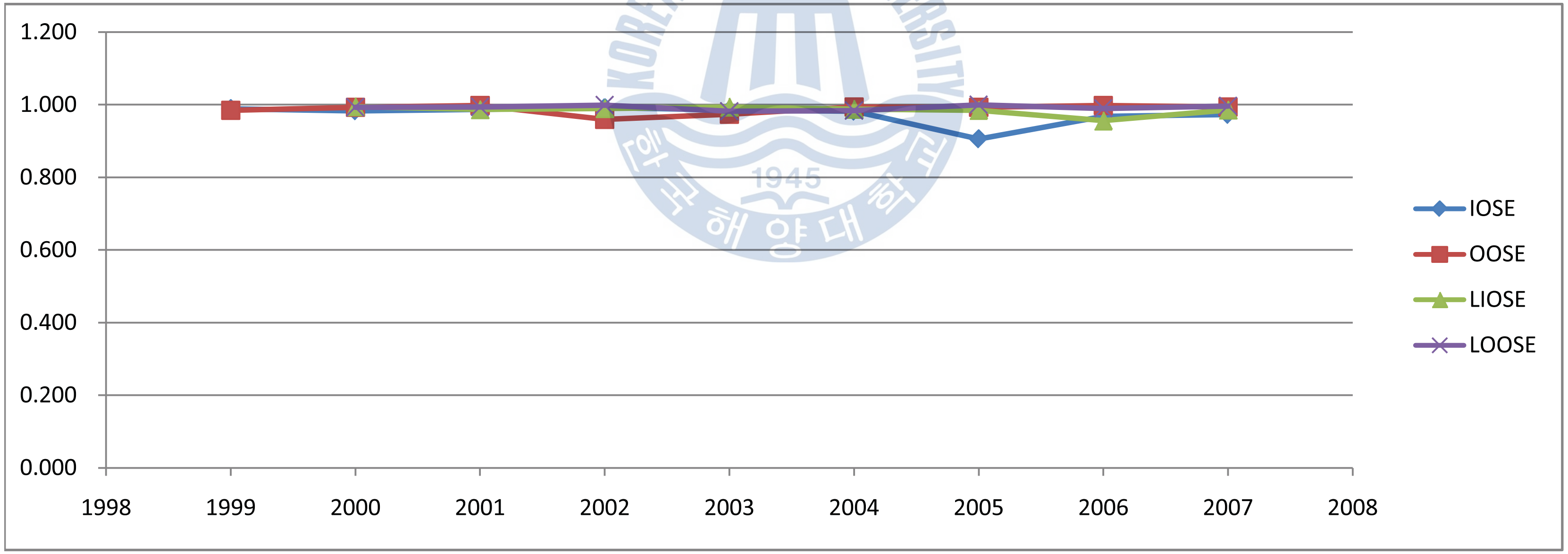
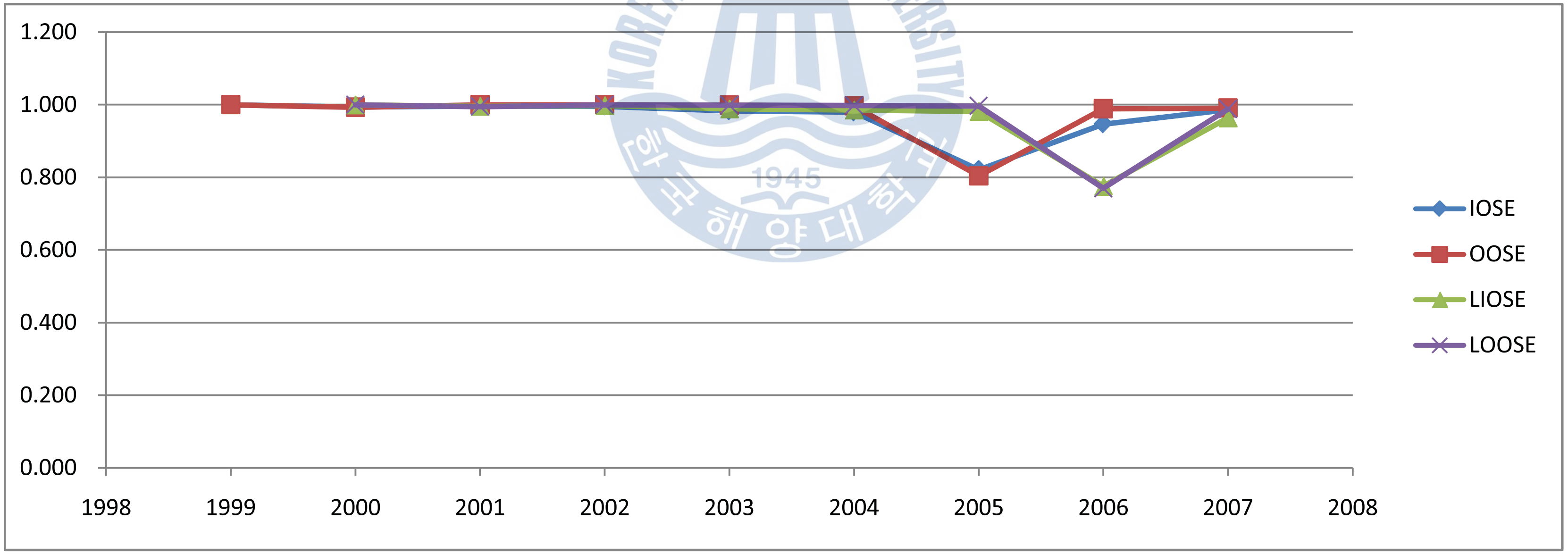


Table 26 Scale economic and returns to scale of Dalian

Dalian		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	1.000	0.994	0.997	0.996	0.983	0.980	0.821	0.947	0.987
	IORS	crs	drs	irs	irs	irs	irs	drs	irs	irs
Output orientated model	OOSE	1.000	0.993	1.000	1.000	0.999	0.997	0.804	0.989	0.991
	OORS	crs	drs	crs	crs	irs	irs	drs	drs	drs
Input orientated model with investment lagged	LIOSE		1.000	0.996	0.998	0.989	0.986	0.982	0.776	0.964
	LIORS		crs	drs	irs	irs	irs	irs	drs	irs
Output orientated model with investment lagged	LOOSE		1.000	0.995	1.000	0.999	0.998	0.997	0.770	0.988
	LOORS		crs	drs	crs	irs	irs	irs	drs	irs

Figure 13 Scale economic and returns to scale of Dalian



scale performance from year 2005 to year 2006. This shows that the investment from both nation and foreign countries are very important for Dalian's economy performance.

5.2.7 Results of scale economic and returns to scale of Shenzhen

The results of scale economic and returns to scale of Shenzhen are showed in Table 27 and Figure 14, and the explanations are as follows:

1) As a newly built city, Shenzhen mainly has experienced increasing returns to scale in the first part of the past 9 years,but later, decreasing returns to scale occurred several times and constant returns to scale came in the later years.

2) As to the scale economy, Shenzhen performed comparatively efficiently, and in the year 2007, it reached the value 1.000, the most efficiency point.

3) The investment lagged effect is not clear in Shenzhen's performance.

5.2.8 Results of scale economic and returns to scale of Zhoushan

The results of scale economic and returns to scale of Zhoushan are showed in Table 28 and Figure 15, and the explanations are as follows:

1) In the last 9 years Zhoushan continue enjoyed constant returns to scale and increase returns to scale, decreasing returns to scale has never happened, good prospect of development is clear.

Table 27 Scale economic and returns to scale of Shenzhen

Shenzhen		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	0.976	0.982	0.986	0.988	0.988	0.988	0.995	0.999	1.000
	IORS	irs	irs	irs	irs	irs	drs	drs	drs	crs
Output orientated model	OOSE	0.987	0.969	0.968	0.967	0.982	0.971	0.993	0.999	1.000
	OORS	drs	drs	drs	crs	drs	drs	drs	drs	crs
Input orientated model with investment lagged	LIOSE		0.981	0.985	0.988	0.992	0.991	0.962	1.000	1.000
	LIORS		irs	irs	irs	irs	irs	drs	crs	crs
Output orientated model with investment lagged	LOOSE		0.973	0.973	0.971	0.998	0.998	0.958	1.000	1.000
	LOORS		drs	drs	drs	drs	irs	drs	crs	crs

Figure 14 Scale economic and returns to scale of Shenzhen

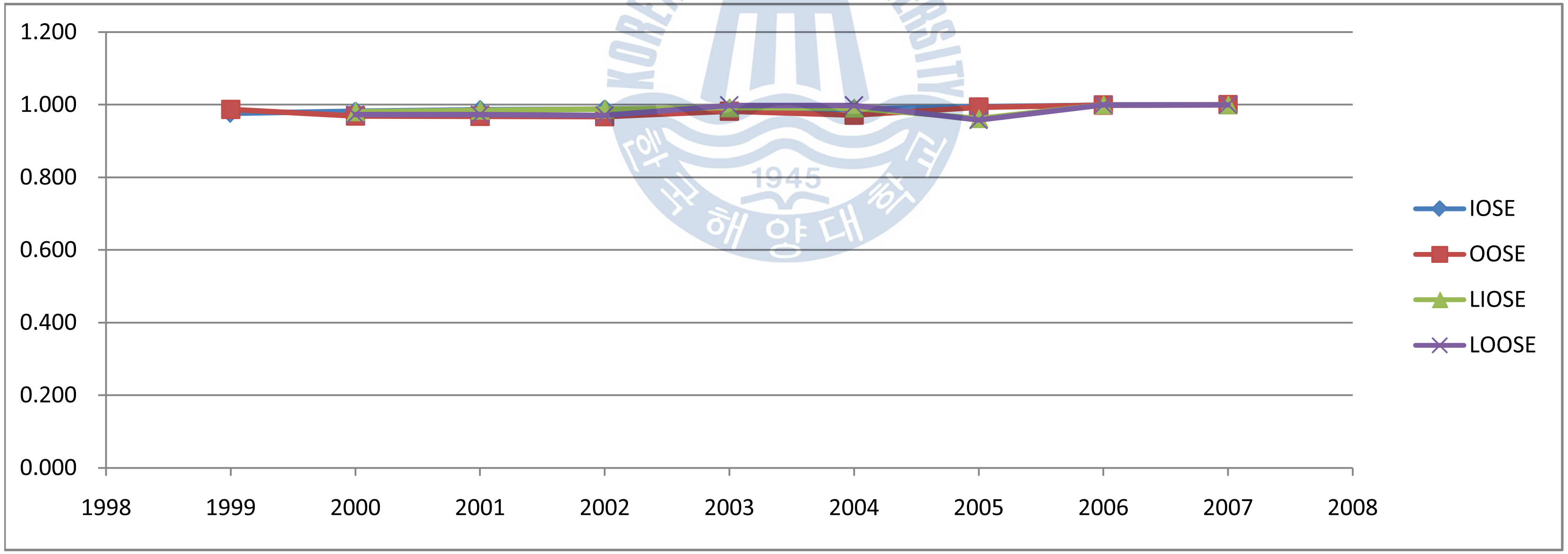
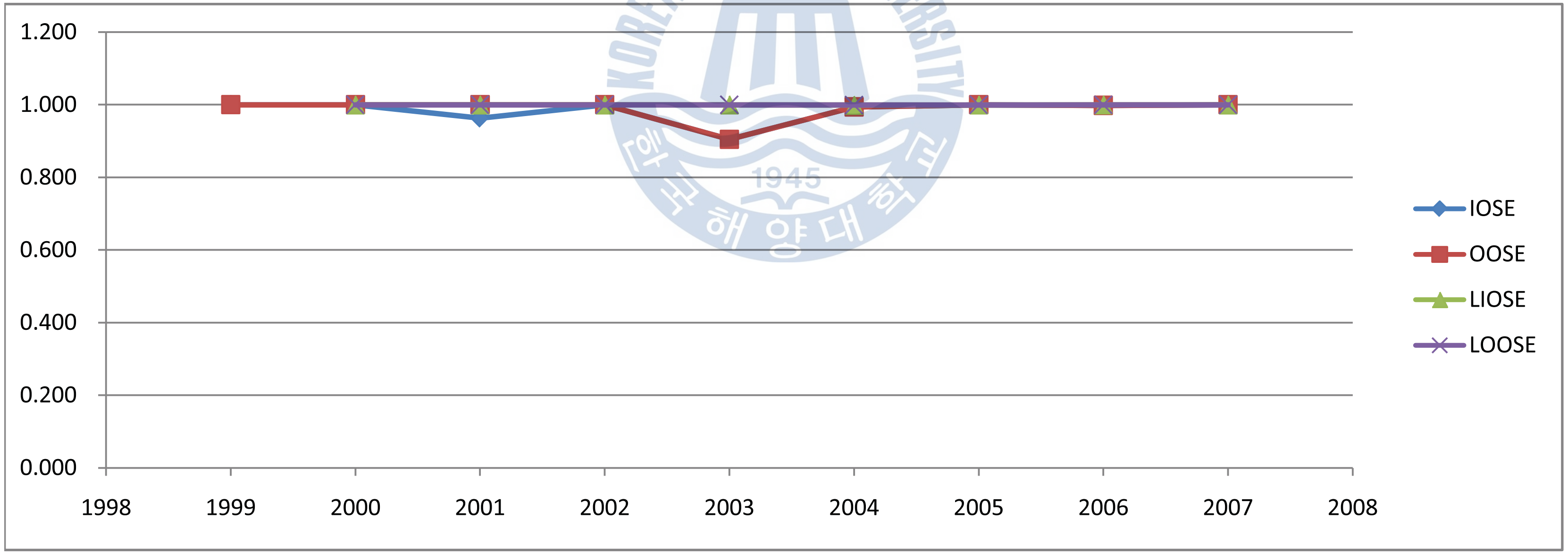


Table 28 Scale economic and returns to scale of Zhoushan

Zhoushan		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	1.000	1.000	0.963	1.000	0.905	0.994	1.000	0.998	1.000
	IORS	crs	crs	irs	crs	irs	irs	crs	irs	crs
Output orientated model	OOSE	1.000	1.000	1.000	1.000	0.905	0.994	1.000	0.998	1.000
	OORS	crs	crs	crs	crs	irs	irs	crs	irs	crs
Input orientated model with investment lagged	LIOSE		1.000	1.000	1.000	1.000	0.999	1.000	1.000	1.000
	LIORS		crs	crs	crs	crs	irs	crs	crs	crs
Output orientated model with investment lagged	LOOSE		1.000	1.000	1.000	1.000	0.999	1.000	1.000	1.000
	LOORS		crs	crs	crs	crs	irs	crs	crs	crs

Figure 15 Scale economic and returns to scale of Zhoushan



2) The scale economic efficiency of Zhoushan performed comparatively more steadily than other cities, with the SE value at about “1”. It is the most efficient seaport city of all the ten cities.

3) Considering the investment lagged effect, the scale efficiency performances are better than the results estimated by current investment. This means investment played a very important part in Zhoushan’s economy performance.

5.2.9 Results of scale economic and returns to scale of Xiamen

The results of scale economic and returns to scale of Xiamen are showed in Table 29 and Figure 16, and the explanations are as follows:

1) As one of the largest container seaport cities of China, Xiamen enjoyed increasing returns to scale form year 1999 to 2006. The foreground is good to Xiamen, although in year 2007 constant returns to scale appears and instead of increasing returns to scale.

2) The scale economic value of Xiamen kept rising in the past nine years. The improvement was comparatively steady, and by the end year reach value “1”.

3) The scale efficiency performs better in Xiamen when we confer the lagged effect in almost all the years.

5.2.10 Results of scale economic and returns to scale of Fuzhou

Table 29 Scale economic and returns to scale of Xiamen

Xiamen		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	0.614	0.668	0.662	0.657	0.642	0.817	0.789	0.876	1.000
	IORS	irs	irs	irs	irs	irs	irs	irs	irs	crs
Output orientated model	OOSE	0.733	0.750	0.737	0.704	0.665	0.817	0.789	0.876	1.000
	OORS	irs	irs	irs	irs	irs	irs	irs	irs	crs
Input orientated model with investment lagged	LIOSE		0.598	0.669	0.671	0.690	0.772	0.839	0.895	1.000
	LIORS		irs	irs	irs	irs	irs	irs	irs	crs
Output orientated model with investment lagged	LOOSE		0.724	0.771	0.746	0.730	0.772	0.839	0.895	1.000
	LOORS		irs	irs	irs	irs	irs	irs	irs	crs

Figure 16 Scale economic and returns to scale of Xiamen

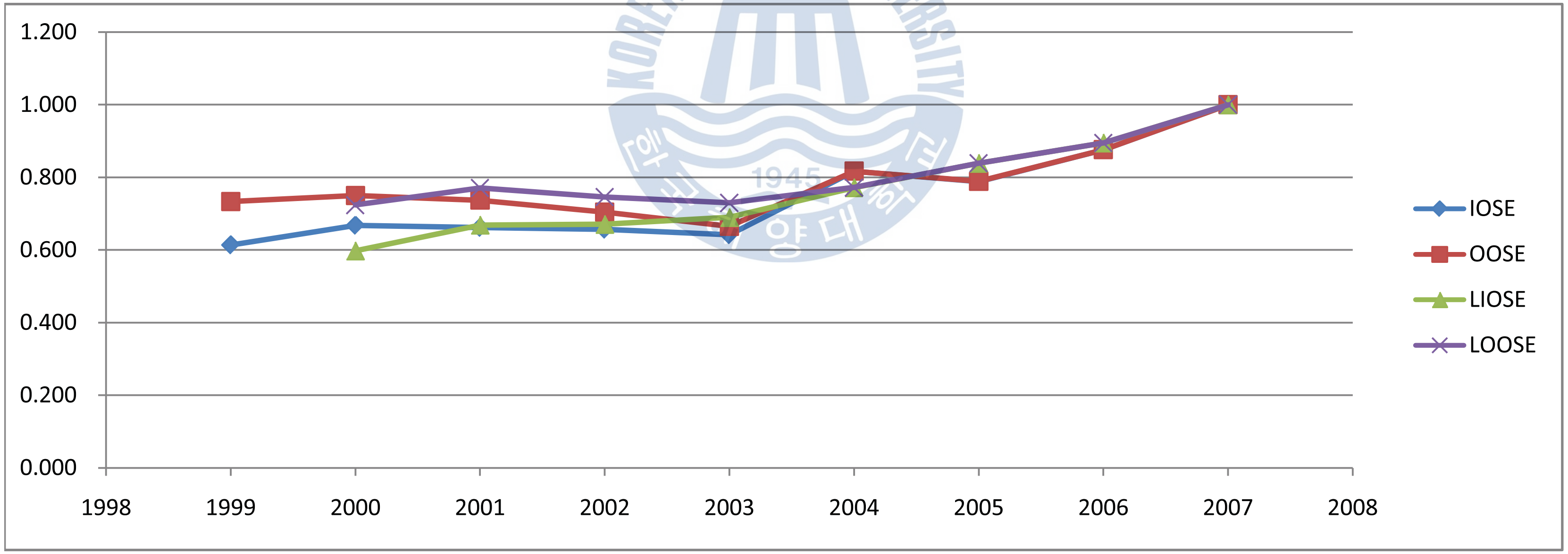
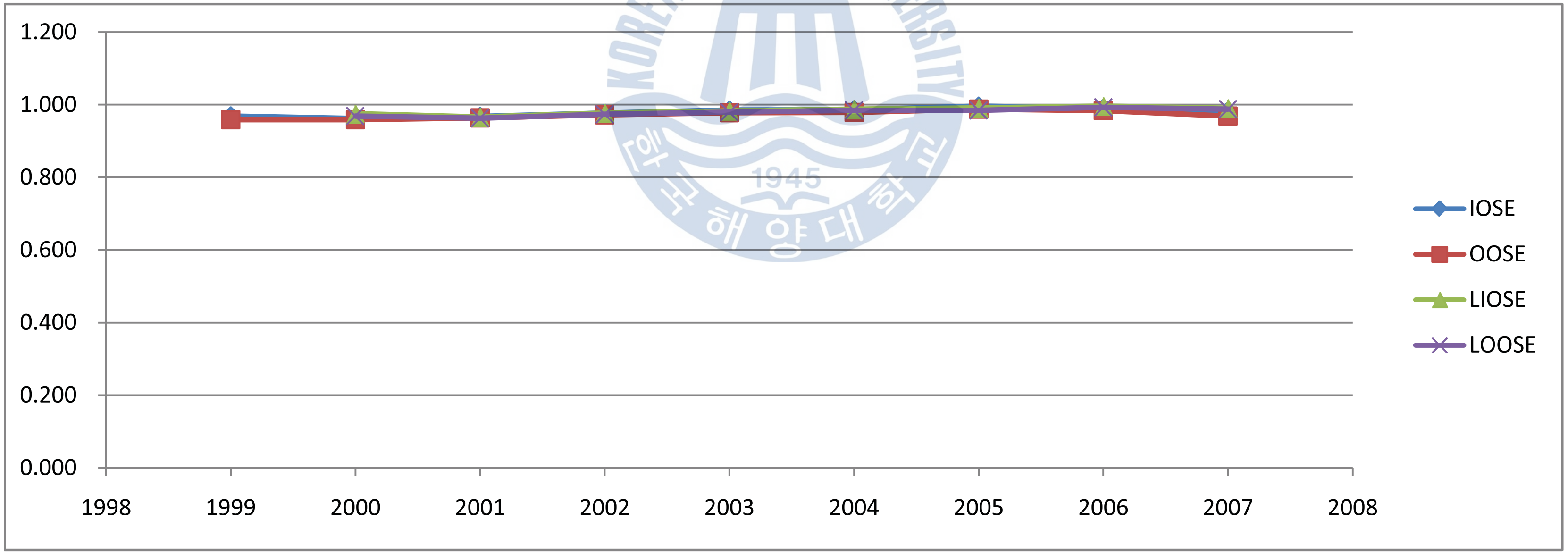


Table 30 Scale economic and returns to scale of Fuzhou

Fuzhou		1999	2000	2001	2002	2003	2004	2005	2006	2007
Input orientated model	IOSE	0.969	0.962	0.968	0.977	0.985	0.986	0.996	0.990	0.983
	IORS	drs	drs	drs	drs	drs	drs	drs	drs	drs
Output orientated model	OOSE	0.959	0.959	0.964	0.972	0.978	0.979	0.988	0.984	0.969
	OORS	drs	drs	drs	drs	drs	drs	drs	drs	drs
Input orientated model with investment lagged	LIOSE		0.975	0.966	0.977	0.983	0.988	0.991	0.996	0.990
	LIORS		drs	drs	drs	drs	drs	drs	drs	drs
Output orientated model with investment lagged	LOOSE		0.969	0.963	0.974	0.980	0.985	0.985	0.993	0.988
	LOORS		drs	drs	drs	drs	drs	drs	drs	drs

Figure 17 Scale economic and returns to scale of Fuzhou



The results of scale economic and returns to scale of Fuzhou are showed in Table 30 and Figure 17, and the explanations are as follows:

1) As an old seaport city, Fuzhou is the main port of Chinese mainland for Taiwan. Fuzhou experienced decreasing returns to scale for the all past 9 years.

2) Fuzhou's scale economy values are all "1" in the last 9 years, scale efficiency is very clear and the increasing is steadily.

3) The IOSE and LIOSE, OOSE and LOOSE line are also similar with each other in Fuzhou, shows that the investment and lagged effect have not notable effect in Fuzhou's economy performance compare with other aspects.

5.3 Results of the productivity of the seaport cities by using the Malmquist Index

5.3.1 Malmquist productivity of Shanghai

The malmquist productivity of Shanghai is showed in Table 31 and Table 32, and the explanations are as follows:

Table 31Malmquist productivity of Shanghai

Shanhai		effch	techch	pech	sech	tfpch
1999-2000	Shanghai	1.000	1.096	1.000	1.000	1.096
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Shanghai	1.000	0.967	1.000	1.000	0.967
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Shanghai	1.000	1.032	1.000	1.000	1.032

	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Shanghai	1.000	1.191	1.000	1.000	1.191
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Shanghai	1.000	1.157	1.000	1.000	1.157
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Shanghai	1.000	1.137	1.000	1.000	1.137
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Shanghai	1.000	1.155	1.000	1.000	1.155
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Shanghai	1.000	1.173	1.000	1.000	1.173
	mean	0.997	1.128	0.997	1.001	1.125
Mean	Shanghai	1.000	1.111	1.000	1.000	1.111
	mean	0.985	1.059	0.985	1.000	1.043

Note: "effch" means efficiency change; "techch" means technical change; "pech" means pure efficiency change; "sech" means scale efficiency change and "tfpch" means total factor productivity change.

Table 32 Malmquist productivity of Shanghai with lagged effect

Shanhai		effch	techch	pech	sech	tfpch
2000-2001	Shanghai	1.000	1.070	1.000	1.000	1.070
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Shanghai	1.000	0.970	1.000	1.000	0.970
	mean	1.000	1.007	0.998	1.002	1.007
2002-2003	Shanghai	1.000	1.207	1.000	1.000	1.207
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Shanghai	1.000	1.178	1.000	1.000	1.178
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Shanghai	1.000	1.116	1.000	1.000	1.116
	mean	0.921	1.118	0.901	1.022	1.030
2005-2006	Shanghai	1.000	1.151	1.000	1.000	1.151
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Shanghai	1.000	1.179	1.000	1.000	1.179
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Shanghai	1.000	1.122	1.000	1.000	1.122
	mean	0.985	1.066	0.985	1.000	1.051

1) In the last 9 years, the average total factor productivity change value of

Shanghai is 1.111, which means that the average total factor productivity of Shanghai increased averagely 11.1%. Compare with the average “tfpch” value 1.043 of all the ten seaport cities, the increasing of Shanghai is comparatively higher. Only in the period 2001-2002 the total factor productivity of Shanghai appears decreaseing.

2) The average total factor productivity change of shanghai appears 1.1% higher with a view to the investment lagged effect.

3) The pure efficiency change average value of Shanghai is 1, it is higher than the average of all the ten seaport cities value of 0.985, which means the pure efficiency of Shanghai stayed constant while the ten cities average experianced decreasing of 1.5% in the past 9 years.

4) The average technical change value techch is 1.111 shows an 11.1% of average technical increase in the past nine years of Shanghai.

5) When considering the investment lagged effect of investment, all performances of shanghai’s economy efficiency appear a little higher than the results in view of current investment.

6) Technical change is the most important element which contribute to Shanghai’s total factor productivity change.

5.3.2 Malmquist productivity of Ningbo

The malmquist productivity of Ningbo is showed in Table 33 and Table 34, and the explanations are as follows:

Table 33 Malmquist productivity of Ningbo

Ningbo		effch	techch	pech	sech	tfpch
1999-2000	Ningbo	1.084	1.067	1.000	1.084	1.157
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Ningbo	0.915	0.942	0.979	0.935	0.862
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Ningbo	0.934	0.972	0.881	1.061	0.908
	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Ningbo	0.837	1.149	0.828	1.011	0.962
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Ningbo	0.843	1.347	0.927	0.909	1.136
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Ningbo	1.408	1.024	1.331	1.058	1.442
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Ningbo	1.131	1.127	1.083	1.045	1.275
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Ningbo	1.051	1.212	1.048	1.003	1.274
	mean	0.997	1.128	0.997	1.001	1.125
Mean	Ningbo	1.011	1.098	1.000	1.011	1.111
	mean	0.985	1.059	0.985	1.000	1.043

Table 34 Malmquist productivity of Ningbo with investment lagged effect

Ningbo		effch	techch	pech	sech	tfpch
2000-2001	Ningbo	0.984	1.013	1.000	0.984	0.997
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Ningbo	0.982	0.950	1.000	0.982	0.934
	mean	1.000	1.007	0.998	1.002	1.007
2002-2003	Ningbo	0.865	1.169	0.859	1.007	1.011
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Ningbo	0.938	1.153	0.988	0.949	1.082
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Ningbo	0.998	1.381	1.033	0.966	1.378
	mean	0.921	1.118	0.901	1.022	1.030

2005-2006	Ningbo	1.160	1.097	1.080	1.074	1.273
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Ningbo	1.102	1.148	1.057	1.043	1.265
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Ningbo	1.000	1.123	1.000	1.000	1.123
	mean	0.985	1.066	0.985	1.000	1.051

1) The average total factor productivity of Ningbo's tfpch value is 1.111, and this shows Ningbo enjoyed an increasing productivity of 11.1% in the past years. Meanwhile, the average of ten seaport cities' total factor productivity tfpch value is 1.043. Ningbo is higher than the average.

2) In most of the past nine year Ningbo enjoyed increasing of total factor productivity, with the value larger than 1. Especially in period 2004-2005 the total factor productivity value reached 1.442.

3) With considering to the investment lagged effect, Ningbo's total productivity efficiency change yearly values are comparatively higher. On average 1.2% higher than the result without considering the investment lagged effect.

4) The average efficiency change value is 1.011 shows 1.1% of increase of efficiency change, higher than the average of the ten cities -0.15%.

5) Technical change is contributes to the total factor productivity with the increase of 9.8%, this is showed by the techch value 1.098.

6) Technical change, scale efficiency change and efficient change are the three important elements which contribute to the total factor productivity change of

Ningbo.

5.3.3 Malmquist productivity of Tianjin

The malmquist productivity of Tianjin is showed in Table 35 and Table 36,and the explanations are as follows:

Table 35 Malmquist productivity of Tianjin

Tianjin		effch	techch	pech	sech	tfpch
1999-2000	Tianjin	1.033	1.024	1.040	0.994	1.058
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Tianjin	0.999	1.026	0.964	1.037	1.025
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Tianjin	1.005	1.003	0.972	1.035	1.009
	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Tianjin	1.250	0.879	1.237	1.010	1.099
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Tianjin	0.685	1.099	0.685	0.999	0.752
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Tianjin	0.941	1.000	0.948	0.993	0.941
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Tianjin	0.903	1.032	0.909	0.993	0.932
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Tianjin	0.880	1.149	0.885	0.994	1.010
	mean	0.997	1.128	0.997	1.001	1.125
Mean	Tianjin	0.950	1.024	0.944	1.007	0.973
	mean	0.985	1.059	0.985	1.000	1.043

Table 36 Malmquist productivity of Tianjin with investment lagged effect

Tianjin		effch	techch	pech	sech	tfpch
2000-2001	Tianjin	1.039	1.033	1.026	1.013	1.073
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Tianjin	0.994	1.024	0.970	1.024	1.018
	mean	1.000	1.007	0.998	1.002	1.007

2002-2003	Tianjin	1.092	0.934	0.992	1.100	1.020
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Tianjin	0.961	0.975	1.129	0.852	0.937
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Tianjin	0.805	1.076	0.674	1.195	0.867
	mean	0.921	1.118	0.901	1.022	1.030
2005-2006	Tianjin	0.927	1.018	0.924	1.003	0.943
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Tianjin	0.910	1.088	0.961	0.948	0.990
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Tianjin	0.957	1.020	0.944	1.014	0.976
	mean	0.985	1.066	0.985	1.000	1.051

1) The total factor productivity of Tianjin experienced decreasing by 2.7% averagely during the past 9 years, which can be find clearly from the average "tfpch" value 0.973; at the same time all the ten cities averagely enjoyed a 4.3% increasing.

2) From table 35 we can find easily that Tianjin suffered decreasing of total productivity in the period of from 2003 to 2006. The pure efficiency decreasing was the main causation.

3) For Tianjin, the malmquist results appear a little higher when with views to the investment lagged effect than the results estimated with the current investment.

4) Although the total factor productivity suffered decreasing in Tianjin, the technical change and scale efficiency change enjoyed increasing. Especially the "sech" value, which stands for scale efficiency change, is 1.007, higher than the average 1 of the ten seaport cities.

5) Anyhow, the decreasing of pure efficiency change is the main causation of the decreasing of the total factor productivity, although the technical and scale economy tried to increase it.

5.3.4 Malmquist productivity of Guangzhou

The malmquist productivity of Guangzhou is showed in Table 37 and Table 38, and the explanations are as follows:

Table37 Malmquist productivity of Guangzhou

Guangzhou		effch	techch	pech	sech	tfpch
1999-2000	Guangzhou	1.000	1.073	1.000	1.000	1.073
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Guangzhou	1.000	1.060	1.000	1.000	1.060
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Guangzhou	1.000	1.123	1.000	1.000	1.123
	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Guangzhou	1.000	1.024	1.000	1.000	1.024
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Guangzhou	1.000	1.139	1.000	1.000	1.139
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Guangzhou	1.000	1.068	1.000	1.000	1.068
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Guangzhou	1.000	1.094	1.000	1.000	1.094
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Guangzhou	1.000	1.150	1.000	1.000	1.150
	mean	0.997	1.128	0.997	1.001	1.125
Mean	Guangzhou	1.000	1.091	1.000	1.000	1.091
	mean	0.985	1.059	0.985	1.000	1.043

Table 38 Malmquist productivity of Guangzhou with investment lagged effect

Guangzhou		effch	techch	pech	sech	tfpch
2000-2001	Guangzhou	1.000	1.068	1.000	1.000	1.068
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Guangzhou	1.000	1.051	1.000	1.000	1.051
	mean	1.000	1.007	0.998	1.002	1.007
2002-2003	Guangzhou	1.000	1.128	1.000	1.000	1.128
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Guangzhou	1.000	1.067	1.000	1.000	1.067
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Guangzhou	1.000	1.114	1.000	1.000	1.114
	mean	0.921	1.118	0.901	1.022	1.030
2005-2006	Guangzhou	1.000	1.088	1.000	1.000	1.088
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Guangzhou	1.000	1.152	1.000	1.000	1.152
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Guangzhou	1.000	1.095	1.000	1.000	1.095
	mean	0.985	1.066	0.985	1.000	1.051

1) Guangzhou enjoyed 9.1% increasing of total factor productivity averagely in the past 9 years. Compares the average “tfpch” value 1.091 with the average of ten seaport cities average value 1.043, Guangzhou’s increasing rate of total factor productivity is higher than the average (4.3%).

2) The total factor productivity of Guanghzou enjoyed increasing in all the past nine years, which is showed by the values of tfpch larger than 1.

3) With considering of the investment lagged effect, Ningbo’s total productivity efficiency change yearly values are comparatively higher, on average 0.3%, than the result without considering the lagged effect.

4) In the past 9 years the technical change of Guangzhou increased 9.1% averagely, which is larger than the average of the ten seaport cities(5.9%). This

is showed by the average techch value of 1.091 and 1.059.

5) The increase of technical efficiency increases is the main reason of the total factor productivity improvement in Guangzhou.

5.3.5 Malmquist productivity of Qingdao

The malmquist productivity of Qingdao is showed in Table 39 and Table 40, and the explanations are as follows:

Table 39 Malmquist productivity of Qingdao

Qingdao		effch	techch	pech	sech	tfpch
1999-2000	Qingdao	1.000	1.021	1.000	1.000	1.021
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Qingdao	1.000	0.976	1.000	1.000	0.976
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Qingdao	1.000	0.905	1.000	1.000	0.905
	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Qingdao	0.849	0.935	0.862	0.985	0.794
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Qingdao	0.849	1.024	0.841	1.009	0.869
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Qingdao	0.810	1.145	0.810	1.000	0.927
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Qingdao	1.087	1.160	1.103	0.985	1.261
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Qingdao	1.081	1.147	1.089	0.993	1.240
	mean	0.997	1.128	0.997	1.001	1.125
Mean	Qingdao	0.954	1.035	0.957	0.996	0.987
	mean	0.985	1.059	0.985	1.000	1.043

Table 40 Malmquist productivity of Qingdao with investment lagged effect

Qingdao		effch	techch	pech	sech	tfpch
2000-2001	Qingdao	1.000	0.986	1.000	1.000	0.986
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Qingdao	1.000	0.968	1.000	1.000	0.968
	mean	1.000	1.007	0.998	1.002	1.007
2002-2003	Qingdao	1.000	0.978	1.000	1.000	0.978
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Qingdao	0.838	0.994	0.867	0.966	0.833
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Qingdao	0.751	1.101	0.730	1.028	0.827
	mean	0.921	1.118	0.901	1.022	1.030
2005-2006	Qingdao	0.984	1.093	0.978	1.006	1.076
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Qingdao	1.115	1.151	1.118	0.997	1.284
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Qingdao	0.948	1.037	0.949	1.000	0.983
	mean	0.985	1.066	0.985	1.000	1.051

1) Just like other old seaport cities, Qingdao also suffered decreasing of total factor productivity. The average decreasing rate of Qingdao is 1.7%, meanwhile, the average of the ten cities enjoyed an increasing rate of 5.1%. This can be find from the average tfpch value 0.983 and 1.051.

2) From Table 39 we can find easily that the decreasing of total factor productivity from year 2000 to 2005. And the decreasing pure efficiency is the main causation.

3) The malmquist results with views to the investment lagged effect is a little higher than the results calculated with the current investment, but they are collectively the same.

4) The pure efficiency change decreasing is the main cause of the decreasing of

total factor productivity. In the past 9 years Qingdao suffered averagely 5.1% decreasing of pure efficiency.

5) In the past nine years, Qingdao's scale efficiency also suffered decreasing of 0.4% averagely which is showed by the sech value of 0.996.

6) Based on the average data we can find that in the past nine years only the technical element was rising.

5.3.6 Malmquist productivity of Dalian

The malmquist productivity of Dalian is showed in Table 41 and Table 42, and the explanations are as follows:

Table 41 Malmquist productivity of Dalian

Dalian		effch	techch	pech	sech	tfpch
1999-2000	Dalian	1.000	0.948	1.000	1.000	0.948
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Dalian	1.000	0.970	1.000	1.000	0.970
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Dalian	1.000	0.942	1.000	1.000	0.942
	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Dalian	0.882	0.824	0.932	0.946	0.727
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Dalian	0.821	0.955	0.833	0.986	0.785
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Dalian	1.076	1.040	1.288	0.836	1.119
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Dalian	0.717	1.076	0.582	1.232	0.772
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Dalian	1.141	1.150	1.111	1.028	1.313

	mean	0.997	1.128	0.997	1.001	1.125
Mean	Dalian	0.945	0.984	0.947	0.998	0.930
	mean	0.985	1.059	0.985	1.000	1.043

Table 42 Malmquist productivity of Dalian with investment lagged effect

Dalian		effch	techch	pech	sech	tfpch
2000-2001	Dalian	1.000	0.948	1.000	1.000	0.948
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Dalian	1.000	0.989	1.000	1.000	0.989
	mean	1.000	1.007	0.998	1.002	1.007
2002-2003	Dalian	0.985	0.876	0.990	0.995	0.863
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Dalian	0.905	0.930	0.934	0.969	0.842
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Dalian	0.814	0.951	0.819	0.995	0.774
	mean	0.951	1.063	0.990	0.960	1.011
2005-2006	Dalian	1.114	1.064	1.321	0.843	1.185
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Dalian	0.752	1.128	0.615	1.222	0.848
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Dalian	0.931	0.981	0.933	0.998	0.913
	mean	0.985	1.066	0.985	1.000	1.051

1) As an old seaport city, Dalian's situation was comparatively worse than Qingdao. The total factor productivity of Qingdao suffered decreasing rate of 7% on average in the past nine years.

2) Only in the period of year 2004 to 2005 and year 2006 to 2007 the total factor productivity of Dalian enjoyed increase.

3) The malmquist results appear a little higher when with views to the investment lagged effect than the results estimated by current investment, but the decreasing of total factor productivity appears the same.

4) From the malmquist results of Dalian of the past nine years, we can find that the technical change, the pure efficiency change and the scale efficiency change were all suffered decreasing, which directly cause the decreasing of the total factor productivity.

5.3.7 Malmquist productivity of Shenzhen

The malmquist productivity of Shenzhen is showed in Table 43 and Table 44, and the explanations are as follows:

Table 43 Malmquist productivity of Shenzhen

Shenzhen		effch	techch	pech	sech	tfpch
1999-2000	Shenzhen	0.989	1.143	1.024	0.965	1.131
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Shenzhen	1.078	1.020	1.090	0.989	1.100
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Shenzhen	0.986	1.039	1.005	0.981	1.024
	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Shenzhen	1.052	1.023	1.000	1.052	1.077
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Shenzhen	1.018	1.197	1.000	1.018	1.218
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Shenzhen	1.019	1.305	1.000	1.019	1.330
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Shenzhen	1.000	1.145	1.000	1.000	1.145
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Shenzhen	1.000	1.108	1.000	1.000	1.108
	mean	0.997	1.128	0.997	1.001	1.125
Mean	Shenzhen	1.017	1.119	1.015	1.003	1.138
	mean	0.985	1.059	0.985	1.000	1.043

Table 44 Malmquist productivity of Shenzhen with investment lagged effect

Shenzhen		effch	techch	pech	sech	tfpch
2000-2001	Shenzhen	0.998	1.124	1.049	0.952	1.122
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Shenzhen	0.980	1.053	1.014	0.966	1.032
	mean	1.000	1.007	0.998	1.002	1.007
2002-2003	Shenzhen	1.118	1.113	1.000	1.118	1.244
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Shenzhen	0.923	1.124	1.000	0.923	1.038
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Shenzhen	1.083	1.293	1.000	1.083	1.401
	mean	0.921	1.118	0.901	1.022	1.030
2005-2006	Shenzhen	1.000	1.105	1.000	1.000	1.105
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Shenzhen	1.000	1.115	1.000	1.000	1.115
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Shenzhen	1.013	1.131	1.009	1.004	1.145
	mean	0.985	1.066	0.985	1.000	1.051

1) Shenzhen is one of the key cities in Chinese government developing plan, compare with Dalian, which we have just talked, the economic performance is entirely different.

2) The total factor productivity increasing rate of Shenzhen in the past nine years is 13.8%, much higher than the average of the ten seaport-cities. And during the past eight periods it is the highest among the ten seaport cities..

3) With considering of the investment lagged effect, Shenzhen's total productivity efficiency change yearly values are comparatively higher, and averagely 0.7% higher than the result without considering the lagged effect.

4) The pure efficiency change kept increasing in Shenzhen though the average of

the ten cities suffered decreasing.

5) The scale efficiency change of Shenzhen enjoyed increasing while the average of the ten cities kept constant in the past nine years.

6) Beside, technical change is the main engine which caused the rapid increase of the total factor productivity of Shenzhen.

5.3.8 Malmquist productivity of Zhoushan

The malmquist productivity of Zhoushani is showed in Table 45 and Table 46, and the explanations are as follows:

Table 45 Malmquist productivity of Zhoushan

Zhoushan		effch	techch	pech	sech	tfpch
1999-2000	Zhoushan	1.000	1.050	1.000	1.000	1.050
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Zhoushan	1.000	0.991	1.000	1.000	0.991
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Zhoushan	1.000	1.078	1.000	1.000	1.078
	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Zhoushan	1.000	0.904	1.000	1.000	0.904
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Zhoushan	1.000	1.080	1.000	1.000	1.080
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Zhoushan	1.000	1.027	1.000	1.000	1.027
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Zhoushan	1.000	0.918	1.000	1.000	0.918
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Zhoushan	1.000	0.966	1.000	1.000	0.966
	mean	0.997	1.128	0.997	1.001	1.125

Mean	Zhoushan	1.000	1.000	1.000	1.000	1.000
	mean	0.985	1.059	0.985	1.000	1.043

Table 46Malmquist productivity of Zhoushan with investment lagged effect

Zhoushan		effch	techch	pech	sech	tfpch
2000-2001	Zhoushan	1.000	1.015	1.000	1.000	1.015
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Zhoushan	1.000	1.006	1.000	1.000	1.006
	mean	1.000	1.007	0.998	1.002	1.007
2002-2003	Zhoushan	1.000	1.067	1.000	1.000	1.067
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Zhoushan	1.000	1.008	1.000	1.000	1.008
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Zhoushan	1.000	1.057	1.000	1.000	1.057
	mean	0.921	1.118	0.901	1.022	1.030
2005-2006	Zhoushan	1.000	1.008	1.000	1.000	1.008
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Zhoushan	1.000	0.946	1.000	1.000	0.946
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Zhoushan	1.000	1.015	1.000	1.000	1.015
	mean	0.985	1.066	0.985	1.000	1.051

1) Zhoushan is a small-sized seaport-city of China, the average total factor productivity of Zhoushan keeps constant according to the average tfpch value of 1.000

2) In the past eight periods, the total factor productivity of Zhoushan suffered decreasing for three times, year 2000 to 2001, year 2002 to 2003 and year 2006 to 2007. For other periods, zhoushan enjoyed increase.

3) With considering of the investment lagged effect, Zhoushan's total productivity efficiency change appears a little increase, whit the tfpch value on average of 1.015..

4) The technical change is the main causation of the increase and decrease of Zhoushan's economic total factor productivity.

5.3.9 Malmquist productivity of Xiamen

The malmquist productivity of Xiamen is showed in Table 47 and Table 48, and the explanations are as follows:

Table 47 Malmquist productivity of Xiamen

Xiamen		effch	techch	pech	sech	tfpch
1999-2000	Xiamen	1.000	1.160	1.000	1.000	1.160
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Xiamen	1.000	1.055	1.000	1.000	1.055
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Xiamen	1.000	1.149	1.000	1.000	1.149
	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Xiamen	1.000	1.211	1.000	1.000	1.211
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Xiamen	1.000	1.360	1.000	1.000	1.360
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Xiamen	1.000	1.019	1.000	1.000	1.019
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Xiamen	1.000	1.115	1.000	1.000	1.115
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Xiamen	1.000	1.144	1.000	1.000	1.144
	mean	0.997	1.128	0.997	1.001	1.125
Mean	Xiamen	1.000	1.148	1.000	1.000	1.148
	mean	0.985	1.059	0.985	1.000	1.043

Table 48 Malmquist productivity of Xiamen with investment lagged effect

Xiamen		effch	techch	pech	sech	tfpch

2000-2001	Xiamen	1.000	1.142	1.000	1.000	1.142
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Xiamen	1.000	1.140	1.000	1.000	1.140
	mean	1.000	1.007	0.998	1.002	1.007
2002-2003	Xiamen	1.000	1.198	1.000	1.000	1.198
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Xiamen	1.000	1.325	1.000	1.000	1.325
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Xiamen	1.000	1.174	1.000	1.000	1.174
	mean	0.921	1.118	0.901	1.022	1.030
2005-2006	Xiamen	1.000	1.108	1.000	1.000	1.108
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Xiamen	1.000	1.132	1.000	1.000	1.132
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Xiamen	1.000	1.173	1.000	1.000	1.173
	mean	0.985	1.066	0.985	1.000	1.051

1) The total factor productivity of Xiamen is comparatively better than the average level of the ten seaport cities, which enjoyed an increasing rate of averagely 17.3%, much higher than the average increasing rate 5.1%.

2) In the eight periods we have examed, the total factor productivity of Xiamen kept increasing. This is showed by the yearly value of tfpch, larger than 1.

3) The malmquist results appear a little higher when with views to the investment lagged effect than with views to current investment.

4) For the technical change, the average increasing rate is 14.8% in Xiamen. This is the highest among the ten seaport cities.

5) According to the yearly malmquist results, the technical change is the main causation of the increase of Xiamen's total factor productivity.

5.3.10 Malmquist productivity of Fuzhou

The malmquist productivity of Fuzhou is showed in Table 49 and Table 50, and the explanations of are as follows:

Table 49 Malmquist productivity of Fuzhou

Fuzhou		effch	techch	pech	sech	tfpch
1999-2000	Fuzhou	1.206	0.983	1.197	1.008	1.186
	mean	1.029	1.055	1.025	1.005	1.086
2000-2001	Fuzhou	1.007	0.931	1.000	1.007	0.937
	mean	0.999	0.993	1.003	0.996	0.992
2001-2002	Fuzhou	1.000	0.949	1.000	1.000	0.949
	mean	0.992	1.016	0.985	1.007	1.009
2002-2003	Fuzhou	0.928	0.924	0.983	0.944	0.858
	mean	0.974	0.998	0.979	0.994	0.972
2003-2004	Fuzhou	0.955	1.004	0.978	0.977	0.958
	mean	0.910	1.129	0.920	0.989	1.028
2004-2005	Fuzhou	0.871	1.031	0.907	0.960	0.897
	mean	1.002	1.076	1.018	0.985	1.079
2005-2006	Fuzhou	1.056	1.040	1.045	1.010	1.098
	mean	0.983	1.084	0.959	1.024	1.065
2006-2007	Fuzhou	0.853	1.102	0.862	0.989	0.940
	mean	0.997	1.128	0.997	1.001	1.125
Mean	Fuzhou	0.979	0.994	0.992	0.987	0.973
	mean	0.985	1.059	0.985	1.000	1.043

Table 50 Malmquist productivity of Fuzhou with investment lagged effect

Fuzhou		effch	techch	pech	sech	tfpch
2000-2001	Fuzhou	1.181	0.974	1.199	0.985	1.150
	mean	1.019	1.036	1.026	0.993	1.055
2001-2002	Fuzhou	1.045	0.938	1.000	1.045	0.981
	mean	1.000	1.007	0.998	1.002	1.007

2002-2003	Fuzhou	1.000	0.987	1.000	1.000	0.987
	mean	1.004	1.060	0.983	1.021	1.064
2003-2004	Fuzhou	0.955	0.942	1.000	0.955	0.899
	mean	0.951	1.063	0.990	0.960	1.011
2004-2005	Fuzhou	0.824	0.982	0.847	0.973	0.810
	mean	0.921	1.118	0.901	1.022	1.030
2005-2006	Fuzhou	1.137	1.020	1.164	0.977	1.160
	mean	1.030	1.074	1.041	0.989	1.106
2006-2007	Fuzhou	0.939	1.088	0.954	0.984	1.021
	mean	0.977	1.111	0.960	1.017	1.085
Mean	Fuzhou	1.005	0.989	1.017	0.988	0.994
	mean	0.985	1.066	0.985	1.000	1.051

1) The same with Xiamen, Fuzhou is another seaport city mainly faced to Taiwan. But the economy performance of Fuzhou was getting worse meanwhile its neighbor Xiamen was keeping increasing with a high speed.

2) In the past eight periods we have examed, Fuzhou suffered six times of total factor productivity decreasing. And the average value appears decreasing though the ten seaportcities were averagely increasing.

3) The results appear a little higher when with views to the investment lagged effect than results with views to current investment, but the decreasing appears the same

4) From the average malmquist results of Fuzhou of the past nine years, we can find that the technical change, the pure efficiency change and the scale efficiency change were all suffered decreasing. These decreasing directly caused the decreasing of the total factor productivity.

5.4 Compare the productivity change by the mamlquist index value of the ten seaport cities (1999-2000)

The average total factor productivities and other element of the ten seaport cities we have calculated are showed in the follow tables, Table 51 and Table 52:

Table 51 Malmquist index results of the ten seaport cities

	effch	techch	pech	sech	tfpch
Shanghai	1.000	1.111	1.000	1.000	1.111
Ningbo	1.011	1.098	1.000	1.011	1.111
Tianjin	0.950	1.024	0.944	1.007	0.973
Guangzhou	1.000	1.091	1.000	1.000	1.091
Qingdao	0.954	1.035	0.957	0.996	0.987
Dalian	0.945	0.984	0.947	0.998	0.930
Shenzhen	1.017	1.119	1.015	1.003	1.138
Zhoushan	1.000	1.000	1.000	1.000	1.000
Xiamen	1.000	1.148	1.000	1.000	1.148
Fuzhou	0.979	0.994	0.992	0.987	0.973
mean	0.985	1.059	0.985	1.000	1.043

Table52 Malmquist index result of the ten seaport cities with investment lagged effect

	effch	techch	pech	sech	tfpch
Shanghai	1.000	1.122	1.000	1.000	1.122
Ningbo	1.000	1.123	1.000	1.000	1.123
Tianjin	0.957	1.020	0.944	1.014	0.976
Guangzhou	1.000	1.095	1.000	1.000	1.095
Qingdao	0.948	1.037	0.949	1.000	0.983
Dalian	0.931	0.981	0.933	0.998	0.913
Shenzhen	1.013	1.131	1.009	1.004	1.145
Zhoushan	1.000	1.015	1.000	1.000	1.015
Xiamen	1.000	1.173	1.000	1.000	1.173
Fuzhou	1.005	0.989	1.017	0.988	0.994

mean	0.985	1.066	0.985	1.000	1.051

1) In general, the ten seaport cities enjoyed increasing of total factor productivity with the average rate of 4.3%. Whereas, Tianjin, Qingdao, Dalian and Fuzhou's total factor productivity were suffered decreasing, and Zhoushan kept constant.

2) Among the five seaport cities which enjoyed increasing of total factor productivity, Xiamen took the highest tfpch value of 1.148. This means Shenzhen enjoyed the highest increasing rate of total factor productivity.

3) Meanwhile, among the seaport cities which suffered from decrease, Dalian performed the worst with the tfpch value of 0.930, which means Dalian experienced the highest decreasing rate of total factor productivity among the then seaport cities.

4) Technical change played the most important role in accelerates the total productivity improvement of the ten seaport cities in the past nine years.

5) The malmquist results appear a little higher when with views to the investment lagged effect than results with views to current investment.

5.5 Compare of the scale efficiency of large-sized, middle-sized and small-sized seaport-city

In this paper large-sized seaport-city is defined as a city which with population more than 8 million, they are Shanghai, Tianjin and Shenzhen; the cities with population of from 5 million to 8 million are defined as middle-sized seaport-city, they are: Ningbo, Guangzhou, Qingdao, Dalian and fuzhou; Zhoushan and Xiamen's population less than 2 million they are treated as small-sized seaport-cities.

The average scale efficiency performances of the same type of cities are calculated in Table 53, Table 54, Table 55 and Table 56. Mean while Figure 18 to Figure 21 make the result much more intuitionistic.

According to the results estimated by the measurements with current investment and the measurements with investment lagged effect applying to both the input-orientated DEA models and output-orientated DEA models, the economy performance results for large-sized cities, middle-sized cities and small-sized cities performs pretty the same thing in the four kinds of calculation:

1) Middle-sized cities perform the best in the past nine years. In Figure 18 to Figure 21, the red line keeps on the top of all the three lines. Middle-sized seaport cities enjoyed the highest scale efficiency.

2) The large-sized cities, although their scale efficiency performance high but still a little lower than the middle-sized cities. Surplus of investment in large-sized cities can explain this situation.

3) As to the small-sized cities, their scale efficiency performance was the lowest

Table 53 Compare the scale efficiency of large-sized, middle-sized and small-sized seaport-cities by input-orientated DEA models

SE	1999	2000	2001	2002	2003	2004	2005	2006	2007
large	0.967	0.966	0.962	0.967	0.971	0.974	0.984	0.988	0.985
middle	0.974	0.975	0.983	0.988	0.987	0.973	0.938	0.978	0.989
small	0.807	0.834	0.813	0.829	0.774	0.906	0.895	0.937	1.000

Figure 18 Compare the scale efficiency of large-sized, middle-sized and small-sized seaport-cities by input-orientated DEA models

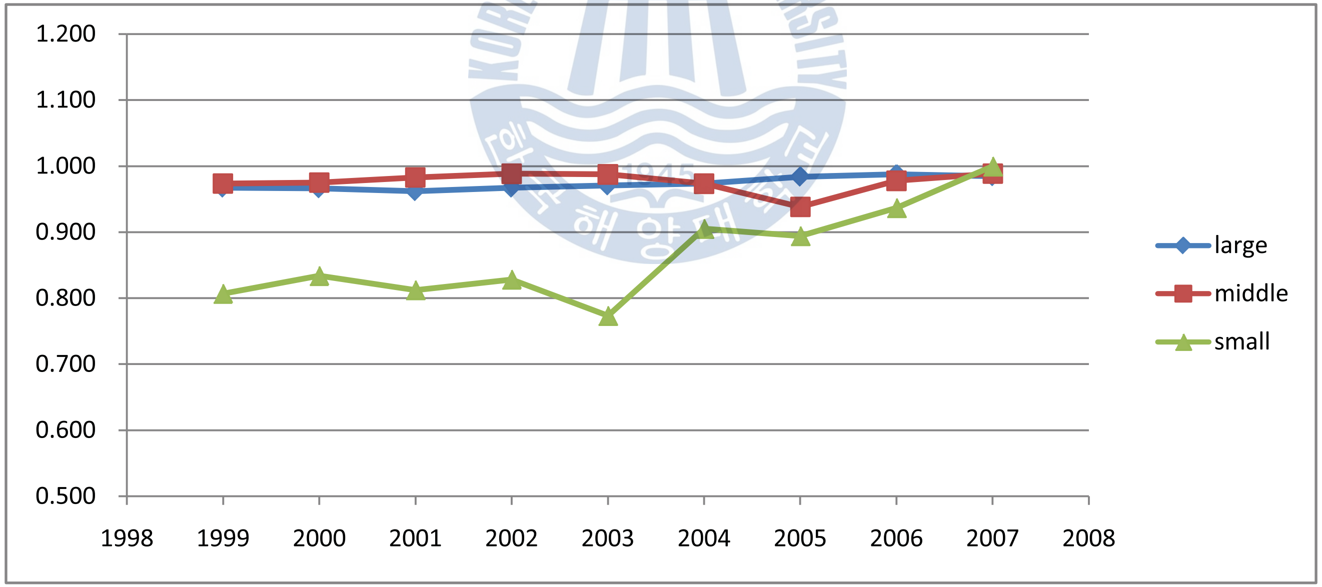


Table 54 Compare the scale efficiency of large-sized, middle-sized and small-sized seaport-cities by output-orientated DEA models

SE	1999	2000	2001	2002	2003	2004	2005	2006	2007
large	0.942	0.937	0.930	0.934	0.936	0.919	0.968	0.969	0.962
middle	0.966	0.971	0.980	0.978	0.986	0.989	0.956	0.994	0.991
small	0.867	0.875	0.869	0.852	0.785	0.906	0.895	0.937	1.000

Figure 19 Compare the scale efficiency of large-sized, middle-sized and small-sized seaport-cities by output-orientated DEA models

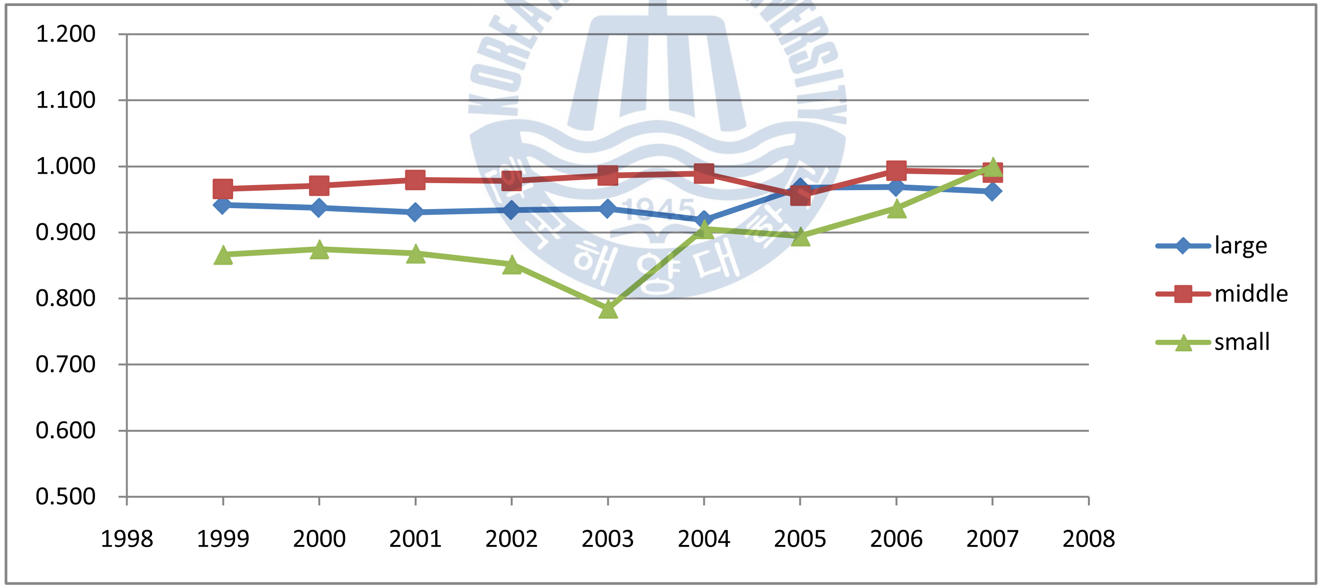


Table 55 Compare the scale efficiency of large-sized, middle-sized and small-sized seaport-cities by input orientated DEA models with lagged effect

SE	2000	2001	2002	2003	2004	2005	2006	2007
large	0.973	0.971	0.969	0.975	0.943	0.970	0.997	0.998
middle	0.982	0.981	0.989	0.991	0.984	0.986	0.943	0.988
small	0.799	0.835	0.836	0.845	0.886	0.920	0.948	1.000

Figure 20 Compare the scale efficiency of large-sized, middle-sized and small-sized seaport-cities by input orientated DEA models with lagged effect

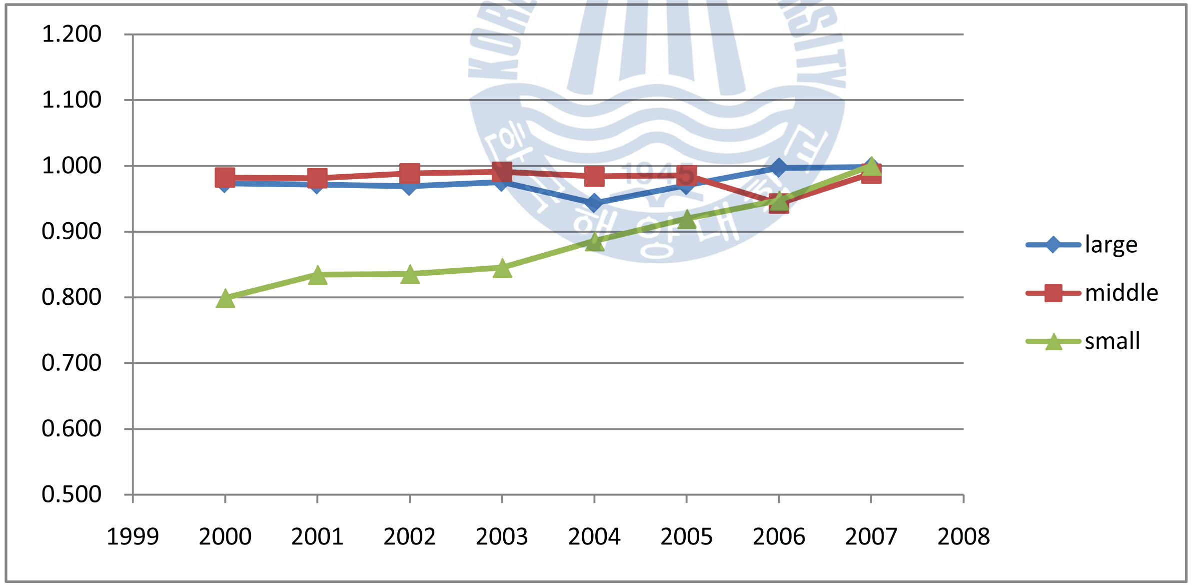
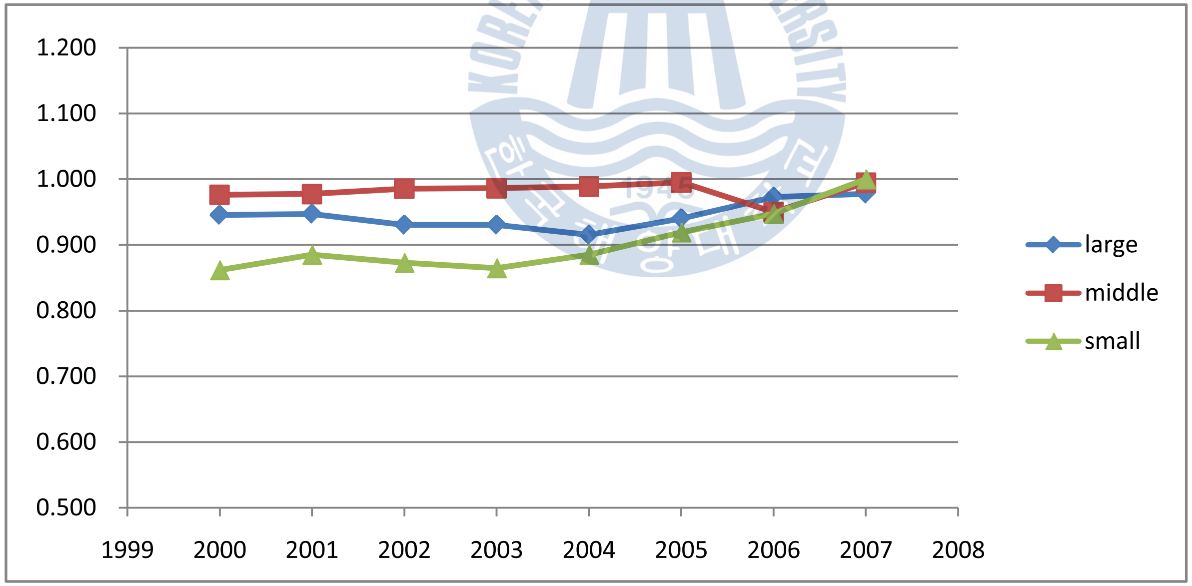


Table 56 Compare the scale efficiency of large-sized, middle-sized and small-sized seaport-cities by output orientated DEA models with lagged effect

SE	2000	2001	2002	2003	2004	2005	2006	2007
large	0.946	0.947	0.931	0.931	0.915	0.940	0.973	0.978
middle	0.976	0.977	0.986	0.986	0.989	0.995	0.950	0.995
small	0.862	0.886	0.873	0.865	0.886	0.920	0.948	1.000

Figure 21 Compare the scale efficiency of large-sized, middle-sized and small-sized seaport-cities by output orientated DEA models with lagged effect



in the three kinds of cities, but the growth speed was the fastest. This is showed by the rise of the green lines in Figure 18 to Figure 21. Rapid development has occurred in the small-sized cities.

5.6 Determinants of efficiency of seaport-cities:

Our main goal in this section is to consider how variables representing the performance of the external sector relater to efficiency. We examine the role of both domestic and external variables in influencing efficiency, and the estimate proceeds with the following equation for the efficiency:

$$\ln ef = a_1 + a_2 \ln pop + a_3 \ln hc + a_4 \ln co + \beta d_1 DMU1 + \ldots \beta d_{10} DMU10$$

Where ef is the efficiency of the seaport city, pop equals the population of the seaport city, hc equals the handling capacity of the city's seaports, co equals the city openness [23] calculated by dividing foreign investment with the city's investment in fixed assets and DMU1 to DMU10 represent the ten seaport cities.

The regression[24] results are as follows:

Table 57 Regression result applying input orientated crste

Predictor	Coef	SE Coef	T	P
Constant	-11.905	2.635	-4.52	0

[23] The openness of the city is the ratio of the city's foreign investment and the city's inner investment-investment in fixed assets.

[24] Software Minitab version 14 was used to make regression.

lpop	2.113	0.4465	4.73	0
lhc	-0.07315	0.04311	-1.7	0.094
lco	0.0788	0.04437	1.78	0.08
DMU1	-1.4781	0.3202	-4.62	0
DMU2	0.2806	0.1087	2.58	0.012
DMU3	-0.9141	0.1807	-5.06	0
DMU4	-0.10797	0.09153	-1.18	0.242
DMU5	-0.39692	0.0963	-4.12	0
DMU6	0.27843	0.09113	3.06	0.003
DMU7	-0.4868	0.1154	-4.22	0
DMU8	4.3337	0.8728	4.97	0
DMU9	2.9958	0.6383	4.69	0

S = 0.119669 R-Sq = 54.9% R-Sq(adj) = 47.9%

Note: lpop means the nature logged population; lhc means the nature logged seaport city's total cargo handling capacity; lco means nature logged of the city's openness and DMU1 to DMU 10 represent for the ten largest cities ranked from large to small.

Table 58 Regression result applying input orientated vrste

Predictor	Coef	SE Coef	T	P
Constant	-8.435	2.561	-3.29	0.001
lpop	1.5672	0.4338	3.61	0.001
lhc	-0.07333	0.04189	-1.75	0.084
lco	0.06682	0.04311	1.55	0.125
DMU1	-1.0367	0.3111	-3.33	0.001
DMU2	0.2306	0.1056	2.18	0.032
DMU3	-0.6726	0.1756	-3.83	0
DMU4	-0.02069	0.08894	-0.23	0.817
DMU5	-0.29566	0.09357	-3.16	0.002
DMU6	0.24507	0.08854	2.77	0.007
DMU7	-0.3644	0.1121	-3.25	0.002
DMU8	3.3052	0.8481	3.9	0
DMU9	2.4331	0.6202	3.92	0

S = 0.116274 R-Sq = 57.1% R-Sq(adj) = 50.5%

Table 59 Regression result applying input orientated scale

Predictor	Coef	SE Coef	T	P
Constant	-3.1589	0.9287	-3.4	0.001
lpop	0.6565	0.1573	4.17	0
lhc	-0.00069	0.01519	-0.05	0.964
lco	0.01681	0.01564	1.07	0.286
DMU1	-0.5302	0.1129	-4.7	0
DMU2	0.05697	0.03831	1.49	0.141
DMU3	-0.29368	0.0637	-4.61	0
DMU4	-0.10146	0.03226	-3.15	0.002
DMU5	-0.12762	0.03394	-3.76	0
DMU6	0.03846	0.03211	1.2	0.235
DMU7	-0.149	0.04067	-3.66	0
DMU8	1.2477	0.3076	4.06	0
DMU9	0.7081	0.2249	3.15	0.002

S = 0.0421734 R-Sq = 78.2% R-Sq(adj) = 74.8%

Table 60 Regression result applying output orientated crste

Predictor	Coef	SE Coef	T	P
Constant	-11.905	2.635	-4.52	0
lpop	2.113	0.4465	4.73	0
lhc	-0.07315	0.04311	-1.7	0.094
lco	0.0788	0.04437	1.78	0.08
DMU1	-1.4781	0.3202	-4.62	0
DMU2	0.2806	0.1087	2.58	0.012
DMU3	-0.9141	0.1807	-5.06	0
DMU4	-0.10797	0.09153	-1.18	0.242
DMU5	-0.39692	0.0963	-4.12	0
DMU6	0.27843	0.09113	3.06	0.003
DMU7	-0.4868	0.1154	-4.22	0
DMU8	4.3337	0.8728	4.97	0
DMU9	2.9958	0.6383	4.69	0

S = 0.119669 R-Sq = 54.9% R-Sq(adj) = 47.9%

Table 61 Regression result applying output orientated vrste

Predictor	Coef	SE Coef	T	P

Constant	-11.905	2.635	-4.52	0
lpop	2.113	0.4465	4.73	0
lhc	-0.07315	0.04311	-1.7	0.094
lco	0.0788	0.04437	1.78	0.08
DMU1	-1.4781	0.3202	-4.62	0
DMU2	0.2806	0.1087	2.58	0.012
DMU3	-0.9141	0.1807	-5.06	0
DMU4	-0.10797	0.09153	-1.18	0.242
DMU5	-0.39692	0.0963	-4.12	0
DMU6	0.27843	0.09113	3.06	0.003
DMU7	-0.4868	0.1154	-4.22	0
DMU8	4.3337	0.8728	4.97	0
DMU9	2.9958	0.6383	4.69	0

S = 0.119669   R-Sq = 54.9%   R-Sq(adj) = 47.9%

Table 62 Regression result applying output orientated scale

Predictor	Coef	SE Coef	T	P
Constant	-9.802	2.633	-3.72	0
lpop	1.7911	0.446	4.02	0
lhc	-0.0797	0.04307	-1.85	0.068
lco	0.06918	0.04432	1.56	0.123
DMU1	-1.1635	0.3199	-3.64	0
DMU2	0.2533	0.1086	2.33	0.022
DMU3	-0.7347	0.1806	-4.07	0
DMU4	-0.04996	0.09144	-0.55	0.586
DMU5	-0.34191	0.0962	-3.55	0.001
DMU6	0.26008	0.09103	2.86	0.005
DMU7	-0.4129	0.1153	-3.58	0.001
DMU8	3.7124	0.8719	4.26	0
DMU9	2.7002	0.6376	4.24	0

S = 0.119544   R-Sq = 53.9%   R-Sq(adj) = 46.7%

Table 63 Regression result applying input orientated crste with lagged effect

Predictor	Coef	SE Coef	T	P
Constant	-14.474	3.495	-4.14	0

lpop	2.5358	0.5915	4.29	0
lhc	-0.09519	0.05249	-1.81	0.074
lco1	0.06753	0.05023	1.34	0.183
DMU1	-1.7662	0.419	-4.22	0
DMU2	0.3365	0.1334	2.52	0.014
DMU3	-1.068	0.2313	-4.62	0
DMU4	-0.1565	0.1083	-1.44	0.153
DMU5	-0.4731	0.1142	-4.14	0
DMU6	0.2991	0.1071	2.79	0.007
DMU7	-0.5942	0.1525	-3.9	0
DMU8	5.101	1.155	4.42	0
DMU9	3.5924	0.8375	4.29	0

S = 0.119571 R-Sq = 56.7% R-Sq(adj) = 48.9%

Table 64 Regression result applying input orientated vrste with lagged effect

Predictor	Coef	SE Coef	T	P
Constant	-10.461	3.405	-3.07	0.003
lpop	1.8981	0.5762	3.29	0.002
lhc	-0.08061	0.05113	-1.58	0.12
lco1	0.07739	0.04893	1.58	0.118
DMU1	-1.2712	0.4082	-3.11	0.003
DMU2	0.2625	0.1299	2.02	0.047
DMU3	-0.8073	0.2254	-3.58	0.001
DMU4	-0.067	0.1055	-0.63	0.528
DMU5	-0.3746	0.1112	-3.37	0.001
DMU6	0.2459	0.1044	2.36	0.021
DMU7	-0.4561	0.1486	-3.07	0.003
DMU8	3.958	1.125	3.52	0.001
DMU9	2.8919	0.816	3.54	0.001

S = 0.116492 R-Sq = 59.8% R-Sq(adj) = 52.5%

Table 65 Regression result applying input orientated scale with lagged effect

Predictor	Coef	SE Coef	T	P
Constant	-3.661	1.205	-3.04	0.003
lpop	0.7429	0.2039	3.64	0.001

lhc	-0.018	0.0181	-0.99	0.323
lco1	-0.00935	0.01732	-0.54	0.591
DMU1	-0.5765	0.1445	-3.99	0
DMU2	0.08183	0.04599	1.78	0.08
DMU3	-0.30729	0.07976	-3.85	0
DMU4	-0.10048	0.03735	-2.69	0.009
DMU5	-0.12187	0.03937	-3.1	0.003
DMU6	0.05911	0.03694	1.6	0.114
DMU7	-0.16177	0.05258	-3.08	0.003
DMU8	1.3415	0.3982	3.37	0.001
DMU9	0.8401	0.2888	2.91	0.005

S = 0.0412279 R-Sq = 77.3% R-Sq(adj) = 73.2%

Table 66 Regression result applying output orientated crste with lagged effect

Predictor	Coef	SE Coef	T	P
Constant	-14.474	3.495	-4.14	0
lpop	2.5358	0.5915	4.29	0
lhc	-0.09519	0.05249	-1.81	0.074
lco1	0.06753	0.05023	1.34	0.183
DMU1	-1.7662	0.419	-4.22	0
DMU2	0.3365	0.1334	2.52	0.014
DMU3	-1.068	0.2313	-4.62	0
DMU4	-0.1565	0.1083	-1.44	0.153
DMU5	-0.4731	0.1142	-4.14	0
DMU6	0.2991	0.1071	2.79	0.007
DMU7	-0.5942	0.1525	-3.9	0
DMU8	5.101	1.155	4.42	0
DMU9	3.5924	0.8375	4.29	0

S = 0.119571 R-Sq = 56.7% R-Sq(adj) = 48.9%

Table 67 Regression result applying output orientated vrste with lagged effect

Predictor	Coef	SE Coef	T	P
Constant	-11.878	3.448	-3.45	0.001
lpop	2.1283	0.5835	3.65	0.001
lhc	-0.08291	0.05178	-1.6	0.114

lco1	0.08704	0.04955	1.76	0.084
DMU1	-1.4026	0.4133	-3.39	0.001
DMU2	0.2827	0.1316	2.15	0.035
DMU3	-0.8807	0.2282	-3.86	0
DMU4	-0.1036	0.1069	-0.97	0.336
DMU5	-0.429	0.1126	-3.81	0
DMU6	0.2563	0.1057	2.42	0.018
DMU7	-0.5143	0.1504	-3.42	0.001
DMU8	4.397	1.139	3.86	0
DMU9	3.1776	0.8262	3.85	0

S = 0.117955 R-Sq = 58.2% R-Sq(adj) = 50.7%

Table 68 Regression result applying output orientated scale with lagged effect

Predictor	Coef	SE Coef	T	P
Constant	-2.525	1.247	-2.03	0.047
lpop	0.5552	0.211	2.63	0.011
lhc	-0.01602	0.01873	-0.86	0.395
lco1	-0.02186	0.01792	-1.22	0.227
DMU1	-0.4853	0.1495	-3.25	0.002
DMU2	0.0713	0.04759	1.5	0.139
DMU3	-0.26048	0.08254	-3.16	0.002
DMU4	-0.07157	0.03865	-1.85	0.068
DMU5	-0.0652	0.04074	-1.6	0.114
DMU6	0.05824	0.03823	1.52	0.132
DMU7	-0.1154	0.05441	-2.12	0.038
DMU8	0.9746	0.412	2.37	0.021
DMU9	0.6097	0.2988	2.04	0.045

S = 0.0426627 R-Sq = 72.2% R-Sq(adj) = 67.2%

In above tables, form Table 57 to Table 68, the results of how variables representing the performance of the external sector relater to efficiency were showed; according to the efficiency that we got from the input orientated DEA models and output orientated DEA models with and without considering the investment lagged effect.

The results showed the relationship between factors of the population, the handling capacity and the city's openness with the city's efficiency. The plus lpop and lco(lco1)value shows that the population, which stands for the city's agglomeration, and the city's openness are direct ratio of the city's efficiency. This means the increasing in labor and the proportion of foreign investment according to the investment in fixed assets are helpful for the cities' efficiency improvement. And, as to the handling capacity, the minus of lhc value shows negative effect of total cargo handling capacity on seaport city's efficiency, more handling capacity cause the reduction of product efficiency. This is telling us that the surplus of investment in port industry.

6. Summary, Limitations and Conclusions

The objective of this dissertation is to examine the Chinese ten largest seaport cities' comparative efficiency, the effect of investment lag and the determinants of their efficiency. The research results of the ten **seaport** cities, as well as the core cities of the Chinese economy, are now summarized.

6.1 Summary

Zhoushan is comparatively the most efficient seaport city among the ten largest seaport cities of China. In the past nine years Zhoushan kept its first rank in both constant returns to scale efficiency and variable returns to scale efficiency in the ten largest seaport cities. In Shenzhen, as the newly built coastal open city, the efficiency improvement is clear and significant. To the contrary, the old north seaport city Dalian suffered decreasing efficiency in the past years. The efficiency rank of Dalian decreased from its first position in year 1999 to 10th in year 2006 and 9th in year 2007. For each city, the average CRS values and average VRS values of the 9 years are relatively steady, and enjoyed a little increasing returns to scale, which means that the productivity efficiency of these seaport cities enjoyed stable efficiency trends and a small amount of efficiency increase. In the past nine years the largest five seaport cities'(Shanghai Ningbo Tianjin Guangzhou Qingdao) efficiency has kept steady efficiency levels, without notable change.

Referring to the Malmquist index measurement results, in general, the ten seaport cities enjoyed increasing total factor productivity with the average rate of 4.3%, whereas Tianjin, Qingdao, Dalian and Fuzhou's total factor productivity suffered decreasing efficiency trends, and Zhoushan remained constant. Among the five seaport cities which enjoyed increasing total factor productivity, Xiamen recorded the first rank. Meanwhile among the seaport cities which showed decreasing efficiency trends, Dalian performed the worst. Technical change played the most important role in accelerating the total productivity of the ten seaport cities in the past nine years. The technical efficiency values appear a little higher in terms of the lagged investment effect.

Middle-sized cities perform the best in the past nine years. The large-sized cities, although, their scale efficiency is high but still a little lower than the middle-sized cities. The surplus of investment in large-sized cities can be the reason of this situation. As to the small-sized cities, the scale efficiency is the lowest in the three kinds of cities, but the growth speed is very fast. The fast increase of scale efficiency showed the rapid development of the small-sized cities.

AS the determinants of efficiency of seaport-cities, the agglomeration(population) and the city's openness played direct roles in the city's efficiency, which means the increase of labor and foreign investment have positive effects on the seaport cities' efficiency. But, as to the cargo handling capacity, the negative effects on the seaport cities' efficiency tell us the possibility of the overinvestment in port industry.

6.2 Limitations

While the models presented herein show potential results corresponding to various models, the variable selection may require further study and improvement. Due to the lack of confident raw data from bureau of statistics, most of data this paper used had to be obtained from the city governments' "National Economic and Social Development Statistical Bulletin" and some specific reports. There were a lot of inconsistencies for the same data in different kinds of reports of different year's reports, and the comparatively reasonable ones were chosen for this paper. Besides, on account of the reliability[25] of the statistical data that are made by the Chinese government and Bureau of Statistics, the factuality of the variables used in this paper can embody some problems.

Further, it must be remembered that, in spite of the benefits offered by DEA method, it does present certain methodological limitations. DEA is deterministic, which means that it does not incorporate random noise into the model. Deterministic models are also very sensitive to outliers and therefore may affect the DEA efficiency estimates seriously. Although DEA is non-parametric, the statistical properties of its efficiency estimates have been developed continuously[26].

Next, DEA is good at estimating "relative" efficiency of a DMU, but it converges very slowly to "absolute" efficiency. In other words, it can tell us how well you are doing compared to our peers but not compared to a "theoretical maximum."

6.3 Conclusions

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[25] Carlos Pestana Barros,and Nicolas Peypoch, Technical efficiency of thermoelectric power plants, 2008.

[26] Patrick L. Brockett, Reuben R. Mcdaniel,Jr, and Barbara wojcik performance of Army Medical Department Health Delivery Components, 2001-2003: A multi-Model Approach.2005.

In the mid-90s 20th century, Chinese leaders aware of the problems of economic growth model, which laid too much stress on export and investment but belittle domestic demand and consumption; so the objectives and strategies for the economic growth model transformation were put forward. These objectives and strategies, which emphasized technology and improved the market system, have accelerated the development and the efficiency increase of the seaports cities. However, according to the study in view of the lagged effect, investment has the direct connection with the seaport cities' yearly economic performance. This kind of development can be hard to keep. Giving up the traditional investment-driven growth strategy, and turning to the growth strategy of making full use of technology are essential for seaport-cities' efficiency improvement in the long run.

References

Patrick L. Brockett, Reuben R. Mcdaniel,Jr, and Barbara wojcik (2005) P*erformance of Army Medical Department Health Delivery Components, 2001-2003: A multi-Model Approach*. The University of Texas at Austin.

Jose Alberto Quintanilha and Linda Lee Ho *A performance index developed by data envelopment analysis(DEA) to compare the efficiency of fire risk mounitoring actions in municipalities of Brazilian Amazon region*.7th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Science. Edited by M. Caetano and M. Painho.

Ho-Soo Nah, (2008) *the Measurement of Korean Large-sized Seaports' Efficiencies and their Relationships with Infrastructures Using DEA and SFA*, Korea Maritime University working paper, 2008.

Coelli T.J.(1996) *A Guid to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program,* Center for Efficiency and Productivity Analysis (CEPA) working paper

W Robert J Alexander, Alfred A. Huang and Mohammad Jaforullah,(2007) *A Two-stage double-bootstrap data envelopment analysis of efficiencies of New Zealand secondary schools,* Department of Economics University of Otago.

N. Rezitis,(2006) *Efficiency and productivity effects of bank mergers: Evidence from the Greek banking industry*, Economic Modelling 25 (2008) 236-254.

Stephen M. Miller and Mukti P. Upadhyay(2002) *Total Factor Productivity, Human Capital and Outward Orientation: differences by Stage of Development and geographic Regions*, University of Connecticut Department of Economics Working Paper Series.

D.da Mata, U.Deichmann, J.V.Henderson, S.V.Lall and H.G.Wang *Determinants of city growth in Brazil,* Journal of Urban Economics (2007) 252-272.

Arief Heru Prasetyo,(2005) *Economic Growth of Indonesian Port Cities,* Airlangga University working paper.

Masahisa Fujita and Tomoya Mori (1995) *The role of ports in the making of major cities: Self-agglomeration and hub-effect,* Journal of Depvelopment Economics Vol.49 (1996) 93-120.

Carsten A. Holz *China's 2004 Economic Census ans 2006 Benchmark Revision of GDP Statistics: More Questions than Answers?* The China Quarterly, 2008.

Brebda Mccabe, Viet Tran, and Joseph Ramani, Construction prequalification usling data envelopment analysis, Can. J. Civ. Eng. 32: 183-193(2005).

William W.Cooper, Lawrence M. seiford and Joe Zhu, *DATA ENVELOPMENT ANALYSIS History, Models and Interpretations.* Red McCombs School of Business, University of Texas.

Valentina Bosetti and Mariaester Cassinelli,(2004) U*sing Data Envelopment Analysis to Evaluate Environmentally Conscious Tourism Management,* Social Science Research Network Electronic Paper Collection, (http:// ssm.com/abstract=XXXXXX).

Carlos Pestana Barros,and Nicolas Peypoch,(2008) *Technical efficiency of thermoelectric power plants,* Energy Economics 30 (2008) 3118-3127.

Al-Faraj, T. N., A. S. Alidi, et al. (1993). *Evaluation of bank branches by means of data envelopment analysis*. International Journal of Operations & Production Management 13(9): 45-52.

Andersen, P. and N. C. Petersen (1993). *A procedure for ranking efficient units in data envelopment analysis.* Management Science 39(10): 1261-4.

Banker, R., R. F. Conrad, et al. (1986). *A comparative application of DEA and translog methods: an illustrative study of hospital production*. Management Science 32(1): 30-44.

Bauer, P. W. (1990). *Recent developments in the econometric estimation of frontiers.* Journal of Econometrics 46: 39-56.

Berg, S. A., F. R. Forsund, et al. (1992). *Malmquist indices of productivity growth during the deregulation of Norwegian banking, 1980-89*. Journal: Scandinavian Journal of Economics 94: 211-228.

Bjurek, H., U. Kjulin, et al. (1992). *Efficiency, Productivity and Determinants of Inefficiency at Public Day Care Centers in Sweden; Comment.* Scandinavian Journal of Economics 94: 173-191.

Chang, K.-P. and Y.-Y. Guh (1991). *Linear production functions and the data envelopment analysis.* European Journal of Operational Research 52(2): 215-23.

Chang, Y.-L. and T. Sueyoshi (1991). *An interactive application of data envelopment analysis in microcomputers.* Computer Science in Economics and Management 4(1): 51-64.

Charnes, A., W. W. Cooper, et al., Eds. (1994). *Data Envelopment Analysis: Theory, Methodology and Applications*. Boston, Kluwer.

Chilingerian, J. A. (1995). *Evaluating physician efficiency in hospitals: A multivariate analysis of best practices.* European Journal of Operational Research 80(3): 548-574.

Clarke, R. L. and K. N. Gourdin (1991). *Measuring the efficiency of the logistics process.* Journal of Business Logistics 12(2): 17-33.

Desai, A. and J. E. Storbeck (1990). *A data envelopment analysis for spatial efficiency*. Computers, Environment and Urban Systems 14(2): 145-56.

Riddington, G. and J. Cowie (1994). *Performance assessment using DEA - A cautionary note*. Journal of the Operational Research Society 45(5): 603-604.

Seiford, L. M. and R. M. Thrall (1990). *Recent developments in DEA: the mathematical programming appoach to frontier analysis.* Journal of Econometrics 46: 7-38.

Sexton, T. R. (1986). *The methodology of DEA. Measuring Efficiency: An Assessment of Data Envlelopment Analysis.* R. H. Silkman. San Francisco, American Evaluation Association, Jossey Bass, Inc. 32.

Shafer, S. M. and J. W. Bradford (1995). *Efficiency measurement of alternative machine component grouping solutions via data envelopment analysis*. IEEE Transactions on Engineering Management 42(2): 159-165.

Sickles, R. C. and M. L. Streitwieser (1992). *Technical inefficiency and productive decline in the U.S. interstate natural gas pipeline industry under the Natural Gas Policy Act. International Applications of Productivity and Efficiency Analysis.* T. R. J. Gulledge and C. A. Knox-Lovell. Dordrecht, Kluwer Academic Publishers: 115-133.

Thanassoulis, E. (1993). *A comparison of regression analysis and data envelopment analysis as alternative methods for performance assessments.* Journal of the Operational Research Society 44(11): 1129-44.

Thomas, D., R. Greffe, et al. (1986). *Application of data envelopment analysis to management audits of electric distribution utilities*. Proceedings of the Fifth NARUC Biennial Regulatory Information Conference, The National Regulatory Research Institute, Ohio State University.

Vakkuri, J. and M. Malkia (1995). *DEA Applications in Finland: a metatheoretical analysis*. University of Tampere, Department of Administrative Science, PO Box 607, FIN-33101 Tampere, Finland: 1-12.

Zuckerman, S., J. Hadley, et al. (1994). *Measuring hospital efficiency with frontier cost functions.* Journal of Health Economics 13(3): 255-280.

National Bureau of Statistic of China http://www.stats.gov.cn/

Shanghai Municipal Statistics Bureau http://www.stats-sh.gov.cn/2005shtj/index.asp

Ningbo Municipal Statistics Bureau http://www.nbstats.gov.cn/

Tianjin Municipal Statistics Bureau http://www.stats-tj.gov.cn/

Guangzhou Municipal Statistics Bureau http://www.gzstats.gov.cn/

Qingdao Municipal Statistics Bureau http://www.stats-qd.gov.cn/statsqd/index/index.asp

Dalian Municipal Statistics Bureau http://www.stats.dl.gov.cn/

Shenzhen Municipal Statistics Bureau http://www.sztj.com/

Zhoushan Municipal Statistics Bureau http://www.zstj.net/info/

Xiamen Municipal Statistics Bureau http://www.stats-xm.gov.cn/

Fuzhou Municipal Statistics Bureau http://www.fuzhou.org.cn/qydg1/ZL/Fzstjj/FZSTJJ.htm