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Authors: Jing Zhang, Yexia Zhang

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Authors: **Jing Zhang , Yexia Zhang**

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Preface

This is our thesis for the master's degree of Logistics at Molde University College Norway. It appeared to fill the vacancy in mainland China for the study of forecasting the airport's efficient development with Delphi method, simultaneously; the latest evaluating approach of DEA model also has been adopted. This research has been carried out under the guidance of Associate Professor Nigel Halpern; we would like to thank him for his assiduous instruction and professional support over our research and writing period. His rigorous academic style and realistic attitude has given us a lot of inspiration and insight.

We are grateful to Professor Sun XiaoMing who is working at Shanghai Jiao Tong University. The impressive discussions with him while he was in France helped us open up a new perspective for the research and his helpful advices in the questionnaire have made our thesis highly valued.

We are also appreciated other fourteen experts and professors' persistent help for our research questionnaire. Their valuable suggestions contributed to our thesis more convincing.

We especially would like to thank our friends, who are in Germany and Beijing, without their help during the questionnaire research, our thesis would have looked like quite different.

Last but not least, we sincerely thank our parents for their support in the past two years and our friends who are in Japan and Shanghai, thanks them for heartfelt encouragement.

Molde, May 2009

Jing Zhang and Yexia Zhang

Abstract

Along with rapid economic growth and aviation industry reform, Chinese airports have undergone a qualitative change in terms of increasing number of airports and mounting throughput of passenger and cargo. However, on the other hand, the construction and management of airports also exposed many manifest shortcomings in operating, which some of them seriously hinder the airports to develop effectively, especially toward the expensing and investment of airports' infrastructure and inter-organization management. Therefore, this survey attempts to evaluate the current airports' operational efficiency by numerically selecting 30 major Chinese airports as sample to establish models, and theoretically putting forward some scientific judgments of current operation and suggestions for future efficient development. In order to achieve analytic objective, two methods of Data Envelopment Analysis (DEA) and Delphi are introduced to investigate. The results demonstrated that Chinese airports, as a whole, are operated inefficiently during 2004-2008. But they keep improving their efficiency level among these five years. Additionally there is an obvious imbalance in the development among regions and still lack scientific management pattern and scientific planning and practical demonstration on the construction.

Key Words: Data Envelopment Analysis (DEA), Delphi method, Airport efficiency.

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CHAPTER 1: INTRODUCTION

Since economic reform and opening up, the rapid development of air traffic market in China provided a favorable environment and conditions for the airport industry. From the first airport reform program enacted in 1987 until 2008, the development of Chinese airport has made a qualitative leap within 20 years. Not only does reflect on the number of civilian airports, but also the airport's size, technology, equipment, and other quality standards have been dramatically improved and enhanced. Moreover, there has a significant decentralization trend in airport development, civil airports have already formed pyramid format of three major airports, secondary airports and small airports.

1.1 The History of Airports Reform

China Aviation Industry Reform has experienced a full 30 years. Today, three reform stages made Chinese air transport become into the second largest air transport system in the world from a small industry which belongs to military affairs. Dating from the year of 1987, Chinese civil aviation authority implemented the first structure reform, which parted Civil Aviation Administration of China as regulator from airlines and airports, followed next year, reforming airport management indicated that airports were officially separated from airlines. This reform also marked the initiation of the reform in airport industry.

Over 1990 and 1993, the operation of airports was transferred from central government control to the municipal government, which firstly experimented on the Xiamen Airport and Shanghai Hongqiao Airport, this reform was called airport localization experiment. Hereafter, in 1994 foreign investors began to be allowed to finance airport infrastructure construction. The investment was related to runway development and other non-aviation business.

By the late 1990s, namely, from 1995 to 2001, due to part of airports operated their activities stage by stage following with the market lines, joint-equity has begun to appear in airport structure ownership, foreign and private capital accessed Chinese airport industry. Six major Chinese airports gradually turned up on the Shanghai, Shenzhen, Hong Kong stock markets (table1). As the investment has been improved and deregulated, China's airports industry marched forward a more liberal international track. The last reform stage was between 2002 and 2004; the objective of reform is to further airports localization thoroughly, except Beijing Capital International Airport and airports in XinJiang district, the management of all other airports which originally controlled directly by Civil Aviation Administration of China such as local small and medium-sized airports were devolved to local authority. Through 30 years of reform, keeping pace with the implementation of bilateral open-skies agreements among countries in the airline market, Chinese airports opened wider door to access international connection.

Table 1: Listing Airports

Airports	Listing year	Stock exchange
Beijing Capital International	2000	Hong Kong
Shanghai International	1998	Shanghai
Guangzhou Baiyun International	2003	Shanghai
Shenzhen Baoan International	1998	Shenzhen
Xiamen Gaoqi International	1996	Shanghai
Haikou Meilan International	2002	Hong Kong

Date Source: The financial report of Beijing, Shanghai, Guangzhou, Shenzhen, Xiamen and Haikou in 2007

1.2 The Current State of Chinese Civil Airports

More than 20 years reform Civil Aviation Administration of China has been explored a development track in line with the China's national conditions and made remarkable achievements on the construction and throughput.

1.2.1 The Construction and Development of Airports

By 2006, the number of National Civil Aviation Airports has reached into 147. Based on the original fundamental, 4E[1]-class international airport which has capability to handle B747 was step up into 25; 122 airports left included 35 4D-class airports, 58 4C-class airports and 29 3C-class airports. In 2007, five new airports was added, the total number of airports increased into 152, the airports which have regular routes reached from 142 in 2006 to 148. Airports which located near Yangtze River Delta and coastal areas in Eastern China are relatively concentrated, In addition, the airports in the Central and South region which regards Guangdong province as economic development center and Southwest region which puts tourism as the development center follows on after (Figure1).

Until the end of 2008, according to the airport production statistical report 2008 by CAAC, the total number of airports was added into 160, and navigable airports have increased into 158, among them, for comparison with two years ago, scheduled flights to airports also raised into 152. At present, the development of airports in China displays three kinds of characteristics: hub airports, route airports and small and medium-sized airports. Beijing Capital, Shanghai Pudong, and Guangzhou Baiyun, which on behalf of major airports have already taken shape hub airports, being representative of route airports mainly centralized in provincial city which located coastal cities in the eastern region as well as in western regional centers, these route airports supported more than 50% carrier capacity of China's air transport. The third

[1].4E-class with a minimum 1800-m-long runway, capable of handing a plane of 52-60m wingspan and space between felloes of 9-14m to takeoff or land. 4D Min1800m, 36-52m, 9-14m. 4C Min 1800m, 24-36m, 6-9m. 3C Under 1800m over 1200m, 24-36m, 6-9m.

ones are small and medium-sized airports which mostly located in undeveloped regions and annual passenger throughput is less than 100 thousand. In accordance with the regions[2], the number of airports as well as the number of runways which located in Eastern, Central and south and Southwest are much higher than other regions (Figure 2).

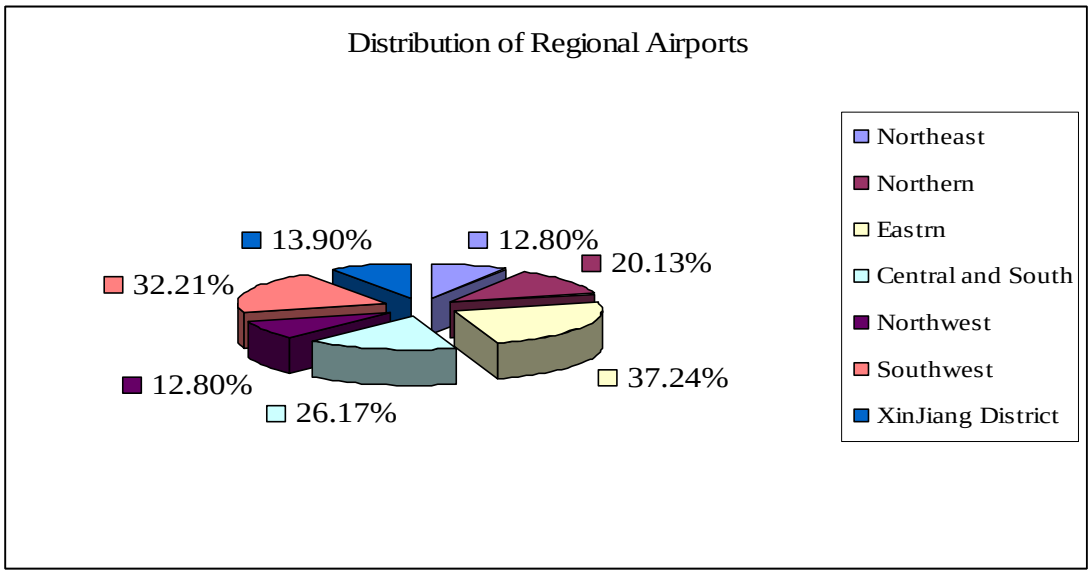


Fig 1: Distribution of Regional Airports

Date source: Airport production statistics report 2007-2008

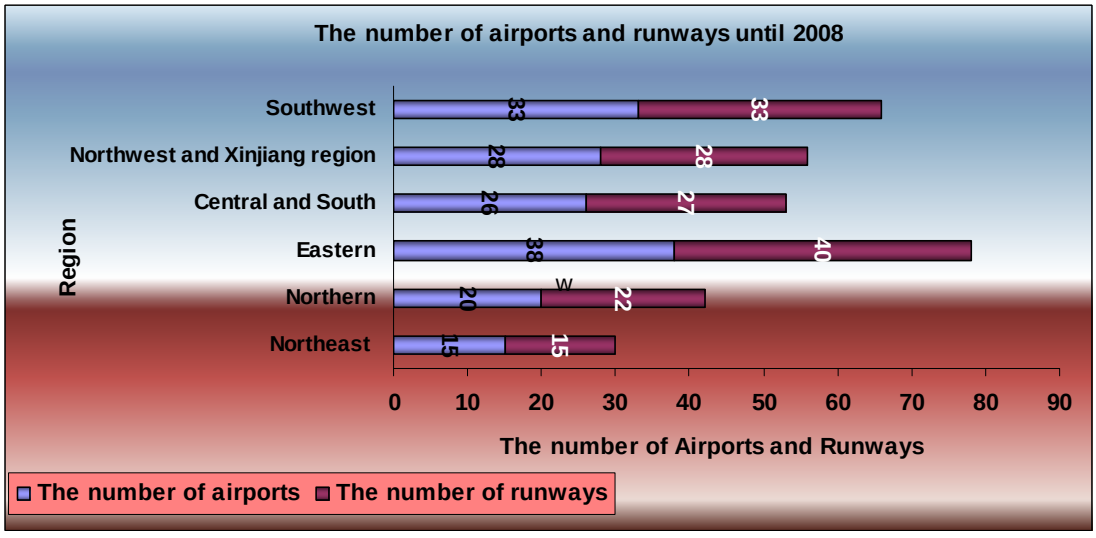


Fig 2: The Number of Regional Airports

Date source: China Civil Airports Association 2009 and Airport distribution planning report 2006

[2] The airports in Xinjiang Autonomous Region to be included in the Northwest Territories

1.2.2 The Actual Throughput of Airports

From 2004, China air transport industry step into a new level, the turnover volume of passenger and cargo are ranked No. fifth in the world, which completed throughput 241,934,678 and 552, 576, 5.2 respectively. Between 2005 and 2006, the total throughputs were keeping on upward trend, especially, in 2006, the passengers achieved 331,973,261 and the cargo tons increased nearly by 19% to 6,330,842.3. Until 2007, the national passenger throughput of the airports completed a total of 387,585,662 people, cargo throughput completed 8,610,982.9 tons. There was an obvious increasing of 16.8 percent in passenger and more than 14.3 percent in cargo comparing with last year. By 2008, the total passenger number went up by 4.7 percent to 405,762,104 and the total cargo tons grew by 2.61 percent to 8,833,590.1. A short period of 5 years, throughput of passenger and cargo increased by 40.3% and 37.4% respectively (Table 2).

Furthermore, in 2008, no matter which the number of throughout, they were still continuing to be led by Eastern and Central and south region as shown in the Figure 3 and 4. However, if analyzing growth rate by region, table 3 indicated that the fastest growth in passengers are Northeast and Northern region, the fastest growth in cargo are Southwest and Northeast region.

Table 2: Throughput of Passengers and Cargos during 2004-2008

Output / Year	Number of Passengers			Cargo tons			Total in same year
	Achievement	Last year	Rate of change	Achievement	Last year	Rate of change	
2004	241,934,678	174,324,727	27.9%	5,525,765.2	4,517,440.6	18.2%	247,460,443.2
2005	284,351,063	241,934,678	14.9%	6,330,842.3	5,525,765.2	12.7%	290,681,905.3
2006	331,973,261	284,351,063	16.7%	7,531,935.2	6,330,842.3	19.0%	339,505,196.2
2007	387,585,662	331,973,261	16.8%	8,610,982.9	7,531,935.2	14.3%	396.196,644.9
2008	405,762,104	387,585,662	4.7%	8,833,590.1	8,610,982.9	2.6%	414,595,694.1

Date Source: Airport production statistics report 2004-2008

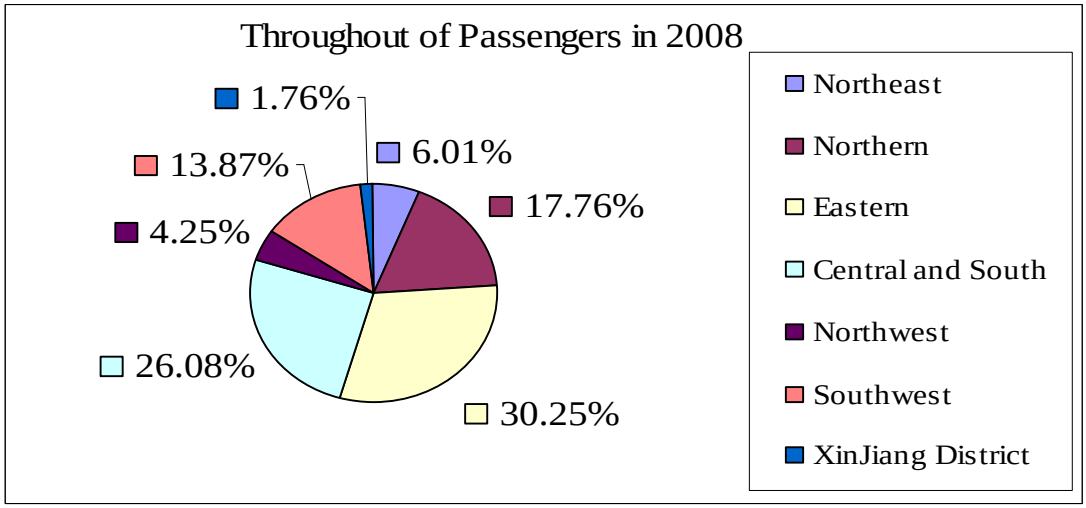


Fig 3: Throughout of Passengers in All Regions in 2008

Date source: Airport production statistics report 2008

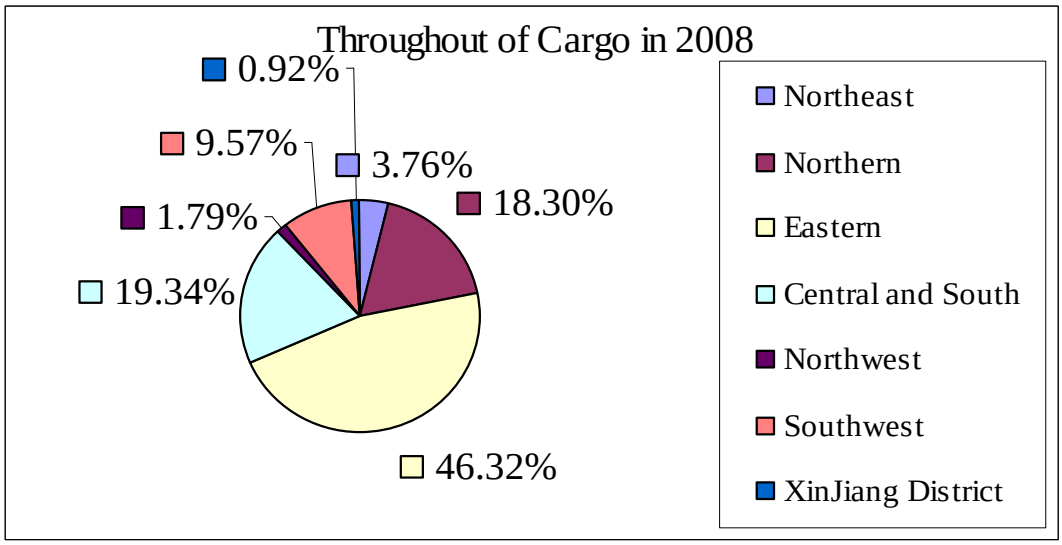


Fig 4: Throughout of Cargo in All Regions in 2008

Date source: Airport production statistics report 2008

Table 3: The Growth Ration in Passenger and Cargo by Region in 2008

Turnover / Region	The growth ration in passenger	The growth ration in cargo
Northeast	**12.0%**	**6.7%**
Northern	**8.6%**	**0.8%**
Eastern	**4.4%**	**4.4%**
Central and South	**7.1%**	**−1.6%**
Northwest	**0.9%**	**1.1%**
Southwest	**−4.5%**	**5.0%**
Mean	**4.7%**	**3.8%**

Date Source: China Civil Airports Association 2009

1.3 The Challenges for Airports' Development

Although since 2004 annual throughput of passenger and cargo have had a rapid growth by an average increasing rate of 16.2% and 13.36% respectively, however, behind the fast growth airports' development is facing with many challenges. According to the China air transport development report 2007, it also described that there are still a lot of adverse factors which influence on the overall airports' efficient development. A summary of main challenges are separated into three aspects.

1.3.1 Imbalance Development among Airports Group

Due to the layout of some airports group is too concentrated, such as the Yangtze River and Pearl River Delta region, the aviation businesses were mainly focused on these metropolis so that the use of tension on the airports' airspace and ground facilities contributed to air traffic congestion and severe flight delays; while the utilization in some airports which located in small and medium-sized cities around metropolis is very low so that inadequate utilization on resources resulted in the idle facilities. Therefore, following this clue, it is also refracted that imbalanced distribution of Chinese airports also brought about this kind of phenomenon.

1.3.2 Unscientific Construction and Investment on Airports

Indeed, unscientific construction and investment in the past have already been the big bottleneck for the development of Chinese airports in the day. At the early stage of reform and opening up, due to many local cities lacked scientific planning on the construction of the airports, the scope of the construction of majority airports were too large, besides because of the actual utilization rate of airports was far less than the designed capacity, by which led to the airports carried a heavy debt in final. On the other hand, which the aviation infrastructure of central cities was far from enough to meet the actual utilization have caused airports overloaded operating, hence, these kinds of chain reactions has seriously affected the efficiency of airport development.

1.3.3 State-owned Managerial Pattern

From a macro perspective, the airports are mainly managed by the Civil Aviation Administration of China and local governments, hence under a market economy system; the nationalization management system has seriously affected the efficiency on various aspects of airport development.

1.4 Research Motivation and Purposes

1.4.1 Background of the Research

As like mentioned above, China's aviation industry has gone through many major reforms for enhancing airports' efficiency on operating in recent years. Nonetheless, despite the those reforms provided more opportunities for airports to develop, which it can be seen from table 2 that a significant noticeable trend was the steady increase in throughout of airports, it also exposed many manifest operating drawbacks on airport's construction and management, which some of them seriously hindered the airports to develop effectively. Whereas, whether or not these reforming policies have been advanced the airports' efficient development or have achieved its objective of improving the airport's efficiency?

Meantime, from the simple point of view, airports as a facility merely provide a locus for bringing airlines and customers together. They are not the same as airlines to forecast directly specific demand for air travel and air freight. There is not to mention how better meet the customers' needs (Doganis, 1992). Therefore, for airports, to provide the airport's capacity in line with the demand, and in the meanwhile, achieve and maintain airport's efficiency and profitability, achieve a certain level of customer satisfactions and even create economic values to local region are not easy task. Besides, due to the airport industry is diverse with different operating characteristics and regulatory structure, distinct ownership and a wide range of service provision, measuring and assessing the performance of airports is sophisticated work. However, according to the development planning and goals of China's airport industry, in the 5

years future and until 2020, no matter which on hardware or software China want to built up a sound airport system in order to cater for China's economic, social development and the increasing needs for air transport. Wherefore how airports should be managed to achieve efficient operating for the goals of Chinese airports industry?

Thus, based on the two reasons above, investigating operational efficiency of China's airports has become important study and it is imperative.

1.4.2 The Significance of Research

The operational efficiency of airports not only bears on the utilization of airports' resources, but also has a direct impact on sustainable development capability of airports. Thereupon, researching the operating efficiency of Chinese airports has a far-reaching significance for the development of Chinese airports.

(1) Catering for the Chinese airports' development

As we known that on one hand, by reason of a lot of airports in China are still in development period, inefficient operation has resulted in a serious loss; while on the other, many large airports' capacity have become highly saturated. According to the official report from Civil Aviation Administration of China, at present a total of 60 airports in facilities capacity have been saturated or will soon reach saturation point, 13 of them have been running at overload, moreover, 36 airports will reach saturation point in 2010, 11 airports will be in 2015, It indicated that the utilization of resources at airports has affected operational efficiency with special severity, large-scale expansion of the airports in China is just around the corner. Therefore scientifically evaluating airports' operational efficiency can more effectively promote the sustainable development of the airport industry.

(2) Strengthening resources allocation for airports

From micro-economics perspective, if each economic unit achieved maximization, then the resources allocation achieved optimization. Therefore, evaluating operational efficiency on airports not only can strengthen resources allocation for airports to maximize economic unit, but also can enhance operational efficiency with less input to gain more output.

(3) Enhancing Chinese major airport's competitiveness

It is obvious that being half of three major airports Beijing Capital, Shanghai Pudong, Guangzhou Baiyun has been the dominant position in Chinese airports industry, no matter which on the construction or on the density of routes, they have been numbers among the major airports in the world list, and are endeavoring to become a world-class hub airport. Thus, evaluating operational efficiency on airports can help them plan and manage effectively, then to enhance their core international competitiveness.

1.5 Infrastructure of Thesis

Hence, the purpose of this study is to theoretically and numerically investigate 30 major Chinese airports' operational efficiency and give scientific suggestions of future development. Three research questions would include: what is the current situation of airports efficiency in China; how the operational efficiency of airport be measured and operated in China, how the airport could achieve operational efficiency in the future. The remainder of research design is organized into following. Chapter 2 gives related literature review on the operational efficiency of airports under DEA and Delphi methods. Methodology would be introduced in Chapter 3, which describes three DEA models and two-round Delphi research. Chapter 4 is data and result that would describe the sample airports' data and propose DEA and Delphi's study results. Suggestion and Limitation compose Chapter 5 and the last Chapter would be conclusion.

CHAPTER 2: LITERATURE REVIEW

Because the inefficient airport operational problem has been proved as a major hinder to the continuous growth of the aviation industry, a lot of scholars studied how to measure the airports' efficiency and how to improve the operational performance. Doganis (1992) pointed out measuring the performance of a business is to ensure that optimal performance can be equated with profitability. However, an overview of Graham (2005) provided that measuring the efficiency of airports was not only focused on the economic aspects. Therefore, in this study, data envelopment analysis and Delphi method were adopted to survey the operational efficiency of Chinese airports.

2.1 Data Envelopment Analysis (DEA)

Data envelopment analysis was firstly introduced by Charnes et al (1978), which use mathematical programming techniques and models to evaluate the performance of peer unit （DMU）in terms of multiple inputs used and multiple outputs produced. DEA applications involve a wide range of contexts, such as non-profit sector, banking, aviation industry and etc. According to the estimation methods that were used, the previous studies on airport operational efficiency could be classified into parametric method (econometric analysis) and non-parametric method. DEA is non-parametric method because it needs no assumptions or estimates of the parameters of the underlying production function. (Parker, 1999)

Airport efficiency studies by using DEA method have been made a significant progress by Gillen and Lall (1997, 2001), Parker (1999), Sarkis (2000), Pels et al. (2001, 2003), Fernandes and Pacheco (2002), Yoshida and Fujimoto (2004), Lam et al. (2009). Especially, Zhang and Hu (2006), Zhu (2007), Fung et al. (2008), Andrew and Zhang (2008) adopted DEA to survey Chinese airports' efficiency.

Gillen and Lall in 1997 used DEA to investigate 21 of the top 30 airports in the United Stated for the period 1989-1993. Their approach in the evaluation of airport performance has been to separate airside and terminals in exploring management strategies to improve efficiency. They found on the airside having hub airlines and expanding gate capacity improved efficiency. In addition, reducing the number of GA movements would also have a dramatic effect on increasing efficiency. On the other hand, expanding the number of gates and managing them in a way to ensure their effective utilization would improve terminal efficiency. In 2001, they used the same inputs and outputs indices and investigated the same period for 22 US airports sample. They constructed a Malmquist index of productivity change and decomposed it into scale effects, efficiency effects and technical change. Their study firstly introduced DEA method to evaluation the efficiency on airports' operating.

DEA was adopted to measure the performance of British Airports Authority (BAA) before and after privatization by Parker (1999). The study took 22 UK airports during the period 1979 to 1996 to concern with the technical efficiency performance of BAA. It found that privatization had no obvious impact on technical efficiency, and BAA performance depended on different airports operated by the company over time.

Sarkis evaluated the operational efficiency of 44 US airports during 1990 to 1994. Three propositions were advanced: airports that are hubs for major air carriers are more efficient than those that are not hubs; airports in multiple airport systems are more efficient than those in single airport systems; airports that are not in snowbelts are more efficient than those in snowbelts. These propositions offered new interesting study on the operational efficiency of airports. Therefore, this study also investigates the different performance between hubs and non-hubs.

Pels et al. in 2001 analyzed terminal output (PAX) and aircraft movements (ATM) separately for 34 European airports during 1995 to 1997. They found most airports in euro are operating under increasing returns to scale. In 2003, they combined the

stochastic production frontier and DEA method which analyzed APM (air passenger movements) and ATM to evaluate the operational efficiency. As the result, they argued that European airports were inefficient on average.

In 2002, 35 Brazilian airports were selected to analyze the capacity efficiency by Fernandes and Pacheco. They adopted DEA to reflect which of airports used airports resources efficiently and which offered surplus in these facilities. In 2004, Yoshida and Fujimoto used DEA and endogenous-weight TFP methods to test the criticism of overinvestment in Japanese regional airports. They found that regional airports in mainland are lower efficient than others. Recently, Lam et al. first attempt to apply DEA across international airports within Asia Pacific region and discriminated against the various efficiency sources and economic conditions that affect the overall cost efficiency of airports. They found that airports in the Asia Pacific are generally technical, scale and mix efficient.

Zhang and Hu (2006) firstly analyzed the operational efficiency of China civil airports by using Malmquist TFP index of DEA. They chose 9 major airports in China to investigate the efficiency during 1995-2005. They argued that China civil airports' operation increment is heavily dependent on the enlargement of airports' infrastructure, but scale factor and technology efficiency remaining unchanged during the process. Zhu (2007) presented DEA approach to evaluate the efficiency of 64 Chinese airports, the time span is from 2000 to 2004. They thought airports with large passenger volume had high efficiency on operation, and there exist unbalance between different regions' airports in China. Fung et al., Andrew and Zhang (2008) both took 25 Chinese airports, the same inputs and outputs indices to evaluate the operational efficiency. Fung et al. adopted the Malmquist index approach to trace the temporal dynamics in airport productivity change. They found that there was a significant difference in efficiency among regional airports in China depending on their geographical location; international hub airports were more efficient than others; and ownership reform might be an effective means of enhancing airport efficiency in

China. Andrew and Zhang used DEA and Tobit to investigate the influence of competition and aviation policy reform in China on the efficiency. They found publicly listed airports are more efficient than non-listed airports; more competition would improve efficiency; airports efficiency and the technical progress are positively correlated with the airport location program; and the impacts of open-skies agreements and airline mergers on the airports' efficiency are insignificant.

Both their paper offer helpful process for the study on Chinese airports' efficiency. However, the lack of accuracy data limited the result of their paper. In addition, the data should be renewed for further research. Therefore, this study surveys the current operational efficiency of Chinese airports and evaluates the performance. Table 4 below summaries the previous DEA studies on airport efficiency, the input and output indices they used were adopted partly for our Delphi questionnaire research.

Table 4: DEA Studies on Airport Efficiency

Paper	**Method**	**Units**	**Period**	**Inputs**	**Outputs**
Gillen and Lall (1997, 2001)	DEA Tobit	21US airports (1997) 22US airports (2001)	1989-1993	Terminal Services: No. of runways, No. of gates, Terminal area, No. of employees, No. of baggage collection belts, No. of public parking spots; Movements: Airport area, No. of runways, Runway area, No. of employees	Terminal Services: No. of passengers, Pounds of cargo; Movements: Air carrier movements, Commuter movement
Parker (1999)	DEA	22UK airports	1979-1996	No. of employees, Capital input, Other inputs	Turnover, Passengers number handled, Cargo and mail business

Sarkis (2000)	DEA	44US airports	1990-1994	Operating cost, No. of employees, No. of gates, No. of runways	Operating revenue, No. of aircraft movement, General aviation movements, Passenger movements, Amount of Cargo shipped
Pels et al. (2001)	DEA, SFA	34 European airports	1995-1997	PAX model: Terminal size, No. of aircraft parking positions, No. of remote aircraft parking positions, No. of check-in desks, No. of baggage claims; ATM model: Total airport area, Total length of runway system, No. of aircraft parking positions, No. of remote aircraft parking positions	PAX: No. of passengers ATM: Air transport movements
Fernandes and Pacheco (2002)	DEA	35 Brazilian airports	1998	Area of apron, Departure lounge, No. of check-in counters, Curb frontage, No. of vehicle parking spaces, Baggage claim area	Domestic passengers
Pels et al. (2003)	DEA SFA	34 European airports	1995-1997	ATM model: Airport surface area, No. of aircraft parking positions, No. of remote	ATM: Air-transport movements, APM: Air-passenger

				aircraft parking positions, No. of runways APM model: No. of check-in desks, No. of baggage claim units	movements
Yoshida and Fujimoto (2004)	DEA, EW-TFP	67 Japanese airports	2000	Runway length, Terminal size, Access cost, No. of employees	Passenger volume Cargo loading, Aircraft movements
Zhang and Hu (2006)	DEA	9 Chinese airports	1995-2005	Terminal area, Aircraft parking positions, vehicle parking area, Cargo area	Passenger volume, Cargo volume, Aircraft movements
Zhu (2007)	DEA	64 Chinese airports	2000-2004	Operating cost, Net value of fixed capital, Current assets	Operating revenue, Passenger volume, Aircraft movement
Fung et al. (2008)	DEA	25 Chinese airports	1995-2004	Runway length, Terminal area	Passenger volume, Cargo volume, Aircraft movement
Andrew and Zhang (2008)	DEA	25 Chinese airports	1995-2006	Runway length, Terminal size	Passenger volume, Cargo volume, Aircraft movement
Lam et al. (2009)	DEA	11 Asian airports	2001-2005	Labor, Capital, Soft input, Trade value	No. of aeronautic movement, No. of passengers, Tonnes of cargo

Note: SFA=Stochastic Production Frontier Analysis,

EW-TFP=Endogenous-weight Total Factor Productivity

2.2 Delphi Method

The first application of Delphi method was initiated by Project RAND at Douglas Aircraft Company during the 1950-1960s by Olaf Helmer, Norman Dalkey, and Nicholas Rescher, which published by Gordon and Helmer in 1964, The objective of

this project was to evaluate the direction of long-range trends, with special stress on science and technology, and their probable effects on society. The project involved into scientific breakthroughs; population control; automation; space progress; war prevention; weapon systems of these six topics(GÜNAYDIN, H. Murat 2008). After few years, Delphi method has been developed into various fields in academic, such as economic, sociology, transportation, operational research, medicine, statistics, psychology and even military. Certainly Delphi method was also applied successfully and with high accuracy in business forecasting, which included marketing expenditure effectiveness (Kotler, 1970), the demand for telephony (Day, 1973), forecasting economic conditions (Decker, 1974), sales forecasting (Basu and Schroeder 1977).

Examples of research problems covered air aviation industry with the Delphi technique has been applied to include: A Delphi forecast for air traffic and technology during the 1990–2000 decade (Morley English, J., Kernan, Gerard L. 1975). The study was conducted with Delphi procedures using internal auditors of Latin American airlines as panel members to achieve 65 performance criteria and 12 goal statements, and authors firstly divided the Delphi method into three kind of types: ‘Delphi Forecasts”, “Policy Delphi” and “Goal Delphi” (Cooper,WilliamW. et al, 1995). Following a modified Delphi method to generate a long list of regulatory and economic forces in terms of various airline consolidation and alliance‘s evolution (Fan, Terence, et al in 2001). Minimum data set development: air transport time-related terms with Delphi method (Thompson, Cheryl Bagley, et al, 2002). Keith et al used a Delphi panel of 26 air transport experts to forecast the structure of air transport in the EU in 2015 in respect of network carriers, low cost airlines and passenger behaviors (Mason, Keith J, et al 2007).

In Taiwan China, Delphi method also has been used in evaluating performance and destination selection in aviation industry. Be half of Chang, three professors selected 16 criteria to compose a Delphi questionnaire and send it to question 15 professionals in related fields in aviation industry to select performance criteria covered airports in

east Asia (Chang et al 2003). Chang et al selected 16 experts and adopted a two-round Delphi study to ascertain the weighting, preference and threshold of relative attributes in low cost carrier's destination selection (Chang et al, 2008).

Yet little previous study used Delphi method to forecast the airport's performance in terms of operating efficient development. This study will offer a Delphi method for selecting the DEA model evaluative criteria and at the same time firstly to provide some scientific judgments of current operation of Chinese airports and some suggestions for the future development on operating efficiency of airports by using Delphi method.

CHAPTER 3: METHODOLOGY

In this study, our objective is to investigate the Chinese airport's operation, measure the airport's efficiency by analyzing 30 major Chinese airports and survey scientific judgments of current operation and suggestions for Chinese airports' development on operational efficiency in future. Two methods were carried out to look into, which included Data Envelopment Analysis (DEA) and Delphi method.

3.1 Data Envelopment Analysis (DEA)

Data Envelopment Analysis is an empirical application of measuring the efficiency and productivity changes based on non-parametric linear-programming technique and the basic model which only requires information on inputs and outputs. In this study, DEA method was used to evaluate and measure the operational efficiency performance for 30 Chinese airports during 2004 to 2008. Three models are used which conclude CCR (Charnes, Cooper and Rhodes), BCC (Banker, Charnes and Cooper) and Malmquist. In addition, there are input-oriented and output-oriented for these models. Input-oriented is to minimize inputs while producing at least the given output levels, and output-oriented is to maximize outputs while using no more than the observed amount of any input. Because the input chosen were assumed to be quasi-fixed, therefore output-oriented analysis was adopted for this study. DEAP software[3] is used for the DEA calculation process.

3.1.1 Basic CCR Model and BCC Model

Charnes et al. (1978) proposed the model, known as CCR or CRS, which is built on the assumption of constant returns to scale of activities. Parker (1999), Sarkis (2000), Fernandes and Pacheco (2002), Yoshida and Fujimoto (2004), Zhu (2007), Fung et al. (2008) and Lam (2009) all used this model to evaluate the efficiency of airports'

[3] DEAP program is the specialist DEA computer packages available, written in Fortran for IBM compatible PCs. It is a DOS program but can be easily run from WINDOWS using file manager.

operation. In our study, this basic model was used to measure 30 Chinese airports performance during 2004-2008. The model is shown below:

$$\max \phi - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

Subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_j^- = x_{io} \qquad i = 1,2.....m;$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi y_{ro} \quad r = 1,2.....s;$$

$$\lambda_j, s_r^+, s_j^- \geq 0 \qquad r, j = 1,2.....n;$$

Where x is the vector of inputs used by the DMUs;

y is the vector of quantities produced by the DMUs;

ε is the infinitesimal non-Archimedean constant that assures that no input or output is assigned zero weight;

s_r^+, s_j^- are the slack vector

ϕ is a scalar variable that represents the possible radial increase to be applied to all outputs

λ_j is the vector whose optimal values form a combination of units which make up the performance of the DMU

In addition, another model used in this study was proposed by Banker et al. (1984), known as BCC or VRS. Parker (1999), Sarkis (2000), Fernandes and Pacheco (2002), Yoshida and Fujimoto (2004), and Lam (2009) used both CCR and BCC models in their study. The BCC model has the assumption of variable returns to scale, which involves the following primal of the linear programming problem:

$$\max \phi - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

Subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_j^- = x_{io} \qquad i = 1,2.....m;$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi y_{ro} \quad r = 1,2.....s;$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j, s_r^+, s_j^- \geq 0 \qquad r, j = 1,2.....n;$$

Table 5: Summary the Envelopment Models

Frontier Type	Output-Oriented
CRS	$\max \phi - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$ Subject to $\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io} \qquad i = 1,2.....m;$ $\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \phi y_{ro} \qquad r = 1,2.....s;$ $\lambda_j \geq 0 \qquad j = 1,2.....n;$
VRS	Add $\sum_{j=1}^{n} \lambda_j = 1$
$\begin{cases} s_i^- = x_{io} - \sum_{j=1}^{n} \lambda_j x_{ij} \\ s_r^+ = \sum_{j=1}^{n} \lambda_j y_{rj} - \phi^* y_{ro} \end{cases}$	$i = 1,2,....., m$ $r = 1,2,..., s$

Source: Joe Zhu (2003)

Table 5 above gives the summary of BCC and CCR models. If ϕ^*=1, then the DMU under evaluation is a frontier point. i.e., there is no other DMU that are operating more efficiently than this DMU. Otherwise, if ϕ^*>1, then the DMU under evaluation is inefficient. i.e., this DMU can either increase its output levels or decrease its input levels. In our study, $1/\phi^*$ defines a TE (technical efficiencies) score reported by DEAP software, which varies between zero and one. Therefore, if the value equals to 1, then this airport is efficiency. If $1/\phi^*$ is under 1 which means this airport is inefficient.

3.1.2 Productivity Changes

Malmquist index proposed by Färe et al. (1994) could reflect the operational efficiency change of airports during the time period. This model is helpful to evaluate whether the operational efficiency is improved or not. Gillen and Lall (2001), Zhang and Hu (2006) and Fung (2008) took this model to calculate the change of airports' performance. The model using the geometric mean of the indexes for the period t and t+1 which yields the following Malmquist index of productivity change:

$$M_0\left(x^t, y^t, x^{t+1}, y^{t+1}\right) = \sqrt{\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)} \times \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^t, y^t\right)}}$$

Where x is an N dimensional vector of inputs;

y is an M dimensional vector of outputs;

M_0 is the Malmquist productivity index;

D(x,y) is the distance function

It also could be expressed as:

$$M_0\left(x^t, y^t, x^{t+1}, y^{t+1}\right) = \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)} \times \sqrt{\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^t, y^t\right)} \times \frac{D_0^t\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)}}$$, in which

$\frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\right)}{D_0^t\left(x^t,y^t\right)}$ measures technical efficiency change (EFFCH) , if EFFCH>1, the technical efficiency is improved, and $\sqrt{\frac{D_0^t\left(x^{t+1},y^{t+1}\right)}{D_o^{t+1}\left(x^t,y^t\right)}\times\frac{D_0^t\left(x^t,y^t\right)}{D_0^{t+1}\left(x^t,y^t\right)}}$ measures technological change (TECHCH), if TECHCH>1, the technological improves. Therefore, Malmquist index = EFFCH * TECHCH.

After adding restriction $\sum\lambda=1$, EFFCH could be expressed as below:

$$\frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\right)}{D_0^t\left(x^t,y^t\right)} = \frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\ \middle|VRS\right)}{D_0^t\left(x^t,y^t\ \middle|VRS\right)} * \left[\frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\ \middle|CRS\right)}{D_0^{t+1}\left(x^{t+1},y^{t+1}\ \middle|VRS\right)}\times\frac{D_0^t\left(x^t,y^t\ \middle|VRS\right)}{D_0^t\left(x^t,y^t\ \middle|CRS\right)}\right],$$ in which $\frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\ \middle|VRS\right)}{D_0^t\left(x^t,y^t\ \middle|VRS\right)}$ measures pure technical efficiency change (PECH), $\left[\frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\ \middle|CRS\right)}{D_0^{t+1}\left(x^{t+1},y^{t+1}\ \middle|VRS\right)}\times\frac{D_0^t\left(x^t,y^t\ \middle|VRS\right)}{D_0^t\left(x^t,y^t\ \middle|CRS\right)}\right]$ measures scale efficiency change (SECH). And then Malmquist index = PECH * SECH * TECHCH.

Calculating Malmquist index and its components requires the calculation of four distances: $D_o^t\left(x^t,y^t\right)$, $D_0^{t+1}\left(x^{t+1},y^{t+1}\right)$, $D_0^{t+1}\left(x^t,y^t\right)$ and $D_0^t\left(x^{t+1},y^{t+1}\right)$. This is accomplished by solving four linear programming problems shown below:

Table 6: Four Distance Linear Programming

$\max_{\theta,\lambda}\theta=\left[D_0^t\left(x^t,y^t\right)\right]^{-1}$	$\max_{\theta,\lambda}\theta=\left[D_0^{t+1}\left(x^{t+1},y^{t+1}\right)\right]^{-1}$	$\max_{\theta,\lambda}\theta=\left[D_0^t\left(x^{t+1},y^{t+1}\right)\right]^{-1}$	$\max_{\theta,\lambda}\theta=\left[D_0^{t+1}\left(x^t,y^t\right)\right]^{-1}$
St $-\theta y_i^t+Y\lambda\geq 0$	St $-\theta y_i^{t+1}+Y^{t+1}\lambda\geq 0$	St $-\theta y_i^{t+1}+Y^t\lambda\geq 0$	St $-\theta y_i^t+Y^{t+1}\lambda\geq 0$
$x_i^t-X^t\lambda\geq 0$	$x_i^{t+1}-X^{t+1}\lambda\geq 0$	$x_i^{t+1}-X^t\lambda\geq 0$	$x_i^t-X^{t+1}\lambda\geq 0$
$N1'\lambda=1$	$N1'\lambda=1$	$N1'\lambda=1$	$N1'\lambda=1$
$\lambda\geq 0$	$\lambda\geq 0$	$\lambda\geq 0$	$\lambda\geq 0$

Source: Zhang and Hu (2006)

Therefore, the Malmquist index of productivity change can be represented as technical efficiency change and technological change. Technical efficiency change could be divided into pure technical efficiency change, scale efficiency change. In this study, these elements were used to analyze efficiency change of 30 Chinese airports and evaluate whether the performance is improved or not.

3.1.3 Data Collection

The data used for these three DEA models are collected from the statistical report of Civil Aviation Administration of China (CAAC) and Civil Aviation Resource Net of China (CARNOC). Some information of these 30 sample airports are gathered from their companies' web. (See Appendix 1)

3.2 Delphi Method

In this research paper, A Delphi methodology was adopted for selecting evaluative criteria and surveying some scientific judgments of current operation and suggestions for Chinese airports' future development associated with the operational efficiency.

Delphi method is an interactive forecasting method aimed at eliciting judgments and obtaining consensual forecasts by means of a series of questionnaires sent either by mail or via systematic way to the pre-selected group of experts who are geographically dispersed and supposed to be knowledgeable in subject fields. Because of the entire procedure remains anonymous interaction with two or more rounds, Delphi method somewhat avoids the biases and influences on the answers from the panel members. Generally speaking, sending the questionnaire designed in advance to pre-selected panel of experts and who are expected to give a response to each question and also a justification for this response in the initial round. After received the questionnaire returned, researchers summarize the experts' judgments and feedback them to the same panel. Until to the second round, each respondent is expected to strength and reassess their own answers, in this round, the additional suggestions

would have possibility to be presented when the answers are collated. Over a number of interactions as the same way, finally, the views of experts would be combined and a degree of consensus would be achieved. (See appendix 3& 4)

For this study, 15 panel members of aviation industry, supply chain management, transport industry experts and sophisticated specialists were participated into a two-round Delphi study. Three of professionals who are working at senior roles for airports, two for airlines and four experts who are working in civil aviation authorities, six experts left who are working at universities in China mainland, Taiwan and England. The panelists were contacted by the email and the whole survey procedure was completed by sending the electronic questionnaire paper (See appendix 5).

Regarding selecting indicators of DEA, Wei (1989) pointed out in his studies that the option of evaluative indicators of DEA should cooperated with the management personnel and experts with similar background, which is due to the appropriate selection has a direct impact on the target, in order to be able to play the maximum advantage of DEA methods, the indicators should be taking into account the links and echo between input and output as well as the coordination of relative and absolute indicators. Therefore, over the first round questionnaire period form March 15, 2009 to April 5, 2009, 16 evaluative criteria which were derived from the previous benchmarking literature involved in technical aspect were provided to expect panelists to select which input indices affect on the airport efficiency and which indices represent output efficiency at airport.

Additionally, based on the previous study of which related to the construction and development of Chinese airport, 18 statements covered evaluative and suggestive aspect were also proposed to survey some judgments of current operating and suggestions for how the operating efficiency could be improved in future development. In order to classify the different opinions, agree, disagree and no opinion column were provided for inquiring the choice, simultaneously, we set up one

writing item for each aspect in order to elicit the new statements from experts as additional suggestions to next round. However, our questionnaire in the initial round did not offer a justification for each expert's answer, as we concerned that no one prefer to write down complex "reason or why" at the outset, complicated questionnaire style only may contribute to lose more return when experts saw the questionnaire at their busy time. Finally, for the purpose of underling the goal of Delphi method, it was determined that if a question reached the three fifths (60%) in agreement, to a certain degree the consensus was achieved.

After the first round finished, through distilling the former answers, despite it showed the technical aspect which for selecting reasonable input and output indices for a DEA model have achieved assessable objective, in order to assure the veracity and appropriateness of indicators, in decided that the same way in accordance with last round was taken to resifting the criteria indicators in second round; simultaneously, in this survey, new questions derived from the comments given by experts in the first round were used in new round. Therefore, the total of 40 statements involved in 16 criteria indicators, 24 evaluative and suggestive statements which covered 6 additional questions suggested by the respondents were adopted for use during the second Delphi questionnaire period from April 10, 2009 to April 30, 2009.

Moreover, in order to reach the goal level of Delphi methodology and identify the areas of agreement or disagreement about evaluative statements and suggestions, we designed a six-point strength ratios with a score of 1 being " strongly disagree" to 6 of " strongly agree which has been used in the studies by Ludlow John, to support experts consider and reassess their own answers to improve how much they held their views so as to reach the consensus on various suggestions related to airports' efficient operation as shown in Figure 5; additionally, a neutral value of 3.5 was regarded as the consensus threshold, no matter which the experts agreed or disagreed with the questions, they were expected to account for their own answers at the same time.

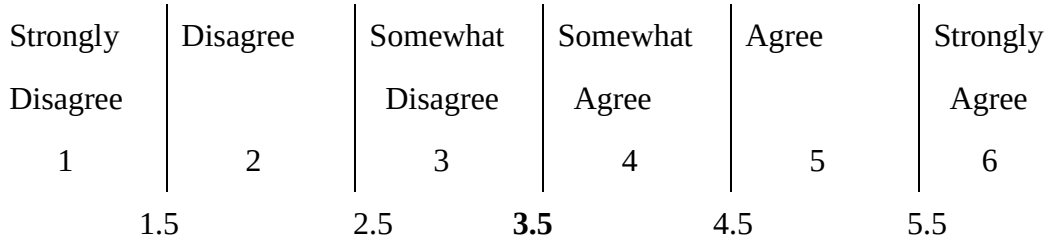


Fig 5: Strength Ratios for Consideration on Each Question

Source: The Delphi method techniques and applications: Delphi Inquiries and Knowledge Utilization by Ludlow John

CHAPTER 4: DATA AND RESULT

4.1 Indices Chosen and Data Describe

According to the Delphi study, 16 evaluative indices which was consisted of which input indices would have a significant impact on airport efficiency and which indicators could represent output efficiency at an airport for applying into DEA model were set up in the two-round questionnaire. A summary of the effectiveness of Delphi method in these 16 indices over first round is shown in table 7, three fifths or more of the respondents were in agreement on the length of runway, terminal area, passenger movements, cargo movements and air carrier movements, which made up the high percentage approximately 66.6%, 73.3%, 80%, 80% and 66.6% respectively, while the number of employees, airport area, prime operating cost, number of check-in desks and number of public parking spots constituted the lower around 6.6% to 25%.

Table 7: Technical Evaluative Criteria for DEA Model in First Round

First Round / **Technical aspect**	**Input indices**	**Agree**	**Disagree**	**Consensus Level%**
Indices listed would have a significant impact on airport efficiency	Number of runways	***5***	***10***	***33.3%***
	Length of Runway	***10***	***5***	***66.6%***
	Terminal area	***11***	***4***	***73.3%***
	Number of employees	***3***	***12***	***25.0%***
	Number of baggage claims	***5***	***10***	***33.3%***
	Number of gates	***6***	***9***	***40.0%***
	Number of public parking spots	***3***	***12***	***25.0%***
	Airport area	***1***	***14***	***6.6%***
	Prime operating cost	***2***	***13***	***13.3%***
	Number of aircraft parking positions	***5***	***10***	***33.3%***
	Number of remote aircraft parking	***6***	***9***	***40.0%***

	positions			
	Number of check-in desks	***3***	***12***	***25.0%***
Indices listed could represent output efficiency at an airport	**Output indices**	**Agree**	**Disagree**	**Level%**
	Passenger movements	***12***	***3***	***80.0%***
	Cargo movements	***12***	***3***	***80.0%%***
	Air carrier movements	***10***	***5***	***66.6%***
	Operating revenue	***6***	***9***	***40.0%***

The most striking contrast of input indicators was the number of employees, which is essential factor of production in airport activities. By distilling the supplementary respondences of one of the panelists who works at Wuhan airport, this study found that airports in China today almost has been group enterprise such as Shanghai airport group and Northern airport group; the airport operators may conduct more than one airport, also with the number of part-time staff, it makes difficult for each individual airport to gather the labor data to measure the contribution of labor input. Hence, this situation might be the reason why most of experts still treat it as an arduous academic difficulty.

Besides, another scenario was presented by the Delphi panel members during first round. The number of self service check-in desks, bag drops for checking in remotely ,Queue time at check-in and security, bag waiting times at arrivals, taxiing time, take off and landing punctuality as the division in input and output indicators were put forward respectively. However, it was concerned that they are arguable as input and output indicators in airport activities; therefore, as additional suggestive questions these statements were proposed into next round.

Until to the second stage, as can be seen from table 8, the proportion of those input and output indices which have achieved high level in the initial round appeared to remain upward trend and reached broad agreement in this round. Especially there occurred a notable increase on passenger movements and cargo movements which

achieved a unanimous vote, air carrier movements also went up to 93.3%. At the same time, it also can be seen that although some input and output indicators were reassessed by experts, for instance, the consensus level of number of runways, number of baggage claims and number of aircraft parking positions raised from 33.3% to 46.6%, yet they still did not exceed the agreement threshold.,

Table 8: Technical Evaluative Criteria for DEA Model in Second Round

Second Round / **Technical aspect**	**Input indices**	**Agree**	**Disagree**	**Consensus Level%**
Indices listed would have a significant impact on airport efficiency	Number of runways	***7***	***8***	***46.6%***
	Length of Runway	***11***	***4***	***73.3%***
	Terminal area	***12***	***3***	***80.0%***
	Number of employees	***3***	***12***	***25.0%***
	Number of baggage claims	***7***	***8***	***46.6%***
	Number of gates	***6***	***9***	***40.0%***
	Number of public parking spots	***6***	***9***	***40.0%***
	Airport area	***1***	***14***	***6.6%***
	Prime operating cost	***2***	***13***	***13.3%***
	Number of aircraft parking positions	***7***	***8***	***46.6%***
	Number of remote aircraft parking positions	***6***	***9***	***40.0%***
	Number of check-in desks	***3***	***12***	***25.0%***
Indices listed could represent output efficiency at an airport	**Output indices**	**Agree**	**Disagree**	**Level%**
	Passenger movements	***15***	***0***	***100%***
	Cargo movements	***15***	***0***	***100%***
	Air carrier movements	***14***	***0***	***93.3%***
	Operating revenue	***6***	***9***	***40.0%***

Therefore, the DEA models which estimated in our study adopted three outputs – passenger movements, cargo movements and air carrier movements and two inputs – runway length and terminal area. (See Appendix 2)

Our data set is composed of information from 30 of the top rank airports in China for

the period 2004-2008. These sample airports could be classified into three categories based on the different attribute. First, according to the geographical location, they could be divided into five sorts- Northern (Beijing Capital, Dalian, Shenyang Taoxian, Harbin Taiping and Taiyuan Wusu), Eastern (Shanghai Pudong, Shanghai Hongqiao, Hangzhou Xiaoshan, Xiamen Gaoqi, Nanjing Lukou and Qingdao Liuting), Central and South (Guangzhou Baiyun, Shenzhen Bao'an, Wuhan Tianhe, Changsha Huanghua, Haikou Meilan and Sanya Phoenix), Southwest (Chengdu Shuangliu, Kunming Wujiaba, Chongqing Jiangbei, Guiyang Longdongbao, Lijiang Sanyi and Xishuangbanna) and Northwest (Xi'an Xianyang, Ürümqi Diwopu, Lanzhou Zhongchuan, Yingchuan Hedong, Xining Caojiabu and Kashi). The distribution of these sample airports is summarized in table 9 below. Second, they could be classed as listed and non-listed. PEK, CAN, PVG and SHA (same group), SZX, XMN and HAK belong to the listed airports while other 23 airports are non-listed category. Third, they also could divided into three sorts-international hub (PEK, CAN, PVG), national hub (SHA, CTU, XIY, SHE, KMG and URC) and others.

Table9: Distribution of Sample Airports

Northern	Eastern	Central and South	Southwest	Northwest
PEK	PVG	CAN	CTU	XIY
DLC	SHA	SZX	KMG	URC
SHE	HGH	WUH	CKG	LHW
HRB	XMN	CSX	KWE	INC
TSN	NKG	HAK	LJG	XNN
TYN	TAO	SYX	JHG	KHG

Among these 30 Chinese airports, seven airports have changed input indices. Haikou airports largened terminal area to 99300 square meters in 2006, and Qingdao Liuting in 2007 rebuilt terminal area to 163000 square meters. In 2008, in order to increase service ability to meet the Olympic Game's demand, Beijing Capital lengthened their runway length from 7000 to 10800 meters, and terminal size from 414000 to 1414000 square meters. Meanwhile Shanghai Pudong changed runway length from 7800 to 11200 meters, terminal area added 485500 square meters. Guangzhou Baiyun, Wuhan

Tianhe and Tianjin Binhai added terminal size from 320000 to 370000, 28400 to 178200 and 25000 to 141000 square meters respectively. Statistics of three output and two input variables of these airports during 2004-2008 are calculated in table 10.

Table 10: Summary of Input and Output Indices

		Passenger Movements (persons)	Cargo Movements (tons)	Aircraft Movements (planes)	Runway Length (meter)	Terminal Area (ten-thousand sq.m.)
2004	Average	6796648	171499	67051	3673	9.0
	Max	34883190	1642176	304882	7800	41.4
	Min	329945	691	3121	2200	0.5
	Stdev	7656343	319704	66206	1311	9.5
2005	Average	7981750	196920	76967	3673	9.0
	Max	41004008	1857120	341681	7800	41.4
	Min	389680	606	3397	2200	0.5
	Stdev	8894963	364149	75035	1311	9.5
2006	Average	9280247	234641	87421	3673	9.2
	Max	48748298	2168072	378888	7800	41.4
	Min	444332	1126	4017	2200	0.5
	Stdev	10278725	442438	82965	1311	9.5
2007	Average	10763617	267590	97779	3673	9.2
	Max	53611747	2559246	399209	7800	41.4
	Min	502591	1286	4139	2200	0.5
	Stdev	11335585	518907	88121	1311	9.5
2008	Average	11231347	273421	102526	3913	15.5
	Max	55938136	2603027	429646	11200	141.4
	Min	427577	1280	3682	2200	0.5
	Stdev	11682305	520649	93160	2097	27.8

4.2 Operational Efficiency Results

4.2.1 Airports Efficiency Levels

Table 11 and 12 show the results of CCR and BCC DEA efficiency scores for output-oriented efficiency measurements. In the following, we would look at both CCR and BCC results in turn.

Firstly, there were only 4 airports (Beijing Capital International Airport, Shanghai

Pudong International Airport, Shanghai Hongqiao International Airport and Shenzhen Bao'an International Airport) which achieved the CCR DEA score among 30 Chinese airports in 2004 and 2005. Wuhan Tianhe yielded the full score in 2006 that increased the number of efficient airports to 5. In 2007, the efficiency score of Shenzhen airport reduced from 1 to 0.996 while Tianjin Binhai increased from 0.99 to full score. Therefore, the numbers of efficient airports were as same as the last year. Because China held the Olympic Game in 2008, there were some airports that rebuilt and used the new runway and terminal area. However, their output indices did not increased as the same step as input, therefore, the efficiency score of airports such as Beijing Capital International Airports and Tianjin Binhai International Airports decreased clearly. On the other hand, Shenzhen Bao'an arrived one again and Changsha Huanghua reached full score made the number of efficiency airports to 4 in 2008. Among these 30 airports, it could be found that a lot of airports were operated below 0.5 efficiency score such as Xiamen Gaoqi, Nanjin Lukou, Qingdao Liuting and etc. Xishuangbanna got the lowest efficiency score of only 0.12. The mean CCR DEA score from 2004 to 2008 was 0.575.

Table 11: CRS Results

Airport	Code	2004	2005	2006	2007	2008
Beijing Capital	PEK	1.000	1.000	1.000	1.000	0.804
Guangzhou Baiyun	CAN	0.622	0.625	0.598	0.628	0.691
Shanghai Pudong	PVG	1.000	1.000	1.000	1.000	1.000
Shanghai Hongqiao	SHA	1.000	1.000	1.000	1.000	1.000
Shenzhen Bao'an	SZX	1.000	1.000	1.000	0.996	1.000
Chengdu Shuangliu	CTU	0.702	0.739	0.815	0.827	0.800
Kunming Wujiaba	KMG	0.702	0.708	0.811	0.832	0.858
Hangzhou Xiaoshan	HGH	0.417	0.440	0.534	0.577	0.603
Xi'an Xianyang	XIY	0.589	0.609	0.628	0.716	0.741
Chongqing Jiangbei	CKG	0.460	0.454	0.528	0.592	0.642
Xiamen Gaoqi	XMN	0.414	0.407	0.427	0.447	0.494
Wuhan Tianhe	WUH	0.917	0.880	1.000	1.000	0.523

Changsha Huanghua	CSX	0.876	0.845	0.930	0.883	1.000
Nanjing Lukou	NKG	0.330	0.324	0.339	0.411	0.461
Qingdao Liuting	TAO	0.486	0.474	0.513	0.529	0.467
Dalian	DLC	0.392	0.383	0.414	0.408	0.483
Haikou Meilan	HAK	0.684	0.552	0.327	0.305	0.339
Shenyang Taoxian	SHE	0.331	0.300	0.324	0.348	0.390
Ürümqi Diwopu	URC	0.355	0.346	0.345	0.358	0.373
Sanya Phoenix	SYX	0.232	0.237	0.276	0.317	0.359
Harbin Taiping	HRB	0.224	0.222	0.232	0.254	0.300
Guiyang Longdongbao	KWE	0.524	0.501	0.554	0.474	0.545
Tianjin Binhai	TSN	0.704	0.916	0.990	1.000	0.354
Taiyuan Wusu	TYN	0.439	0.594	0.631	0.507	0.740
Lanzhou Zhongchuan	LHW	0.350	0.337	0.338	0.310	0.348
Lijiang Sanyi	LJG	0.620	0.697	0.865	0.820	0.980
Xishuangbanna	JHG	0.112	0.104	0.131	0.140	0.131
Yingchuan Hedong	INC	0.411	0.397	0.385	0.322	0.454
Xining Caojiabu	XNN	0.396	0.312	0.313	0.292	0.354
Kashi	KHG	0.374	0.370	0.388	0.352	0.325
Mean		0.555	0.559	0.588	0.588	0.585

And then, look at the BCC DEA efficiency score results. BCC measurement evaluates the pure technical efficiency, not the scale efficiency. Airports that achieved full score in CCR DEA are efficient in terms of both technical and scale efficiencies while BCC only means the pure technical efficiency. Thus, besides Beijing Capital, Shanghai Pudong, Shanghai Hongqiao and Shenzhen Bao'an International Airport, Changsha Huanghua, Lijiang Sanyi, Xishuangbanna, Kashi got the full efficiency score in 2004 and 2005. Wuhan Tianhe and Tianjin Binhai went up to full score in 2006 and 2007, and then the number of efficient airports increased from 8 to 10 which achieved 1/3 of sample airports. However, the score of Wuhan and Tian airports reduced quickly in 2008, from 1 to 0.523 and 0.364 respectively. Guangzhou Baiyun improved the pure technical efficiency score to one. Therefore, there were 9 efficient airports in 2008. Meanwhile, Xiamen Gaoqi, Nanjin Lukou, Qingdao Liuting and etc. also operated

inefficiency obviously. Among 30 airports, Harbin Taiping got the lowest efficiency score. The mean BCC DEA score from 2004 to 2008 was 0.6592.

Table 12: VRS Result

Airport	Code	2004	2005	2006	2007	2008
Beijing Capital	PEK	1.000	1.000	1.000	1.000	1.000
Guangzhou Baiyun	CAN	0.717	0.741	0.722	0.769	1.000
Shanghai Pudong	PVG	1.000	1.000	1.000	1.000	1.000
Shanghai Hongqiao	SHA	1.000	1.000	1.000	1.000	1.000
Shenzhen Bao'an	SZX	1.000	1.000	1.000	1.000	1.000
Chengdu Shuangliu	CTU	0.730	0.740	0.824	0.836	0.823
Kunming Wujiaba	KMG	0.703	0.710	0.811	0.832	0.861
Hangzhou Xiaoshan	HGH	0.418	0.442	0.535	0.578	0.623
Xi'an Xianyang	XIY	0.762	0.796	0.798	0.887	0.893
Chongqing Jiangbei	CKG	0.515	0.511	0.589	0.654	0.696
Xiamen Gaoqi	XMN	0.415	0.407	0.439	0.458	0.494
Wuhan Tianhe	WUH	0.994	0.937	1.000	1.000	0.523
Changsha Huanghua	CSX	1.000	1.000	1.000	1.000	1.000
Nanjing Lukou	NKG	0.330	0.324	0.344	0.414	0.474
Qingdao Liuting	TAO	0.492	0.478	0.513	0.529	0.467
Dalian	DLC	0.397	0.387	0.416	0.413	0.488
Haikou Meilan	HAK	0.694	0.559	0.328	0.306	0.351
Shenyang Taoxian	SHE	0.357	0.311	0.331	0.354	0.390
Ürümqi Diwopu	URC	0.358	0.349	0.346	0.364	0.380
Sanya Phoenix	SYX	0.235	0.240	0.278	0.317	0.361
Harbin Taiping	HRB	0.229	0.226	0.234	0.258	0.301
Guiyang Longdongbao	KWE	0.556	0.525	0.564	0.487	0.546
Tianjin Binhai	TSN	0.802	0.989	1.000	1.000	0.364
Taiyuan Wusu	TYN	0.482	0.639	0.644	0.529	0.741
Lanzhou Zhongchuan	LHW	0.380	0.360	0.339	0.312	0.351
Lijiang Sanyi	LJG	1.000	1.000	1.000	1.000	1.000
Xishuangbanna	JHG	1.000	1.000	1.000	1.000	1.000
Yingchuan Hedong	INC	0.502	0.464	0.409	0.357	0.464

Xining Caojiabu	XNN	0.544	0.397	0.350	0.337	0.373
Kashi	KHG	1.000	1.000	1.000	1.000	1.000
Mean		0.654	0.651	0.660	0.666	0.665

To sum up, because these 30 airports are the top rank airports in China, but there were only 4-5 airports among them achieved the CCR DEA efficiency level and 8-10 airports obtained the BCC DEA efficiency, it could be argued that the airports in China, as a whole, are operated inefficiently. Moreover, some airports (PEK, WUH, TAO, HAK and TSN) dropped obviously after they extended the runway length or expanded the terminal area. For example, the CCR and BCC DEA efficient score of TSN reduced from one to 0.354 and 0.364 respectively. And PEK decreased from full score to 0.804 on CCR efficient score in 2008. The development of airports' infrastructure also has not reached the efficient level yet.

As mentioned in data description, according to the geographical location, listed or non-listed and hub or non-hub, 30 sample airports could be divided into three categories. In the following, these three categories' operational efficiency would be compared and analyzed.

(1) Classified by Geographical Location

Table 13 shows the efficiency score for different regions in China. From the table, it could be found that Central and South performed best under CRS DEA while Southwest became top region under VRS DEA method. For CRS, the efficient sequence were Central and South > Eastern > Southwest > Northern > Northwest. And the sequence for VRS were Southwest > Central and South > Eastern > Northern > Northwest. Therefore, by comparison, the coastland got high operational efficiency score than Northern region in China. Figure 6 and 7 illustrate these five regions' efficiency performance.

Table 13: Different Region Efficiency Performance

CRS	Northern	Eastern	Central and South	Southwest	Northwest
2004	0.515	0.608	0.722	0.520	0.413
2005	0.569	0.608	0.690	0.534	0.395
2006	0.599	0.636	0.689	0.617	0.400
2007	0.586	0.661	0.688	0.614	0.392
2008	0.512	0.671	0.652	0.659	0.433
Mean	0.556	0.636	0.688	0.589	0.406
VRS	**Northern**	**Eastern**	**Central and South**	**Southwest**	**Northwest**
2004	0.545	0.609	0.773	0.751	0.591
2005	0.592	0.609	0.746	0.748	0.561
2006	0.604	0.639	0.721	0.798	0.540
2007	0.592	0.663	0.732	0.802	0.543
2008	0.547	0.676	0.706	0.821	0.577
Mean	0.576	0.639	0.736	0.784	0.562

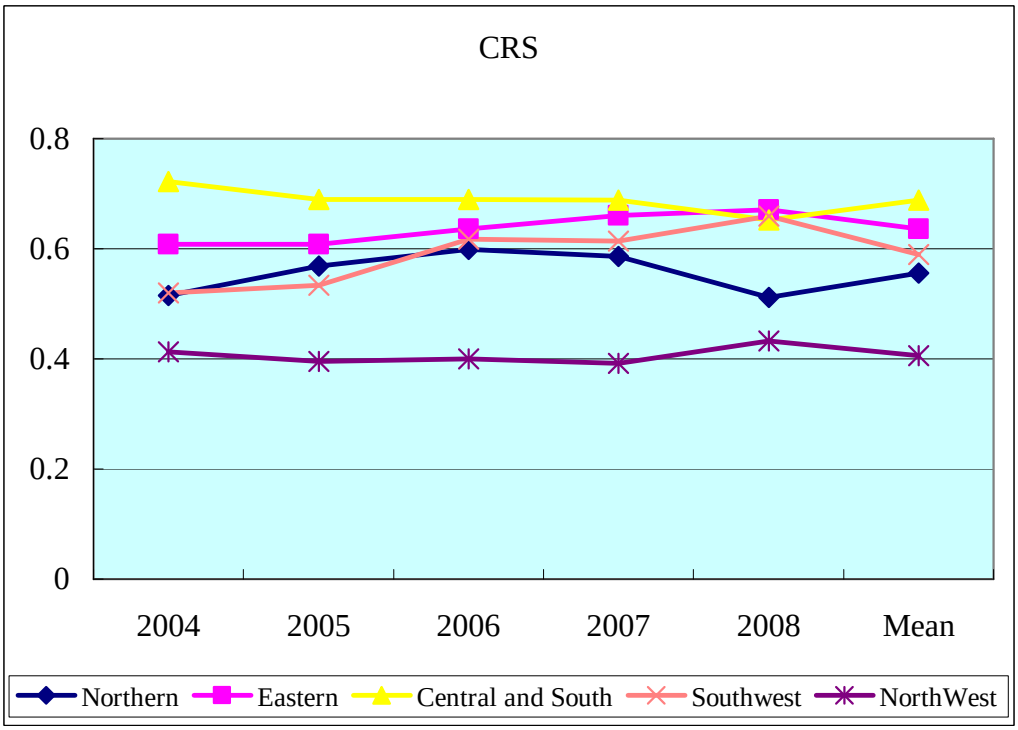


Figure 6: Different Region CRS Efficiency Score

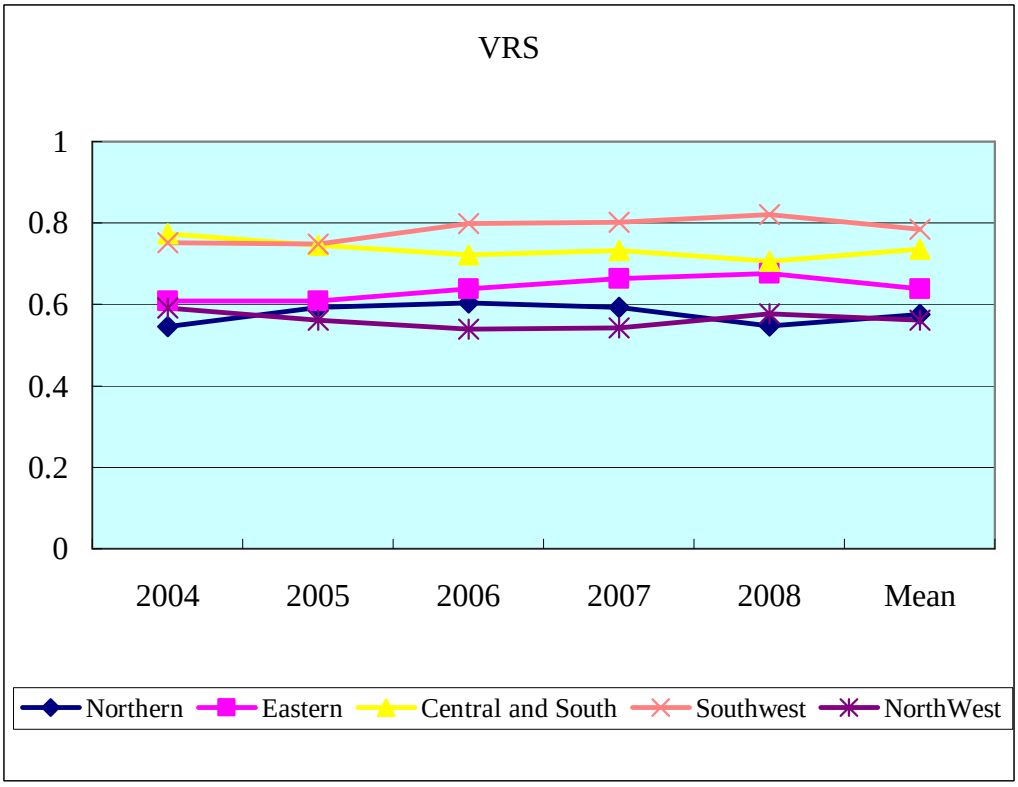


Figure 7: Different Region VRS Efficiency Score

From the figure above, Northern and Northwest region were always behind the coastland regions. There are some reasons for this result: First, coastland is the economic core regions in China. Cities such as Shanghai and Guangzhou are more focus on the economic development and foreign trade, thus airports there would have larger volume of cargo movements and aircraft movements. Second, the population distribution in China is dense in coastland regions where there are some megalopolis, thus airports could have larger passenger volume than Northwest region.

(2) Classified by Listed or non-listed

There are 7 airports -Beijing Capital, Guangzhou Baiyun, Shanghai Airports Group (Shanghai Pudong and Shanghai Hongqiao), Shenzhen Bao'an, Xiamen Gaoqi and Haikou Meilan International Airports that are listed on the stock market and belong to the listed group. From table 14 and figure 8, it is evident that the listed airports, on average, were more efficient than the non-listed airports both by CRS and VRS DEA.

Table 14: Compare Listed with Non-listed

	Listed	Non-Listed
04CRS	0.817	0.476
04VRS	0.832	0.599
05CRS	0.798	0.486
05VRS	0.815	0.601
06CRS	0.765	0.534
06VRS	0.784	0.623
07CRS	0.768	0.533
07VRS	0.790	0.629
08CRS	0.761	0.532
08VRS	0.835	0.614
CRS Mean	0.782	0.512
VRS Mean	0.811	0.613

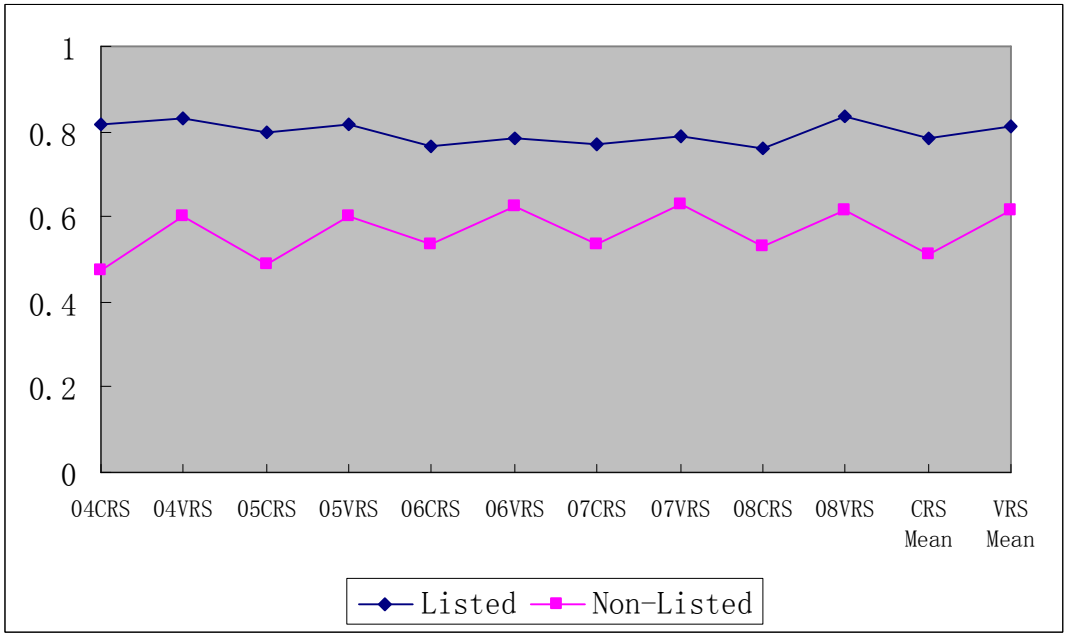


Figure 8: Compare Listed with Non-listed

Beside the external factors such as location and population reasons, listed airports performed well because the more efficient management. These listed airports have systemic and professional management than non-listed airports.

(3) Classified by Hub or Non-Hub

The last category is according to hub or non-hub. There are 3 international hub

airports, 6 national hub airports and 21 non-hub airports that we noticed in data description. Table 15 and figure 9 reflect that international hubs were the most efficient group during periods, and non-hub airports were the least efficient.

Table 15: Compare International Hub, National Hub with Others

	2004	2005	2006	2007	2008	Mean
International Hub(CRS)	0.874	0.875	0.866	0.876	0.832	0.865
International Hub(VRS)	0.906	0.914	0.907	0.923	1.000	0.930
National Hub (CRS)	0.613	0.617	0.654	0.680	0.694	0.652
National Hub (VRS)	0.652	0.651	0.685	0.712	0.725	0.685
Others (CRS)	0.493	0.497	0.529	0.521	0.519	0.512
Others (VRS)	0.618	0.614	0.618	0.617	0.601	0.614

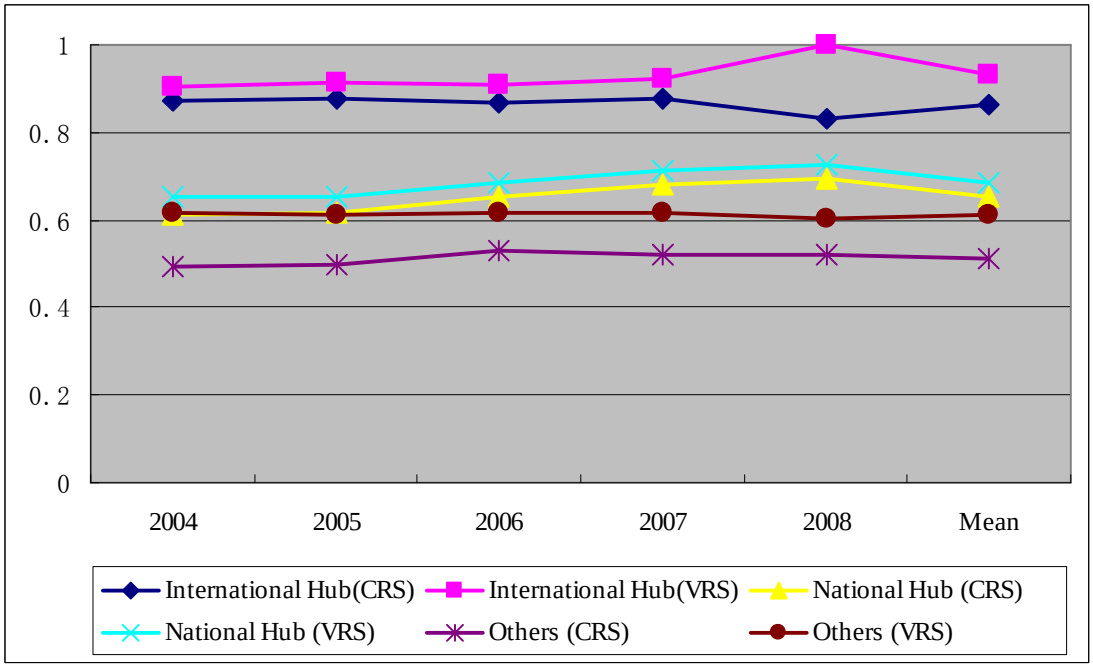


Figure 9: Compare International Hub, National Hub with Others

4.2.2 Airports Productivity Changes

The results of Malmquist indices are shown in table 16, which indicate the technical efficiency change (EFFCH), technological change (TECHCH), pure technical efficiency change (PECH), scale efficiency change (SECH) and Malmquist for each airports during 2004-2008. As a whole, the mean value of Malmquist index was 1.093, which means the average airport productivity level at the end of 2008 was 109.3% of that in last five years. In addition, there were 24 airports that had a productivity level higher or equal than one score, which means they had improved efficiency performance than before.

In terms of SECH, there were seven airports below one score which means they were not scale efficient. For example, PEK decreased its SECH by 5.3% over the whole period. On the other hand, 23 airports' operational efficiency were improved by the increasing passenger volume, cargo volume and aircraft movements. From PECH, 8 airports had not reached pure technical efficient while 22 airports improved their efficiency such as Taiyuan Wusu increased by 11.4%. Because Malmquist equals to TECHCH*PECH*SECH, there were 29 airports achieved technological efficient. Only Shanghai Pudong International Airports reduced its TECHCH by 2.9%. On the other hand, Malmquist also equals to EFFCH*TECHCH, 22 airports improved their technical efficiency in this factors.

Table 16: Malmquist Index (2004-2008)

Airport	Code	EFFCH	TECHCH	PECH	SECH	TFPCH (Malmquist)
Beijing Capital	PEK	0.947	1.064	1.000	0.947	1.007
Guangzhou Baiyun	CAN	1.027	1.083	1.087	0.945	1.112
Shanghai Pudong	PVG	1.000	0.971	1.000	1.000	0.971
Shanghai Hongqiao	SHA	1.000	1.086	1.000	1.000	1.086
Shenzhen Bao'an	SZX	1.000	1.081	1.000	1.000	1.081
Chengdu Shuangliu	CTU	1.033	1.059	1.030	1.003	1.094

Kunming Wujiaba	KMG	1.051	1.078	1.052	1.000	1.133
Hangzhou Xiaoshan	HGH	1.096	1.059	1.105	0.992	1.160
Xi'an Xianyang	XIY	1.059	1.057	1.040	1.018	1.120
Chongqing Jiangbei	CKG	1.087	1.057	1.078	1.008	1.148
Xiamen Gaoqi	XMN	1.045	1.064	1.044	1.001	1.112
Wuhan Tianhe	WUH	0.869	1.108	0.852	1.020	0.963
Changsha Huanghua	CSX	1.034	1.083	1.000	1.034	1.120
Nanjing Lukou	NKG	1.087	1.066	1.095	0.993	1.158
Qingdao Liuting	TAO	0.990	1.067	0.987	1.003	1.056
Dalian	DLC	1.053	1.089	1.053	1.001	1.147
Haikou Meilan	HAK	0.839	1.082	0.843	0.996	0.908
Shenyang Taoxian	SHE	1.042	1.078	1.022	1.019	1.124
Ürümqi Diwopu	URC	1.012	1.065	1.015	0.997	1.078
Sanya Phoenix	SYX	1.115	1.113	1.113	1.002	1.242
Harbin Taiping	HRB	1.076	1.077	1.070	1.005	1.159
Guiyang Longdongbao	KWE	1.010	1.082	0.995	1.015	1.093
Tianjin Binhai	TSN	0.842	1.088	0.821	1.026	0.916
Taiyuan Wusu	TYN	1.139	1.084	1.114	1.023	1.235
Lanzhou Zhongchuan	LHW	0.999	1.087	0.980	1.019	1.086
Lijiang Sanyi	LJG	1.121	1.082	1.000	1.121	1.214
Xishuangbanna	JHG	1.038	1.059	1.000	1.038	1.100
Yingchuan Hedong	INC	1.026	1.093	0.980	1.046	1.121
Xining Caojiabu	XNN	0.972	1.094	0.910	1.068	1.064
Kashi	KHG	0.966	1.108	1.000	0.966	1.070
Mean		1.017	1.075	1.007	1.010	1.093
Number>=1		22	29	22	23	26
Number<=1		8	1	8	7	4

To sum up, although the airports in China have the lower operational efficiency during 2004-2008, most of them keep improving the efficiency level among these five years. It is clearly that they are on the progress of operating.

4.2.3 Two-Round Delphi Results

The Delphi questionnaire used in this study appeared to fill in the vacancy in main land China for the study of forecasting the airport's efficient development. The panel group of twenty five experts invited to participate in two-round survey. 15 experts joined to complete two round Delphi questionnaires. Being surely, being start with 18 evaluative and suggestive statements into second rounds of 24 statements which asked experts to present the options and evidences for forecasting and identifying the possibilities of efficient development, the augmentation of the statements did not restrict the questionnaire to proceed, the return ration achieved 60% in each round. Although the number of return are far from our satisfaction, according to the Linstone and Turroff (1975), Fowles (1978), who pointed out that in practical operation, Delphi experts in small group is more easily to reach a consensus than in larger group, generally the panel members of 10 to 50 is better, the perfect is around 15, so to speak, our Delphi research methodology embodied the relative value and effectiveness.

4.2.3.1 Evaluative Aspect

Table 17 depicted the results of the first round of the Delphi survey regarding evaluation of current Chinese airports. The consensus level reflected the approved ratio as well as demonstrated that there still have a lot of problems and restrictions on the construction and management in Chinese airports industry.

Regarding the first evaluative statement of which the number of airports in China can not meet the overall demand currently, the consensus just reached 40%, six experts expressed agreement, while four were in disagreement and five reserved their views. However, a large proportion of panelists agreed with that a serious imbalance distribution of airports in China resulted in the development between Eastern and Western region in inequality, comparing with other options of disagreement and no-opinion, twelve experts thought that Chinese airports industry indeed facing such problem.

Simultaneously, although minority of panel members pointed out that the efficiency of large airports might not be higher than the small and the medium-size airports, a large majority of respondents still agreed that the efficiency of large airports is significantly higher than the small and the medium-size airport. From the table 17, it also can be seen that most experts pulled out the agreement on statements of which three large hub airports of Beijing, Shanghai, and Guangzhou in China still lack international competitiveness. Whereas, a significant large proportion of experts agreed that Chinese airports are mainly focus on infrastructure construction, and two third panelists expressed their belief on the question of which the regulation on various aspects of Chinese airports is still stringent.

To end with table 17, as shown that due to the statements of which the development of passengers and cargo business as well as non-aeronautical business of Chinese airports is unbalanced did not reach the broad agreement; therefore, a very large ratio of experts presented a significant belief on the statement of which profitability of Chinese airports faces a severe challenge.

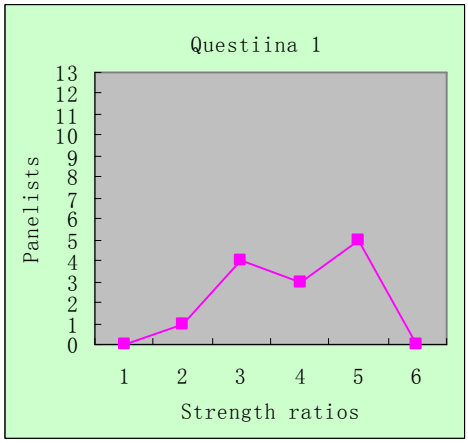
Table 17: Delphi First Round Survey - Evaluation of Current Chinese Airports

First Round / Evaluative aspect	Agree	Disagree	No opinion	Consensus Level%
The number of airports in China can not meet the overall demand currently	***6***	***4***	***5***	***40.0%***
The development of eastern and western airports in China is under a serious imbalance situation	***12***	***1***	***2***	***80.0%***
The development of passengers and cargo business as well as non-aeronautical business of Chinese airports is unbalanced	***7***	***5***	***3***	***46.6%***
The regulation on various aspects of Chinese airports is still stringent	***10***	***2***	***3***	***66.6%***
The efficiency of large airports is significantly higher than the small and the medium-size airport	***12***	***3***	***0***	***80.0%***
Chinese airports are mainly focus on infrastructure construction	***10***	***2***	***3***	***66.6%***
The profitability of Chinese airports faces a severe challenge	***10***	***2***	***3***	***66.6%***
Three large hub airports (Beijing, Shanghai, and Guangzhou) in China lack international competitiveness	***7***	***4***	***4***	***46.6%***

Until to the second round, according to a neutral value of 3.5 was regarded as the consensus threshold, it was apparent from the table 18 that the most questions in evaluative aspect obtained the combination. In this round, not only did the experts reassess their own answers in the first round and some of them presented constructive opinions for explaining the reasons, but also expressed a general belief in three of new statements. Although some of them reserved the opinions on a certain question, the ratio of respondences reached 80 percent in average or beyond, the curve graph of the effectiveness of Delphi method in returning opinions of contacted panelists is shown in Figure 10.

Table 18: Delphi Second Round Survey - Evaluation of Current Chinese Airports

Second Round Evaluative aspect	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Somewhat agree (4)	Agree (5)	Strongly agree (6)	Mean μ	Standard deviation σ
The number of airports in China can not meet the overall demand currently	**0**	**1**	**4**	**3**	**5**	**0**	**3.92**	**1.04**
The development of Eastern and Western airports in China is under a serious imbalance situation	**0**	**0**	**0**	**4**	**10**	**0**	**4.71**	**0.47**
The efficiency of large airports is significantly higher than the small and the medium-size airport	**0**	**0**	**3**	**4**	**7**	**1**	**4.4**	**0.91**
Chinese airports are mainly focus on infrastructure construction	**0**	**1**	**1**	**6**	**6**	**1**	**4.33**	**0.97**
The profitability of Chinese airports faces a severe challenge	**0**	**2**	**1**	**5**	**5**	**1**	**4.14**	**1.17**
Three large hub airports of Beijing, Shanghai, and Guangzhou in China lack international competitiveness	**0**	**3**	**1**	**3**	**6**	**1**	**4.07**	**1.33**
The regulation on various aspects of Chinese airports is still stringent	**0**	**3**	**0**	**8**	**3**	**1**	**3.93**	**1.16**
The development of Passengers and Cargo business as well as Non-aeronautical business of Chinese airports is unbalanced	**1**	**4**	**2**	**3**	**2**	**0**	**3.08**	**1.31**
Most of Chinese airports were failed to plan scientifically on constructing, which resulted in expanding and modifying to cope with saturation issues shortly after building up	**0**	**0**	**1**	**5**	**7**	**1**	**4.57**	**0.75**
Chinese airports still lack scientific management pattern	**0**	**0**	**0**	**8**	**5**	**1**	**4.5**	**0.65**
Being short of regular routes in the most of small and medium-sized airports has been a stiff issue, which affects the efficiency of those airports	**0**	**0**	**2**	**8**	**4**	**0**	**4.14**	**0.66**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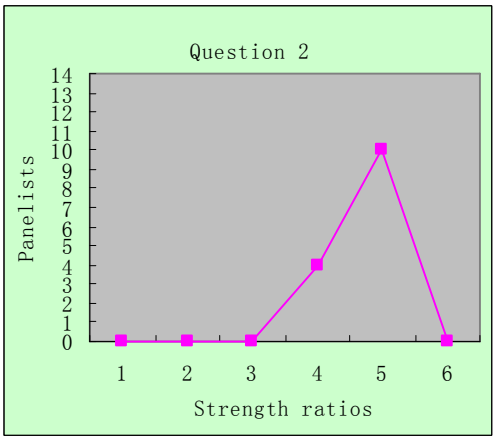
Strength ratios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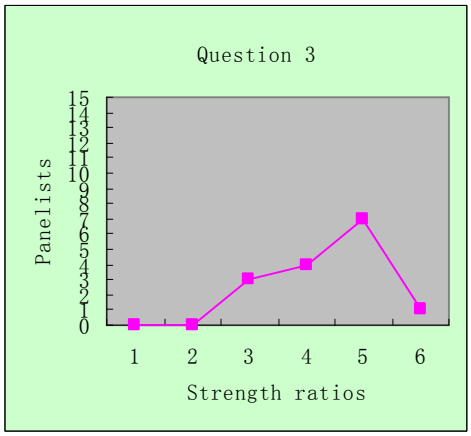
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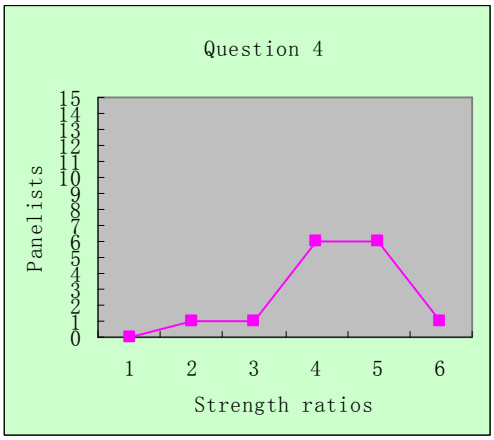
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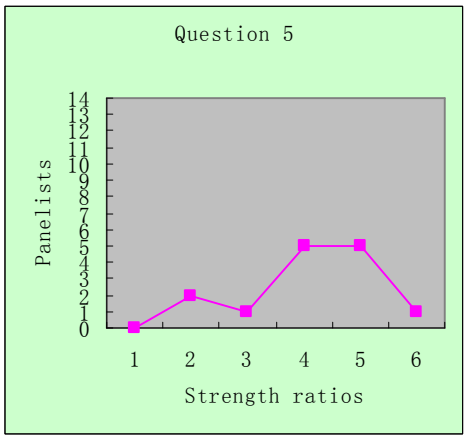
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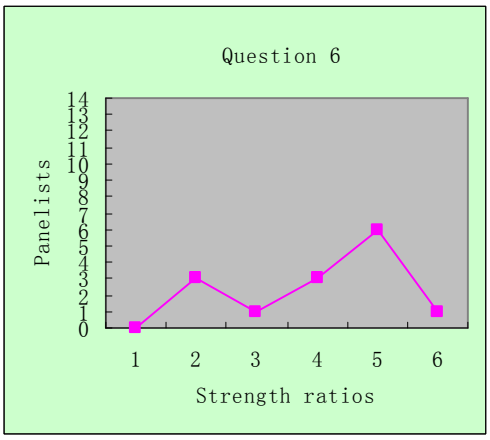
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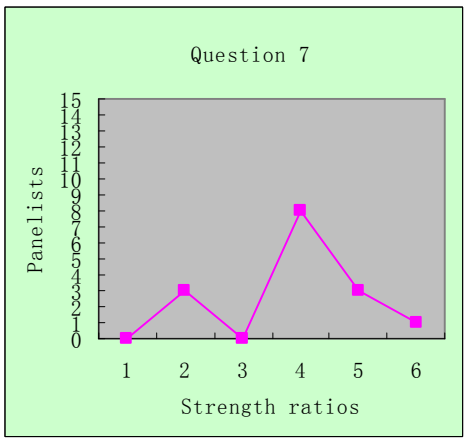
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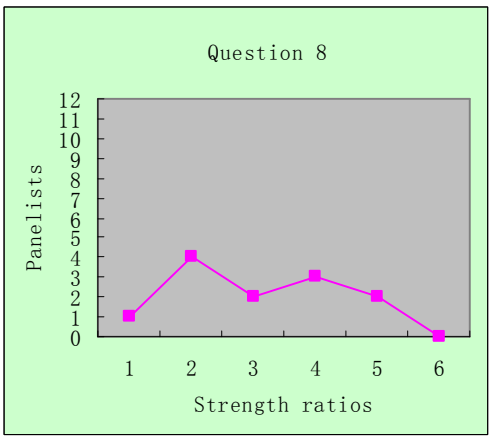
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Strength ratios

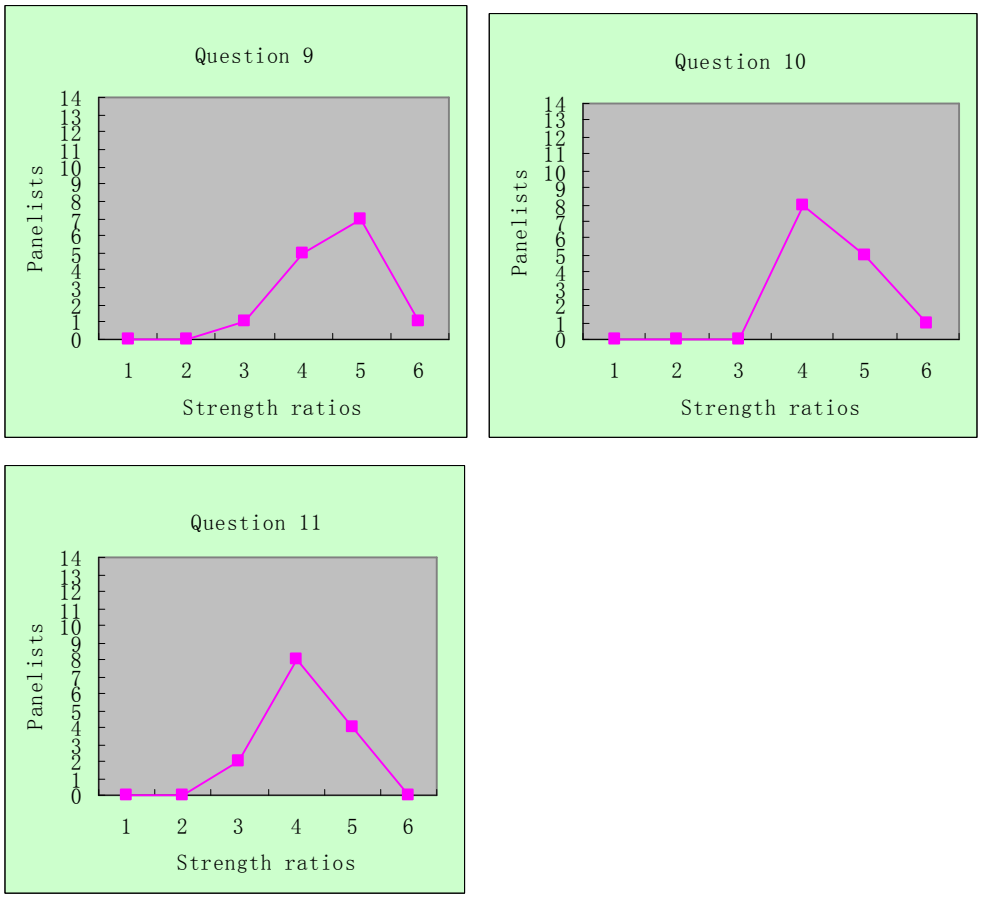


Figure 10: Results of Round Two Rating Analysis

Replies to the questions indicated that few experts amended their opinions so that it made different results comparing with last round. Eight panel members re-orientated themselves in the question of which the number of airports in China can not meet the overall demand currently. Looking into the justification presented by the experts, some of them believed that the entire shortage in quantity of Chinese airports brought about that the overall demand can not be met, others pointed out that which the construction of Chinese airports can not catch up the China economic development resulted in this kind of condition. The most apparent instance is that averaged each 100 thousand square kilometers, there are 4.2 airports in the Eastern region comparing with the region in Western which have only 0.9, the Pearl River Delta and Yangtze River Delta have high density, there is an opposite in the Western region. Additionally a simple statistics from official also can explain this conclusion, which 2.7 hundred million populations have 14807 airports in American, 2 million populations have 444

airports in Australia, and then China facing 13 hundred million people, only has 158 navigable airports until 2008, while there still has one opposite position from the panelist who thought that instate of the quantity and economic aspect, the qualitative problem is only the main reason.

On the second evaluative statement of if there is a serious imbalance situation in development between eastern and western airports in China, absolute mean value point of 4.71 demonstrated that almost experts supported this statement. A summary of justifications provided by the experts indicated that due to the construction of airports in China were associated with a high degree of economic development, so it is obvious that there is an evident peak and trough-building. Besides, in order to cater for the economic development, Chinese government only concentrated on the development of airports in Eastern region in previous years and at the same time it ignored the population radiation factors on the construction of airports from the entire geographical point of view. Therefore imbalance economic development directly contributed to the gap of airports' development between the Eastern and the Western region.

Further, the statement of if the efficiency of large airports is significantly higher than the small and the medium-size airport also unanimously was adopted by experts. Experts believed that with improved facilities, the relative sound management and high utilization has brought the high-efficiency to the large airports. Besides, the result of this statement also has been improved by the DEA model, which confirmed that the high efficiency to a certain degree depends on the high utilization.

Simultaneously, there is also a controversial phenomenon came into being. Despite a very large proportion of experts agreed that Chinese airports are mainly focus on infrastructure construction, through analyzing the proposals of experts, which was shown that there are two opposing justification. A part of experts pointed out that the reason why they agreed with is that due to the infrastructure construction for weak

Chinese airports in standard is still important, the focus should be put on the basic construction, they supposed that enhancing infrastructure construction has an auxiliary affect for the airports' management in safe and efficiency, hence, to focus on the basic construction is not bad strategy. While other experts felt thought that Chinese airports concentrated on much more on basic construction so that to a certain degree, they ignored the software construction.

Facing this condition, the new statement of which Chinese airports still lack scientific management pattern can account for it. As can be seen from the table 18 and figure 10, 14 of 15 member panelists lifted up their agreed ballot to this question. The summary of the feedback from the experts was separated into two aspects. The first one was that the management system within a large part of airports was still operated with the governmentalism style and store-owner behavior, the concept of management can not meet the needs under the market economy situation as an airports enterprise in service industry. The second one was described as software management by them, who demonstrated that a part of air traffic control officers' knowledge and skills were not up to professional standards as well as ground service personnel and airport logistics systems, in consequence, inefficient management in software system always induced the flight delay, flight postponed and cancelation by airports, to a large extent, the operational efficiency of airports and airlines has been suffering from those problems.

Related to the questions of infrastructure construction and management, a lot of official reports demonstrated that in spite of civil aviation industry indeed invested a lot of money for the basic and air traffic control construction, for instance, in 2006; amount of 260 hundred million RMB was invested for the basic expansion and modification and communications facilities, and then until 2007, 350 hundred million RMB was invested, while on the management system, civil aviation also carried out a lot of policies, strategies and training program in order to improve the management of airports. Therefore, this study found that the main challenges which infrastructure construction and management facing was included in three aspects: insufficient

coordination within internal-organization management system, unreasonable airport's orientation and unclear airport's work division.

Moreover, eleven experts believed that Chinese airports are facing a severe challenge in profitability. The explanation given by experts is same to the report of Civil Aviation Administration of China, which indicated that not but that the number of navigable Chinese airports in 2008 has increased into 158, only have a small number of large-scaled airports is profitable, 75% of airports do belong to deficit statues; the overall financial performance of airports in China therefore is still far from satisfaction. Indeed, it is clear that the remaining of this situation not only harmful for the future growth of commercial aviation industry, but it would also affect the operation of the whole air transport system.

A large of majority of respondents stood the point on that three large hub airports of Beijing, Shanghai, and Guangzhou still lack the competitiveness in being an international hub, on the contrary four experts are against this proposal. The former considered that three major airports are facing the same problems, which reflected on the large randomness in the layout of network routes, low convergence in flights and insufficient flights wave. Although the three major airports in terms of total traffic throughput or routes have been considered as the list of the world's largest airport, however, compared to international hub airports, they still lack a lot of efforts. The latter deemed that three major airports as the gateway to China, from the view of the density of both domestic and international routes, or from the view of the scale of construction and passenger throughput, they have been into comprehensive hub airports among the Asia-Pacific region.

Finally, two of three new statements which unscientific planning on constructing and being short of regular routes in the most of small and medium-sized airport also were achieved consensus in a large proportion. Provided that looking into the first question, it can be seen that a lot of Chinese airports actually were failed to build up long-term

and rational planning on the construction. This study picked up several sample airports such as Kunming and Haikou are small in design, they had to face a situation of expanding and modifying shortly after building up to cope with the saturation issues which actual traffic capacity is far beyond the designed. Example is always happened on plane queuing and full apron issue. On another side, some airports such as Zhuhai and Zhengzhou had a larger scale in original design; hence, it contributed to enormous waste and a heavy financial burden to airports after they run (table 19). Hence, actual issues indicted that unscientific construction has generated unnecessary waste for the airports, and seriously has affected the operational efficiency of the airports.

Table 19: Utilization ration

Airports	Start up	Passenger capacity designed	Actual passenger throughout in 2008	Utilization ratio	Expanded & Modified times	Expanded & Modified year
Kunming Wujiaba	1923	10,370,000	15,877,814	153.1%	4	1958,1993, 1998,now
Haikou Meilan	1999	6,000,000	8,221,997	137.0%	1	2003
Zhengzhou Xinzheng	1997	12,000,000	5,887,598	49%	2	2005,2007
Zhuhai	1995	12,000,000	1,121,831	9.3%	0	0

Data source: Civil aviation database and Airport production statistics report 2008

The second new statement which can reflect the survival state of small and medium-sized airports also reached the consensus. Experts believed that being short of regular routes in the most of small and medium-sized airports also has been a stiff issue, which affects the efficiency of those airports. The judgments from who were in agreement indicated that due to unscientific estimation for the flights routes and the lacking of management attitude in seeking truth from facts, the survival state of these

airports have been standing the edge of a cliff, while experts who were in opposite thought that small and medium-sized airport itself existed a weakness of small capacity. Factually, the numbers of small and medium-sized airports in China accounted for 80% in national civil airports, while only have less than 10% of aircraft carriers are running in these airports. Besides ,due to limited customer could not meet high passenger load factor for airlines and it directly increased the airline's operating costs, so eventually, vicious spiral have already pushed small and medium-sized airports and airlines onto a dilemma scrape of survival or development. It should be thought-provoking question for the China's civil aviation industry; a healthy system of airports is not only supported by major airports.

4.2.3.2 Suggestive Aspect

The first round results of Delphi method in surveying suggestions for improving the operational efficiency in Chinese airport's industry were shown in table 20. As can be seen from the table, five statements related to airport's construction, management system and operating were exceeded the three fifth (60%) consensus threshold. Improving inter-organizational and software operational management were agreed as an important factor for Chinese airport to ameliorate their efficiency. Followed by it, concerning the radiation factor of airports' construction in Western region and advocating to catching regular and charter routes for increasing output efficiency were also achieved broadly agreement. Regarding the question of which if China should to expand airports in the Western region, nine experts stood at the agree side, while six conserved their opinions. However, in this round, other five statements which about if deregulating policies in airports industry could promote efficiency, if expanding commercial business scope can better the efficiency and if large airports would face a efficiency-losing problem were not beyond the consensus level of 60%, especially, the question of which the inefficient airports should be closed was merely agreed by three experts, eleven experts disagreed with it.

Table 20: The First Round of the Delphi Survey Concerning Suggestive Aspects

First Round / Suggestive aspect	Agree	Disagree	No opinion	Consensus Level%
China should to expand airports in the Western region	***9***	***0***	***6***	***60.0%***
Construction of airports in the Western region in China should be linked to GDP and the local population density	***13***	***1***	***1***	***86.6%***
Deregulation and the implementation of delegation can improve efficiency of airports.	***8***	***5***	***2***	***53.3%***
Chinese airports should enhance the non-aeronautical business income	***6***	***6***	***3***	***40.0%***
Airports in China with poor efficiency should be closed	***3***	***11***	***1***	***20.0%***
After a specific period(such as the Olympic Games), the expansion project of large-scale airports will face an efficiency-losing problem	***8***	***5***	***2***	***53.3%***
Improving management pattern, which not only on inter-organizational, but also on software aspects(operation) could effectively enhance operational efficiency	***14***	***1***	***0***	***93.3%***
It is conducive to implement merges to improve efficiency in the Chinese airport industry	***7***	***4***	***4***	***46.6%***
Chinese airports should speed up the development of cargo	***12***	***0***	***3***	***80.0%***
The establishment of regular routes and charter routes will help Chinese airports to improve output efficiency	***13***	***0***	***2***	***86.6%***

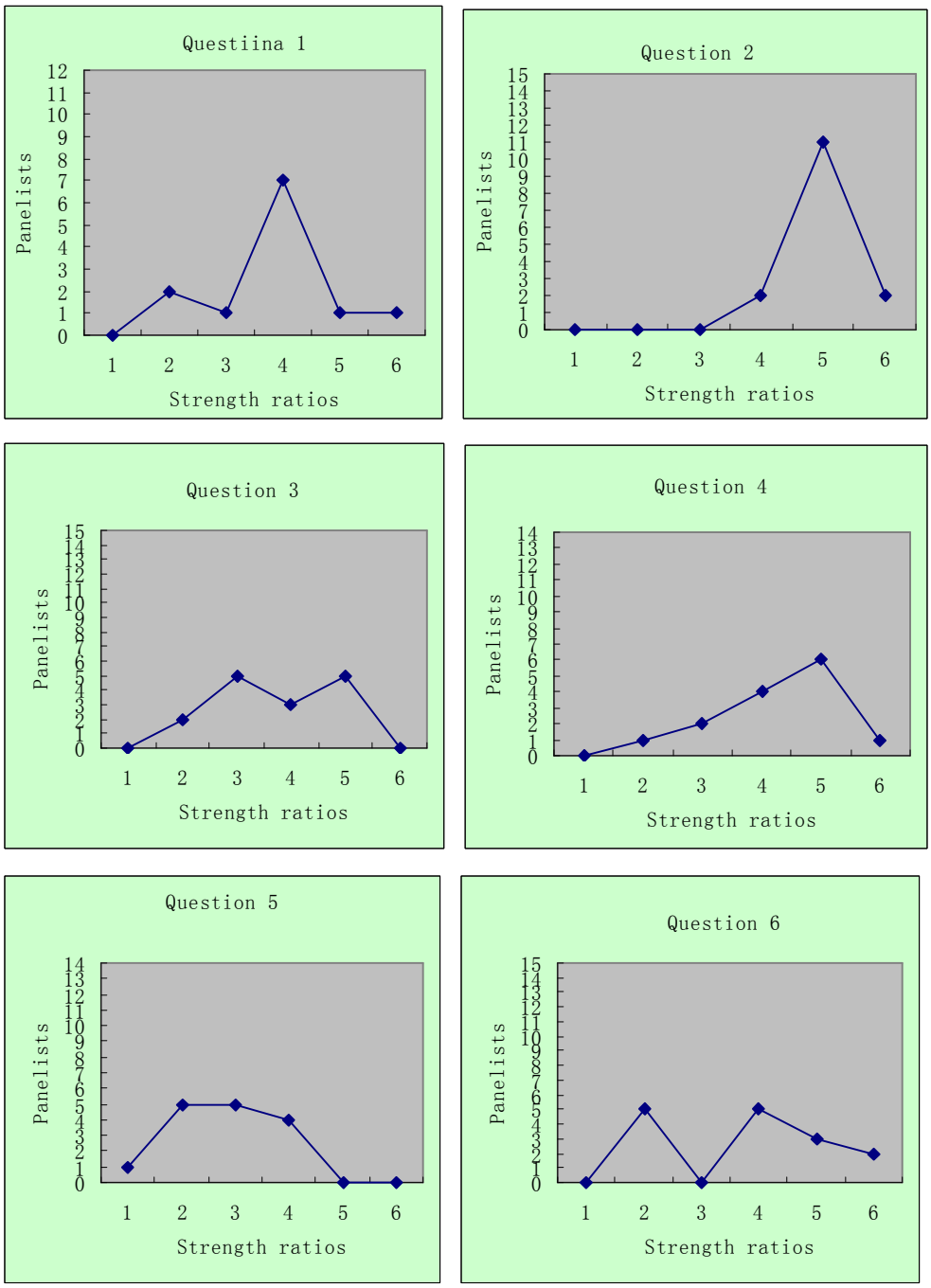
After experts finished reassessing and re-determining their own opinions with our feedback, the results of second round survey was depicted from the table 21; it is obvious that the panelists were attempted to change their opinions, the strength ratio of all most statements in the Delphi panel achieved 3.5 natural value points and appeared in broad somewhat agreement, agreement and minority was in strong agreement on them, while there still was two statements' ration was much less than the threshold according to an analysis of their mean value was 2.71 and 2.93 respectively.

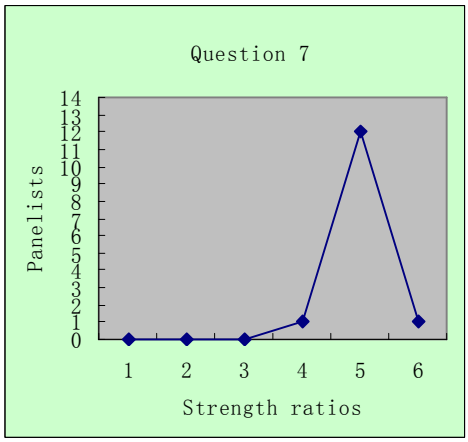
Table21: The Second Round of the Delphi Survey Concerning Suggestive Aspects

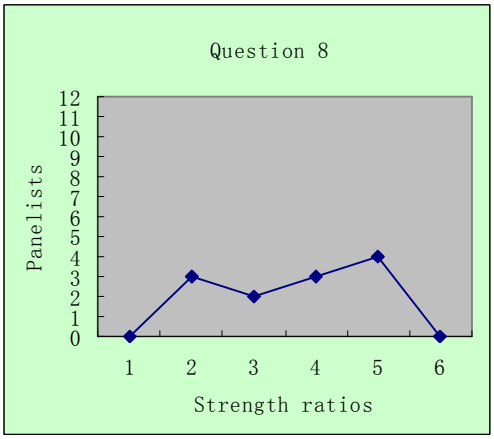
Second round Suggestive aspect	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Somewhat agree (4)	Agree (5)	Strongly agree (6)	Mean μ	Standard deviation σ
China should to expand airports in the Western region	**0**	**2**	**0**	**8**	**1**	**1**	**3.92**	**1.08**
Construction of airports in the Western region in China should be linked to GDP and the local population density	**0**	**0**	**0**	**2**	**11**	**2**	**5**	**0.53**
Deregulation and the implementation of delegation can improve efficiency of airports.	**0**	**2**	**5**	**3**	**5**	**0**	**3.73**	**1.10**
Chinese airports should enhance the non- aeronautical business income	**0**	**1**	**2**	**4**	**6**	**1**	**4.29**	**1.07**
Airports in China with poor efficiency should be closed	**1**	**5**	**5**	**4**	**0**	**0**	**2.71**	**0.91**
After a specific period(such as the Olympic Games), the expansion project of large-scale airports will face an efficiency-losing problem	**0**	**5**	**0**	**5**	**3**	**2**	**3.8**	**1.47**

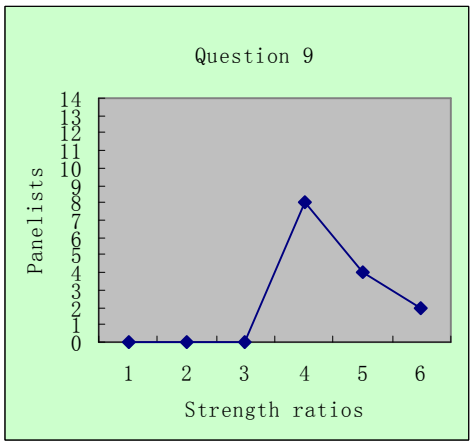
Improving management pattern, which not only on inter-organizational, but also on software aspects(operation) could effectively enhance operational efficiency	**0**	**0**	**0**	**1**	**12**	**1**	**5**	**0.39**
It is conducive to implement merges to improve efficiency in the Chinese airport industry	**0**	**3**	**2**	**3**	**4**	**0**	**3.67**	**1.23**
Chinese airports should speed up the development of cargo	**0**	**0**	**0**	**8**	**4**	**2**	**4.57**	**0.76**
The establishment of regular routes and charter routes will help Chinese airports to improve output efficiency	**0**	**1**	**1**	**5**	**8**	**0**	**4.33**	**0.90**
Airports should concern the ratio of profitability involved in aeronautical (50%) and non-aeronautical (50%)	**0**	**5**	**6**	**2**	**1**	**0**	**2.93**	**0.92**
Airports should reduce possible efficient risk ,which was consisted with queue time at check-in and security, bag waiting time at arrivals, proper take off and land time	**1**	**0**	**1**	**8**	**4**	**1**	**4.13**	**1.13**
In order to improve output efficiency, airports should gather stake hold(hotel, tourism agency, taxi, shops) to create commercial “package” to catch demand	**0**	**0**	**1**	**8**	**6**	**0**	**4.33**	**0.62**

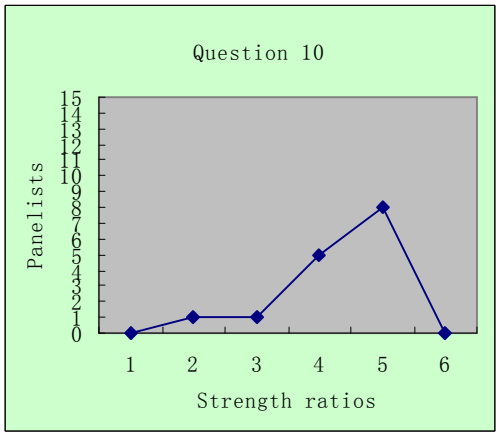
Besides, although the same issues of which some of experts conserved their opinions toward a certain question occurred once again to what it has been in previous round, the summary of contacted panelists was still positive (Figure 11).

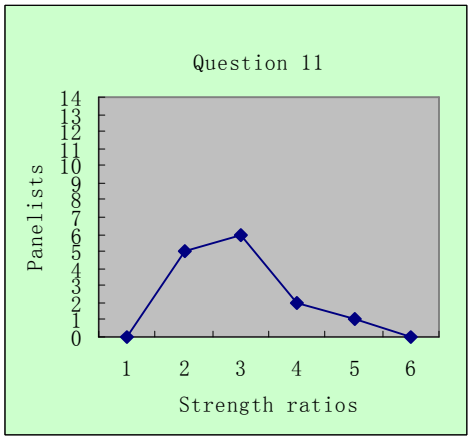


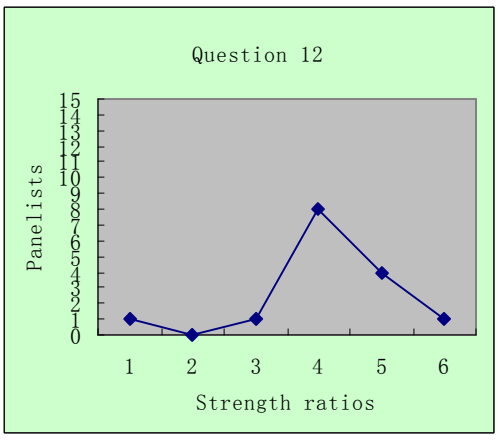

Question 7
Panelists
Strength ratios


Question 8
Panelists
Strength ratios


Question 9
Panelists
Strength ratios


Question 10
Panelists
Strength ratios


Question 11
Panelists
Strength ratios


Question 12
Panelists
Strength ratios

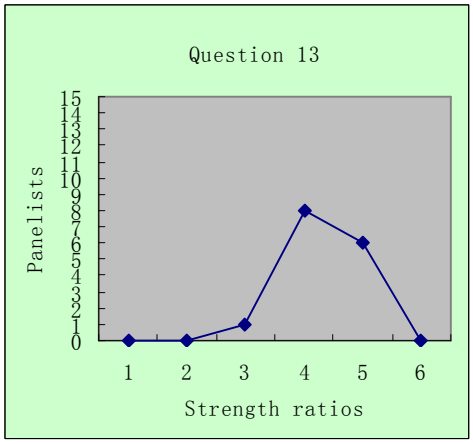

Question 13
Panelists
Strength ratios

Figure 11: Results of Round Two Rating Analysis

In the second stage the question related to if China should to expand airports in the western region was provided again to expect experts to reassess with justification. The final result was that eight members showed somewhat agree, one expressed agree and one strongly agreed with it. The judgments provided by the respondents could be divided into two aspects, the first one they considered is that with the implementation of the strategy of development in western region, the cooperation between the western and eastern economic zone have been strengthened, no matter which the number of passengers or freight transport, they all appeared the potential to go rapid growth, therefore, the expansion of the airport in the western region would contribute to local economic development, and from the concerning of national development planning, the expansion also is an important part of the national airport layout, the second one experts thought is that expanding airports in the western region could guarantee the basis air traffic to carry out and ensure the demand for aviation to be met completely. Meanwhile, from the table 21 above, it was shown that there were two experts disagreed with this statement. They pointed out that the rather than the expansion; first mission for airports in western region is to improve their efficiency, in addition, they were wondering that as for start-up western economic, expansion appeared a little bit early.

On the question of if the construction of airports in the western region in China should be linked to GDP and the local population density, almost all the experts voted for agreement. Through distilling the justifications given by the panel members, they all thought these two factors are most important prerequisite to construct the airports in western region in order to avoid unscientific planning and surplus investment in capacity. Moreover, eight experts agreed that deregulation and the implementation of delegation can improve airport's efficiency, while seven rejected it. The comments in the opposition mainly focused on the airport's safety problem. They suggested deregulation and delegation would affect the airport's security directly, ensuring the

security of airport is to ensuring the efficiency. Nevertheless, agreed experts thought that deregulating and delegating ground handing service and operational decisions to the “front line” can improve the response times and customer service levels as well as can lower the cost. At the same time another suggestion which related to the commercial operation in airports is about asking experts whether they agree or disagree with airports through mergers to increase efficiency. The results indicated that seven panel members agreed due to they believed that the annexation of airports will play a catalytic role for unified management of the airports as well as the waste of resources could be reduced so that airports can quickly and efficiently promote development into economies of scale, whereas five experts worried about if the airports could support effective management mechanism to follow up after the completion of merger and reorganization, the management at airports would result in various serious consequences.

Further, in terms of questions which were about how to increase Chinese airports’ output efficiency, the panelists also mentioned their arguments. Typical examples the questionnaire offered to ask experts involved in if the airports should enhance the non-aeronautical business, if the airports should speed up the development of cargo and if the Chinese airports should attract and establish more regular and charter routes to improve output efficiency have achieved a large proportion in agreement.

On the first question, eleven panelists agreed that non-aeronautical is also important for the airport’s income, although large proportion of experts did not provide justification to express the reason why they agreed, from just two proposals, it can be seen obviously that they believed Chinese airports still have to strive to improve non-aeronautical business to enhance entire profitability, three panel members argued that increasing non-aeronautical business would reduce the input of aeronautical business, aeronautical business is still the core as for the airports. Therefore, except one reserved his option, fourteen panel members concurred with Chinese airports should enhance the cargo promotion. Simultaneously, thirteen experts accepted the

third question of which Chinese airport should try to increase establishing the regular and charter routes to improve output efficiency due to they viewed that the new routes introduced can be used to fill relatively quiet times at the airports so that to reduce relative peaks in demand, meantime, their establishing can attract potential demand and improve service, surely, different argument always appeared to be cautious but does not make nonsense. For instance, they concerned if one airport was under a low capacity in passenger and cargo, there does not need to increase.

This study assumed two questions in the questionnaire. The first one is that should be closed if some airports were facing a serious poor efficiency. However, the resulted showed that almost all the experts rejected this idea after the replies were combined. Within their justifications, majority of them proposed that airport not only have to concern the output efficiency and economic factors, but also should concern the social factors, besides, experts recommended that airport should try to develop non-aeronautical business to make up as much as possible based on the airport's actual situation. To be sure, there were still four experts who voted in agreement, because they took into account the possibilities of resources which could continue to be waste.

The second question this study assumed is that after a specific period (such as the Olympic Games), if the expansion project of large-scale airports will face an efficiency-losing problem. On this assumed question, a large proportion of experts consented to the view, leading to the waste of resources and increasing the operational cost of airports during a certain period are their main concern, and minority of experts who disagreed insisted that the expansion of airports was in line with the scientific evaluation, even if the end of the specific period such as Olympic Games, the airport itself will not cause too much waste and idle issue.

Facing fast development, the managerial orientation and style always has been one crux for the airports. Hence, the question of which improving inter-organizational and

software operational management could effectively enhance operational efficiency achieved a large agreement. by analyzing the judgments from the experts, this study found most experts believed that the managerial concept within internal-organization of China's airport is still relatively old, which is not still transformed from business-type to management-base, many airports are operated still in the attitude of state-owned enterprises, additionally, the operating orientation of airports is not clear enough.

Finally, two of three new suggestions reached the consensus. The experts did not agree with the question on which airports should concern the ratio of profitability involved in aeronautical (50%) and non-aeronautical (50%). The justifications have an overwhelming tendency towards about that airports as a special enterprise, the focus should still be put on aeronautical fields. Even two experts assumed that the aeronautical profit must be 75%, one expert pointed out that the airports in china could not balance the profit within short period. However, two suggestions left on which airports should reduce possible efficient risk during operation and airports should gather stake holder to catch demand for improving output efficiency achieved consensus in high majority of experts, who believed that reducing efficient risk and improving win-win situation with airlines are the main strategy for the airports to promote efficiency.

On the whole, views on the issue in the question vary widely. By summarizing the responses of two round questionnaires, 10 evaluative and suggestive statements reached consensus in the initial round. In order to avoid the somewhat ambiguous decision accordance on evaluative indicators and other suggestive statements, ensure the strength of the experts their own answers, 24 statements included 6 new ones was adopted to carry out into the second round, to the end, 21 statements achieved the high consensus strength.

4.3 Summary

This study was firstly adopted both DEA and Delphi methods to survey the operational efficiency of Chinese airports. Different from Gillen and Lall (1997, 2001), Parker (1999), Sarkis (2000), Fernandes and Pacheco (2002), Pels et al. (2001, 2003) and Yoshida and Fujimoto (2004), Chinese airports have their own operational characteristic. In addition, compare to the previous study of the Chinese airports' operational efficiency, this study took more sample airports and updated inputs and outputs data. Different from Zhang and Hu (2006), this study found the increasing trend of technology efficiency during 2004-2008. And part of results supported the arguments of Zhu (2007), Andrew and Zhang (2008). The following shows the summary of this chapter.

Through both of DEA estimation and Delphi's second-round questionnaire survey, some viewpoints for the evaluation related to the current operating of Chinese airports are generalized into following respects:

- Airports in China, as a whole, are operated inefficiently during 2004-2008.
- DEA study pointed out that the airport in coastland region operated more efficient than other regions. Meanwhile, Delphi study also concludes that there is an obvious imbalance in the development of eastern and western airports and large and small and medium-sized airports.
- DEA found that the development of airports' infrastructure has not reached the efficient level yet while Delphi pointed that Chinese airports are mainly focus on infrastructure construction and still lack scientific management pattern.
- DEA revealed that listed airports operated more efficiency than non-listed airports. In addition, hub airports perform better than non-hub airports. Delphi study indicated there are still many Chinese airports which lack scientific planning and practical demonstration on the construction.
- The regulation on various aspects of Chinese airports is still stringent

- Most of Chinese airports are on the process of improving the operational efficiency level. The reforming policies are helpful to improve the airport's efficiency.

Furthermore, the following recapitulations based on the experts' justifications in the questionnaire for the suggestions about how the operating efficiency could be improved in future are compressed into several aspects:

- Airports should enhance the non-aeronautical business, speed up the development of cargo and attract and establish more regular and charter routes to improve output efficiency.
- Improving management system, which not only on inter-organizational, but also on software aspects (operating) could effectively enhance operational efficiency.
- China should balance the distribution of airports between eastern and western region and the construction of airports in the western region in China should be linked to GDP and the local population density
- Accelerating market-driven pattern and reducing possible efficient risk, which was consisted with queue time at check-in and security, bag waiting time at arrivals, proper take off and land time could promote efficiency of airports.

CHAPTER 5: SUGGESTIONS AND LIMITATION

According to the DEA results, although DEA found that few major large airports has been maintaining the efficient operating after the completion of a thorough reform in 2004-2008, majority of airports were still operated inefficiently. As like mentioned above, until 2008, China have had 158 navigable airports, namely, except those minority major large airports, the airports left almost are faced with enormous challenges. Delphi research also apparently discovered that entire civil airport industry is facing serious challenges in the actual operating. These challenges not only reflected on the airports' infrastructure, but also sounded the alarm on the orientation of the airports, management, operating, even security. If China want to achieve the objective of being a powerful country in civil aviation industry, it is necessary to accelerate the development of air transportation so that to improve long-term competitiveness of industry, the development was involved in consummating the basic facility system of airports, enhancing scientific management of airports, and strengthening governance in each system from a strategic view. Thereby here some macro and micro suggestions for Chinese civil aviation industry to promote effective development of the airports were put forward.

5.1 Macro-Views

5.1.1 Creating Scientific Construction and Investment Concepts on Airports

As the expansion of three large hub airports are in the process, many local governments also paid a lot of fiery enthusiasm on construction of airports, at present the projects of construction and expansion of airports occurred over everywhere in China. According to the Airport distribution planning report, long-term goal of Chinese civil aviation industry is to have 97 new airports until 2020 and complete 46 major expansion projects. Facing these costly plans, actually there are many airports which are suffering from the saturated state or nearly saturation will be reached, but for a considerable portion of the airports there is no need for expansion. Thus why the

local governments want to expand or build a new airport? One of the most direct reasons is that many local leaders treated the construction of the airport as the image project, it is therefore necessary to advance and scale the construction of the airport. However, if the local governments really want to develop airport project from the view of the game at present, in reality the most urgent and important work for them is to adopt scientific management and integrate each system to those airports which were in poor efficiency and facing deficit state. Otherwise, blind investment and construction will not get return and will lead to waste resources. In this Delphi study, most experts believed that China should expand airports in western region to balance development, nevertheless if China want to narrow the gap between eastern and western by expanding airports, they have to avoid to construct airports in blind just as face-saving project and pursuit in large scale, besides, in order to be able to achieve efficient development, the construction and expansion of the airports should ensure the reasonability after through scientific considerations on the local economy and the scope of the airport's radiation in demand as well as implement scientific long planning. Moreover, airports should exert current resources as possible as they can and consider how to create a win-win situation with carriers.

5.1.2 Creating a Scientific Managerial System

Overall, firstly airports should change the managerial idea positively, as the goal of improving operating efficiency, the better way for the airports is to create a special operating idea which follow it selves' operating characteristics and reasonably develop human resources. Moreover, the important thing is to eliminate traditional management thinking of state-owned enterprises, the market-driven and customer value-oriented mechanism should be introduced to promote commercially viable operation with airports. The suggestions for management is subdivided into the following several sections.

5.1.2.1Changing Inter-Organization Management Pattern

After the reform of territoriality, airports should thoroughly break the traditional management thinking and concepts within inter-organization and at the same time change the personnel use and allocation mechanism with forms of ownership. In particular, in order to effort to create a knowledge-based management structure and circumvent the cumbersome staff system, the airports have to copy with a comprehensive transition within the management structure.

5.1.2.2 Airport's Safety Management

Management of airport security has a direct impact on the output efficiency of the airport, the slack of resource management on the ground is a catalyst for the accident, so to speak, the airport should effectively organize and control ground maintenance, service, equipment and resources so that to ensure the security both in air and on ground. In addition, strengthening security awareness and cultivating responsibility are also particularly important. In detail, first of all, airport should establish a strict management system to divide the ground work in detail, because of with increasing number of flights at airport, the past way of which relying solely on voluntary co-ordination style on the ground has been far behind the development of the today's airport, clear and precise work content can strengthen staff's security awareness and responsibility. Secondly, airport should strengthen the supervision and inspection for the equipment' safety. Finally, airport should ensure the coordination between the ground staff and information exchanges so that try to reducing the flight delays phenomenon cause by ground crew and air security.

5.1.3 Business Concept

Comparing with the development speed, the profitability of airport is far from the satisfaction. The main reason for this situation should be that airport has not developed a real market-driven idea.

5.1.3.1 Market Concept

The perspective on which Chinese airports should carry out enterprise style

management step by step to increase efficiency has been recognized by our Delphi study. Generally speaking most airports lack market-driven concepts reflected on unclear market orientation and division, biased service concept and unclear marketing objectives. Therefore, first of all, airports should have a clear market distinction and identify a clear market targets to avoid blindly rely on the experience. As for customer's behavioral factors, especially for the customers' psychology and behavior of airlines airport should have a detailed analysis; because they have a decisive impact on the airport operational efficiency. At the same time in order to establish long-term strategic objective, airports should have an effective forecast on consumer market size. Within commercial marketing, maintaining close communication with the Government, airlines and other related non-competitive relations is a necessary prerequisite to ensure the airport's overall publicity and market promotion. Finally in order to improve output efficiency, airports should gather stakeholder (hotel, tourism agency, taxi, shops) to create commercial "package" to catch demand

5.1.3.2 Establishing Diverse Business Infrastructure

Oum et al (2003) and Oum and Yu (2004) pointed out that developing a diverse business structure at airports could effectively promote operating efficiency, because these diversification could attract additional demands between commercial and aeronautical service. With private capital entered the airports, such as China Capital International Airport, Shanghai Airports and other several major large airports have begun to diversify the airports' commercial operating and management, but because of still many airports in local areas are remaining a single business operating mode, operating efficiency has been unable to be improved.

According to the statistics of Civil Aviation Administration of China, in 2006 the total income of all airports in China was 22.85 billion Yuan, of which non-aeronautical business revenue just shared of less than 40%. Therefore, it is not necessary to only develop passenger transportation, trying to positively develop cargo market and striving to increase the income in non- aeronautical areas are most prescriptions for

those airports. The example of developing cargo market are included establishing cargo logistics centers, outsourcing cargo transportation services and integrating the cargo transportation into the supply chain management through advanced e-commerce method; regarding non-aeronautical income, airports could establish retail bossiness, catering, hotels, car rental and advertising business and so on, but at the same time attention should be paid to the layout which can not be too scattered as well as attention on the retail's price which should not be too high so that to avoid the reduction of the desire of customer's consumption.

5.1.3.3 Service Concept

Airports in China have been lacking a customer value-oriented business philosophy. Due to the airports still exist "iron rice bowl" concept within internal, the staff at airports generally lack service concept. Therefore, the airports should establish effective customer satisfaction measures and methods, besides strive to treat customers by sincere enthusiasm and abide by the commitments to customers. Regardless the complaint or the consulting of aircraft delays caused by airport, the airports should be done in various areas by standardization, personalization and user-friendly services. In addition, airports should reduce possible efficient risk which was consisted with queue time at check-in and security, bag waiting time at arrivals, proper take off and land time through providing fast and high quality service to the airlines and passengers.

5.2 Micro-Views

5.2.1 The Development of Three Large Hub Airports

Beijing, Shanghai, Guangzhou airports as the gateway of China, from the network density of both domestic routes and international routes to the concentration of traffic point have become the three large important hub airports. However, comparing with other large hub airports around the world, three major airports are still inadequate in the layout of network routes and the convergence of flights schedule. Thus, the first

way three airports should do is to create a close relationship with airlines, and then they can cooperate together for expanding network density, compiling network routes and optimization flight wave as well as improving the convergence of flight and ground-based flight's transfer frequency. In addition, the three major airports as listed company should be avoided in some extensive management forms and striving to resolve the deficiencies in management systems; in terms of profitability, the airports should strengthen the airport's cost control management. Finally they can improve efficiency by strengthening the development of supply chain management and information management so that not only they can adapt the changes in the aviation market, but also can enhance the competitiveness of the airports.

5.2.2 Local Hub and Small and Medium-Sized Airports

The main problem of constraining the development of local large airports is still the airport's orientation. From the perspective of overall resources allocation, the pattern of sustained, stable and coordinated development is only the way for those local hub airports. They might set up their own network routes and capacity allocation by attracting local demand and surrounding three large hubs and they also could make every effort to reduce the call time of flights and improve punctuality and service to improve the efficiency so that finally to form a new competitiveness mode in differentiation comparing with three large major airports. For small and medium-sized airport, the problems involved in route establishing and profitability have been haunting them. Therefore, for these airports, they can attract some low-cost airlines to join and regarding the infrastructure, they should avoid investment in blind. On the operating management, these small and medium-sized airports should absorb some experiences from those large airports and strive to drive airports by market-oriented management and scientific administration. But to some extent these additional suggestions also provided useful guidance and reference for the studies in measuring efficiency of Chinese airport in future.

5.3 Limitation

There are some limitations of this study. Firstly, CCR and BCC are the basic models in the DEA method. In future study, more complicated DEA models could be used to survey airports' operational efficiency. In addition, DEA model is sensitive to the inputs and outputs indices. Thus, if we take other indices such as number of employee, different outcomes might be obtained. Moreover, even 30 Chinese airports are selected in this study; some extensions to overall airports' performance could be evaluated in the future as well. On the other hand, to on a certain degree the Delphi method also identified some weaknesses and limitations in our study. As mentioned above, the objective of Delphi method is to achieve a consentaneous opinion for a certain question from a sample of experts in related subject field, and in order to avoid bias and interpersonal influence among them, the experts usually were selected dispersedly. In our questionnaire research, the experts are mainly distributed into three locations; some of them are not in mainland China. Thus the panelists who are not in mainland China may contribute to inappropriate answers by reason of insufficient understanding of actual state of China. Additionally due to in our study few experts who are not majoring in civil aviation industry, some experts had reservations about their views for a certain question, some of them have not given justification for a certain question, hence the respondents to the questionnaire did not well informed in the appropriate area.

CHAPTER 6: CONCLUSION

With the development of economy and aviation reform, airports industry has made significance progress in China. And at the end of 2008, there are 158 navigable airports. However, behind the fast growth, Chinese airports are facing with many challenges. Some operational drawbacks are exposed, which seriously hinder the airports' efficiency.

This study aims to evaluate the operational efficiency of Chinese airports by selecting top 30 sample airports during the period 2004 to 2008, and provide opinions on how airports should be managed to achieve efficiency. The survey is helpful to promote the sustainable development, strengthen resources allocation and enhance airports' core international competitiveness in China.

Three models in Data Envelopment Analysis and two-round Delphi methods are used to investigate the operational issues. The main findings are that: firstly, there are only 4-5 airports among 30 sample airports achieved the CCR DEA efficiency level and 8-10 airports obtained the BCC DEA efficiency. It could be argued that the airports in China, as a whole, are currently operated inefficiently. However, although the airports in China have the lower operational efficiency during 2004-2008, most of them keep improving the efficiency level among these five years, thus the reforming policies are helpful to improve the airport's efficiency. In addition, there is an obvious imbalance in the development of eastern and western airports and between large and small and medium-sized airports. Moreover, most Chinese airports lack scientific planning and practical demonstration on the construction contributed to a sever challenge in profitability. In final, lacking of unscientific management attitude in seeking truth from facts brought about the stiff survival state of those small and medium-sized airports and the efficient development of airports also was seriously. According to Delphi, along with increasing aeronautical business, non-aeronautical business also

should be speed up. Besides, establishing a sound and scientific managerial system and market-driven pattern could help airports to promote efficiency in operating. Toward the expansion and modifying of airports, it is much better to comply with both factors of economic and population density and avoid efficiency-losing problem caused by unscientific investment. Finally, decreasing diverse possible efficient risk during the operating process could advance the airports' efficiency.

In terms of management or the infrastructure construction of airport, Chinese airports should change the traditional "iron rice bowl" concept within internal and establishing a correct market-driven philosophy. Besides, in lime with positively develop positively aeronautical industry, airports also should speed up the input of non-aeronautical industries in order to create diverse industrial structure and balance the issue of airport revenue. In the end, local government should avoid large expansion with unconcern for consequences on infrastructure construction.

The findings are limited because the basic models are adopted in DEA and it is sensitive to the inputs and outputs indices. It is recommended that future studies could use more complicated DEA models to survey airports' operational efficiency. And adopt more input indices such as the number of employee and etc. Moreover, the number of sample airports and distribution of experts also constitute the limitation. Some extensions to overall airports' performance could be evaluated in the future as well.

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Appendix 1

List of Sample Airports:

	Airport Name	IATA Code	Region	Web
1	Beijing Capital International Airport	PEK	Northern	http://www.bcia.com.cn
2	Guangzhou Baiyun International Airport	CAN	Central and South	http://www.gbiac.net/
3	Shanghai Pudong International Airport	PVG	Eastern	http://www.shanghaiairport.com
4	Shanghai Hongqiao International Airport	SHA	Eastern	http://www.shanghaiairport.com/
5	Shenzhen Bao'an International Airport	SZX	Central and South	http://www.szairport.com
6	Chengdu Shuangliu Internatioanl Airport	CTU	Southwest	http://www.cdairport.com
7	Kunming Wujiaba International Airport	KMG	Southwest	http://www.ynairport.cn
8	Hangzhou Xiaoshan Internatinal Airport	HGH	Eastern	http://www.hzairport.com
9	Xi'an Xianyang International Airport	XIY	Northwest	http://www.xxia.com.cn
10	Chongqing Jiangbei Internationl Airport	CKG	Southwest	http://www.cqa.cn
11	Xiamen Gaoqi International Airport	XMN	Eastern	http://www.xiagc.com.cn
12	Wuhan Tianhe International Airport	WUH	Central and South	http://www.whairport.com
13	Changsha Huanghua Airport	CSX	Central and South	http://www.hncaac.com/
14	Nanjing Lukou International Airport	NKG	Eastern	http://www.njiairport.com/
15	Qingdao Liuting International Airport	TAO	Eastern	http://www.qdairport.com
16	Dalian International Airport	DLC	Northern	http://www.dlairport.com
17	Haikou Meilan International Airport	HAK	Central and South	http://www.mlairport.com
18	Shenyang Taoxian International Airport	SHE	Northern	http://www.taoxianairport.com/
19	Ürümqi Diwopu International Airport	URC	Northwest	http://www.xjairport.com
20	Sanya Phoenix International Airport	SYX	Central and South	http://www.sanyaairport.com
21	Harbin Taiping International Airport	HRB	Northern	http://www.haerbinairport.com
22	Guiyang Longdongbao International Airport	KWE	Southwest	-
23	Tianjin Binhai International Airport	TSN	Northern	-
24	Taiyuan Wusu International Airport	TYN	Northern	-
25	Lanzhou Zhongchuan Airport	LHW	Northwest	-
26	Lijiang Sanyi Airport	LJG	Southwest	http://www.lijiang-airport.com
27	Xishuangbanna Airport	JHG	Southwest	http://www.xsbnairport.com
28	Yingchuan Hedong Airport	INC	Northwest	http://www.cwag-yc.com/
29	Xining Caojiabu Airport	XNN	Northwest	http://www.cwag-xn.com/
30	Kashi Airport	KHG	Northwest	http://www.xjairport.com

Appendix 2

Output-Passengers Movements Data (2004-2008):

	Code	Passengers Movements (person)				
		2004	2005	2006	2007	2008
1	PEK	34883190	41004008	48748298	53611747	55938136
2	CAN	20326138	23558274	26222037	30958467	33435472
3	PVG	21021723	23664967	26788586	28920432	28235691
4	SHA	14889198	17797365	19336517	22632962	22877404
5	SZX	14253046	16283071	18356069	20619164	21400509
6	CTU	11685643	13899929	16280225	18574284	17246806
7	KMG	9797260	11818682	14443607	15725791	15877814
8	HGH	6338042	8092641	9919532	11729983	12673198
9	XIY	6362409	7942034	9368958	11372630	11921919
10	CKG	5233774	6631420	8050007	10355730	11138432
11	XMN	5576369	6585489	7501004	8684662	9385436
12	WUH	4327101	4743877	6100582	8356340	9202629
13	CSX	3802550	5301396	6592602	8069989	8454808
14	NKG	4573987	5385933	6269103	8037189	8881261
15	TAO	4808416	5879552	6791240	7867982	8200367
16	DLC	4614166	5407452	6351089	7281084	8205454
17	HAK	7478210	7027397	6668795	7265349	8221997
18	SHE	4100174	4560162	5343566	6190448	6807235
19	URC	3891385	4424458	5136028	6169981	5817274
20	SYX	2525851	3087045	3905956	5311622	6006300
21	HRB	2726010	3222907	3643232	4432645	4985212
22	KWE	2719799	3125390	3717999	4248005	4324085
23	TSN	1705271	2193914	2766504	3860752	4637299
24	TYN	1680127	2240291	2843482	3613308	4312910
25	LHW	1041484	1439164	1861148	2510903	2212306
26	LJG	888708	1114264	1542722	1906250	1881745
27	JHG	1174006	1217734	1594186	1807633	1637454
28	INC	697052	876455	1077580	1369961	1642342
29	XNN	448396	537551	742429	920612	951330
30	KHG	329945	389680	444332	502591	427577

Output-Cargo Movements Data (2004-2008):

	Code	Cargo Movements (ton)				
		2004	2005	2006	2007	2008
1	PEK	668690	782066	1201815	1416452.3	1367710.3
2	CAN	506988	600604	653261.3	695092.7	685867.9
3	PVG	1642176	1857120	2168072	2559245.9	2603027.0
4	SHA	294020	359595	363581.4	388904.0	415726.3
5	SZX	423270	466476	559243.7	616172.2	598036.4
6	CTU	213040	251018	295497.9	325944.9	373067.3
7	KMG	171013	196530	219197.6	232656.3	236347.7
8	HGH	128209	165918	185518.1	195710.6	210793.0
9	XIY	73369	83256	99433.7	112053.7	117084.5
10	CKG	87568	100910	120178.3	143522.5	160256.4
11	XMN	141654	158740	175011.1	193642.4	195462.9
12	WUH	61378	64017	73770	89595.7	89852.8
13	CSX	43133	52360	62571.3	68668.9	71151.9
14	NKG	117802	139369	152063.2	180401.1	187604.1
15	TAO	75498	89058	101266.9	115781.4	130450.2
16	DLC	89699	99078	108992.5	121693.4	129388.1
17	HAK	66583	60590	62510	69829.6	74062.5
18	SHE	85343	83351	90253.9	97412.1	102487.5
19	URC	48465	61617	76215.1	85255.7	77748.1
20	SYX	17055	21378	23827.9	28633.9	29298.9
21	HRB	35085	41106	44920.8	52483.0	58695.3
22	KWE	30019	33311	39713.1	39730.0	41967.9
23	TSN	70995	80192	96755.7	125087.3	166558.1
24	TYN	28086	29759	27889	27909.3	31511.4
25	LHW	10446	10686	14886.1	20491.7	21747.9
26	LJG	691	606	1125.7	1286.3	1279.5
27	JHG	4925	6854	6264.9	6154.5	5192.4
28	INC	5694	7464	9124	10536.7	11734.8
29	XNN	3256	3436	4720.7	5219.0	6691.4
30	KHG	833.4	1128.6	1539.4	2121.2	1832.891

Output-Aircraft Movements Data (2004-2008):

	Code	Aircraft Movements (plane)				
		2004	2005	2006	2007	2008
1	PEK	304882	341681	378888	399209	429646
2	CAN	181192	211309	232404	260828	280392
3	PVG	176376	205046	231994	253532	265735
4	SHA	149486	169957	177626	187045	185304
5	SZX	138879	151430	169493	181450	187942
6	CTU	110186	132901	155484	166312	158615
7	KMG	91851	109035	135573	148128	150353
8	HGH	66030	79262	100799	114672	118560
9	XIY	77655	91372	99315	119341	121992
10	CKG	64701	72674	88929	105092	112565
11	XMN	60390	67014	77355	85251	92785
12	WUH	47494	51793	66876	93498	98372
13	CSX	54277	59534	71139	82041	85339
14	NKG	51076	55508	64591	82392	91242
15	TAO	56759	62826	72008	82367	87828
16	DLC	46509	50387	56374	63416	73082
17	HAK	61435	68879	61738	60579	66411
18	SHE	40628	43072	48931	56879	62531
19	URC	44102	48916	51602	59284	59462
20	SYX	20686	26351	32850	42292	47373
21	HRB	26540	30870	33863	40194	46364
22	KWE	32481	35318	43205	47685	46259
23	TSN	28087	47460	54948	65664	70279
24	TYN	20643	31761	38356	43061	47909
25	LHW	17531	19186	21902	28107	23897
26	LJG	8772	11414	15431	18721	19428
27	JHG	10804	11397	15606	17508	15872
28	INC	11234	12334	13589	15921	17111
29	XNN	7736	6931	7733	8766	9455
30	KHG	3121	3397	4017	4139	3682

Input-Runway Length and Terminal Size Data (2004-2008):

	Code	Runway length (meter)					Terminal Size (ten-thousand square meter)				
		2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
1	PEK	7000	7000	7000	7000	10800	41.4	41.4	41.4	41.4	141.4
2	CAN	7400	7400	7400	7400	7400	32	32	32	32	37
3	PVG	7800	7800	7800	7800	11200	27.8	27.8	27.8	27.8	76.35
4	SHA	3400	3400	3400	3400	3400	8.2	8.2	8.2	8.2	8.2
5	SZX	3400	3400	3400	3400	3400	14.6	14.6	14.6	14.6	14.6
6	CTU	3600	3600	3600	3600	3600	13.8	13.8	13.8	13.8	13.8
7	KMG	3400	3400	3400	3400	3400	7.69	7.69	7.69	7.69	7.69
8	HGH	3600	3600	3600	3600	3600	10	10	10	10	10
9	XIY	3000	3000	3000	3000	3000	10	10	10	10	10
10	CKG	3200	3200	3200	3200	3200	10.2	10.2	10.2	10.2	10.2
11	XMN	3400	3400	3400	3400	3400	14.9	14.9	14.9	14.9	14.9
12	WUH	3400	3400	3400	3400	3400	2.84	2.84	2.84	2.84	17.82
13	CSX	2600	2600	2600	2600	2600	3.4	3.4	3.4	3.4	3.4
14	NKG	3600	3600	3600	3600	3600	13.2	13.2	13.2	13.2	13.2
15	TAO	3400	3400	3400	3400	3400	6.4	6.4	6.4	6.4	16.3
16	DLC	3300	3300	3300	3300	3300	6.5	6.5	6.5	6.5	6.5
17	HAK	3600	3600	3600	3600	3600	6.0175	6.0175	9.93	9.93	9.93
18	SHE	3200	3200	3200	3200	3200	7	7	7	7	7
19	URC	3600	3600	3600	3600	3600	6.815	6.815	6.815	6.815	6.815
20	SYX	3400	3400	3400	3400	3400	6	6	6	6	6
21	HRB	3200	3200	3200	3200	3200	6.7	6.7	6.7	6.7	6.7
22	KWE	3200	3200	3200	3200	3200	3.4	3.4	3.4	3.4	3.4
23	TSN	3600	3600	3600	3600	3600	2.5	2.5	2.5	2.5	14.1
24	TYN	3200	3200	3200	3200	3200	2.58	2.58	2.58	2.58	2.58
25	LHW	3600	3600	3600	3600	3600	2.75	2.75	2.75	2.75	2.75
26	LJG	2500	2500	2500	2500	2500	0.79	0.79	0.79	0.79	0.79
27	JHG	2200	2200	2200	2200	2200	0.7859	0.7859	0.7859	0.7859	0.7859
28	INC	3200	3200	3200	3200	3200	1.5	1.5	1.5	1.5	1.5
29	XNN	3000	3000	3000	3000	3000	1.0727	1.0727	1.0727	1.0727	1.0727
30	KHG	3200	3200	3200	3200	3200	0.4856	0.4856	0.4856	0.4856	0.4856

Appendix 3

1st round questionnaire on operational efficiency of Chinese airport

To [whom it may concern]:

The following is an operational efficiency questionnaire regarding Chinese airports. The reason for this survey is to choose reasonable input and output indices for a DEA model, to evaluate the current situation at Chinese airports and to provide some suggestions. The results of this questionnaire will be used for our master thesis. Responses from individuals will remain anonymous and respondents can request a copy of the results. Please fill out the following information to the best of your knowledge. Should you have any questions, please contact us. Thank you for your cooperation.

Selection method (1): You can double-click the **gray selection box**; it will appear **"check box form field options"** window, and then click on the **"checked"** in the **"default value" items** to complete the selection. Or (2) you can also directly **deepen the characters** of the content you want to select to complete the selection. We are very sorry for the inconvenience, but we hope you can continue to help us complete this questionnaire. Thank you very much.

● Basic Information

Name: Date:

Company:

E-mail Address:

● Technical Aspect

1. Which input indices listed below, do you think would have a significant impact on airport efficiency? Please tick all that apply

☐ Number of runways ☐ Length of Runway ☐ Terminal area

☐ Number of employees ☐ Number of baggage claims ☐ Number of gates

☐ Number of public parking spots ☐ Airport area ☐ Prime operating cost

☐ Number of aircraft parking positions ☐ Number of remote aircraft parking positions

☐ Number of check-in desks

☐ Others(please state) ：

2. Which indicators listed below, do you think could represent output efficiency at an airport? Please tick all that apply

☐ Passenger movements ☐Cargo movements

☐ Air carrier movements ☐ Operating revenue

☐ Others(please state)：

● Evaluative Aspect

Please tick one box for each statement	Agree	Disagree	No opinion
The number of airports in China can not meet the overall demand currently	Agree☐	Disagree ☐	No opinion ☐
The development of airports in Eastern and Western region in China is under a serious imbalance situation	Agree☐	Disagree ☐	No opinion ☐
The development of Passengers and Cargo business as well as Non-prime business of Chinese airports is unbalanced	Agree☐	Disagree ☐	No opinion ☐
The regulation on various aspects of Chinese airports is still stringent	Agree☐	Disagree ☐	No opinion ☐
The efficiency of large airports is significantly higher than the small and the medium-size airports	Agree☐	Disagree ☐	No opinion ☐
Chinese airports are mainly focus on infrastructure construction	Agree☐	Disagree ☐	No opinion ☐

The profitability of Chinese airports faces a severe challenge	Agree☐	Disagree ☐	No opinion ☐
Three large hub airports (Beijing, Shanghai, Guangzhou) in China lack international competitiveness	Agree☐	Disagree ☐	No opinion ☐

Please provide any other comment you might have regarding the evaluation of Chinese airports：

- **Suggestions**

Please tick one box for each statement

	Agree	**Disagree**	**No opinion**
China should to expand airports in the Western region	Agree☐	Disagree ☐	No opinion ☐
Construction of airports in the Western region in China should be linked to GDP and the local population density	Agree☐	Disagree ☐	No opinion ☐
Deregulation and the implementation of delegation can improve efficiency of airports	Agree☐	Disagree ☐	No opinion ☐
Chinese airports should enhance the non-prime business income	Agree☐	Disagree ☐	No opinion ☐
Airports in China with poor efficiency should be closed	Agree☐	Disagree ☐	No opinion ☐
After a specific period(such as the Olympic Games), the expansion project of large-scale airports will face an efficiency-losing problem	Agree☐	Disagree ☐	No opinion ☐
Improving management pattern, which not only on inter-organizational, but also on software aspects(operation) could effectively enhance operational efficiency	Agree☐	Disagree ☐	No opinion ☐
It is conducive to implement merges to improve efficiency in the Chinese airport industry	Agree☐	Disagree ☐	No opinion ☐
Chinese airports should speed up the development of cargo	Agree☐	Disagree ☐	No opinion ☐
The establishment of regular routes will help Chinese airports to improve efficiency	Agree☐	Disagree ☐	No opinion ☐

Please provide any other comment you might have regarding the suggestions of Chinese airports：：

Thank you for your help!

Appendix 4

2nd Round Questionnaire on operational efficiency of Chinese airport

To [whom it may concern]:

The following is an operational efficiency questionnaire regarding Chinese airports. **In the 2nd round, each respondent is expected to strength and reassess their own answers, in this round, the additional suggestions also were presented after distilling the answers in the first round.** The results of this questionnaire will be used for our master thesis. Responses from individuals will remain anonymous and respondents can request a copy of the results. Please fill out the following information to the best of your knowledge. Should you have any questions, please contact us. Thank you for your cooperation.

Selection method (1): You can double-click the **gray selection box**; it will appear **"check box form field options"** window, and then click on the **"checked"** in the **"default value" items** to complete the selection. Or (2) you can also directly **deepen the characters** of the content you want to select to complete the selection. We are very sorry for the inconvenience, but we hope you can continue to help us complete this questionnaire. Thank you very much.

- **Basic Information**

Name: Date:

Company:

E-mail Address:

● Technical Aspect

1. Which input indices listed below, do you think would have a significant impact on airport efficiency? Please tick all that apply

☐Number of runways ☐Length of Runway ☐Terminal area

☐Number of employees ☐Number of baggage claims ☐Number of gates

☐Number of public parking spots ☐Airport area ☐Prime operating cost

☐Number of aircraft parking positions ☐Number of remote aircraft parking positions

☐Number of check-in desks

☐Others(please state) ：

2. Which indicators listed below, do you think could represent output efficiency at an airport? Please tick all that apply

☐Passenger movements ☐Cargo movements

☐Air carrier movements ☐Operating revenue

☐Others(please state)：

● Evaluative Aspect

Please tick one box for each statement

Strength scale
Strongly disagree (1), Disagree (2), Somewhat disagree (3)
Somewhat agree (4), Agree (5) Strongly agree (6)

The number of airports in China can not meet the overall demand currently.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
The development of airports in Eastern and Western region in China is under a serious imbalance situation.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
The efficiency of large airports is significantly higher than the small and the medium-size airports.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
Chinese airports are mainly focus on infrastructure construction.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
The profitability of Chinese airports faces a severe challenge.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
Three large hub airports (Beijing, Shanghai, and Guangzhou) in China lack international competitiveness.						**Justification**:

☐1	☐2	☐3	☐4	☐5	☐6	
The regulation on various aspects of Chinese airports is still stringent.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
The development of passengers and cargo business as well as non-aeronautical business of Chinese airports is unbalanced.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	

- **Added Statements**

Please tick one box for each statement

1. Most of Chinese airports were failed to plan scientifically on constructing, which resulted in expanding and modifying to cope with saturation issues shortly after building up.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
2. Chinese airports still lack scientific management pattern.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
3. Being short of regular routes in the most of small and medium-sized airports have been a stiff issue, which affects the efficiency of those airports.						**Justification**:

☐1	☐2	☐3	☐4	☐5	☐6	

Please provide any other comment you might have regarding the evaluation of Chinese airports：

- **Suggestions**

Please tick one box for each statement

Strength scale

Strongly disagree (1), Disagree (2), Somewhat disagree (3)
Somewhat agree (4), Agree (5) Strongly agree (6).

China should to expand airports in the Western region.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
Construction of airports in the Western region in China should be linked to GDP and the local population density.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
Deregulation and the implementation of delegation can improve efficiency of airports.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
Chinese airports should enhance the non-aeronautical business income.						**Justification**:

☐1	☐2	☐3	☐4	☐5	☐6	
Airports in China with poor efficiency should be closed.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
After a specific period (such as the Olympic Games), the expansion project of large-scale airports will face an efficiency-losing problem.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
Improving management pattern, which not only on inter-organizational, but also on software aspects (operation) could effectively enhance operational efficiency.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
It is conducive to implement merges to improve efficiency in the Chinese airport industry.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
Chinese airports should speed up the development of cargo.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	

The establishment of regular routes and charter routes will help Chinese airports to improve output efficiency.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	

● Added Statements

Please tick one box for each statement

1. Airports should concern the ratio of profitability involved in aeronautical (50%) and non-aeronautical (50%).						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
2. Airports should reduce possible efficient risk, which was consisted with queue time at check-in and security, bag waiting time at arrivals, proper take off and land time.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	
3. In order to improve output efficiency, airports should gather stake hold (hotel, tourism agency, taxi, shops) to create commercial “package” to catch demand.						**Justification**:
☐1	☐2	☐3	☐4	☐5	☐6	

Please provide any other comment you might have regarding the evaluation of Chinese airports：

Thank you for your help!

Appendix 5

Panelists List of Questionnaire on Operational Efficiency of Chinese Airport

Professors

- **China mainland**

1. Song Dong. Ju

   School of Economics and Management, Beijing Jiaotong University

   E-mail: sdju@263.net

2. Xiao Ming. Sun

   School of Management Science and Engineering, Shanghai Jiaotong University

   E-mail: xmsun@sjtu.edu.cn

3. Yao Qiu. Wang

   School of Economics and Management, Beijing Jiaotong University

   E-mail: yqwang1@bjtu.edu.cn

4. Zu Jun. Ma

   School of Logistics, Xinan Jiaotong University

   E-mail: zjma@home.swjtu.edu.cn

- **China Taiwan**

5. Chien Hang. Cheng

   National Kaohsiung Hospitality College

   E-mail: martin@mail.nkhc.edu.tw

- **England**

6. Richard. Moxon

   School of Air transportation, Cranfield University

   E-mail: r.moxon@cranfield.ac.uk

Experts

- **Airport**

1. Hong Ming. Shan

Shanghai Hongqiao International Airport

E-mail: shanhongming@yahoo.cn

2. Qin Wei. Shi

   Shanghai Pudong International Airport

   E-mail: shiqw330@126.com

3. Xiao Tian. Long

   Wuhan Tianhe International Airport

   E-mail: long9997204@163.com

- **Airline**

4. Bo. Cheng

   China Airline Beijing

   E-mail: hasegawa510@msn.com

5. Chi. Zhang

   China Airline Chongqing

   E-mail: elevedog@yahoo.com

- **Aviation Authority**

6. Cheng

   Air Traffic Management Bureau

   E-mail: swxlishang@hotmail.com

7. Gan

   Civil Aviation Administration Authority

   E-mail: shangrila@atmb.org

8. Qiu

   Air Traffic Management Bureau Guangzhou

   E-mail: ciue@163.com

9. Wang

   Air Traffic Management Bureau

   E-mail: tiankong8359@hotmail.com

Appendix 6

The summary of the supplementary comments provided by experts' responses of questionnaire on operational efficiency of Chinese airport

- **Technical aspect:**
  - Software technique, number of employees may be difficulty to be used as criteria by reason of most of Chinese airports have been several group enterprises.
  - Number of self service check-in desks and bag drop for those checking in remotely.
  - Queue time at check-in and security. Bag waiting times at arrival. Taxing time, take off and landing punctuality.
  - Management technology.

- **Evaluative aspect:**
  - In order to meet the needs of economic development, China must increase the number of airports.
  - In order to further accelerate the space of airports' construction, gradually improve the layout of the airports' planning, and promote the opening up and economic construction in western region, the airports should be vigorously developed in this region.
  - The basic construction of the airports is an important contribution for the airports' security.
  - Chinese airports should treat aeronautical as key activities, and non-aeronautical as auxiliary activities.
  - Three large hub airports have a big potential to compare with other large hub in the world. From the view of the density of both domestic and international routes, or from the view of the scale of construction and passenger throughput, they have been into comprehensive hub airports among the Asia-Pacific region. Besides, the efficiency of these airports is certainly higher than other those small and medium-sized airports by reason of improved facilities, the relative sound management and high utilization.
  - Entirely, Chinese airports lack advanced managerial concept.
  - The distribution of airports mainly gathered in the eastern coast cities and southern regions.
  - Chinese civil aviation industry lack small sized airports and low cost airline to support them.
  - Infrastructure is still inadequate, so it is necessary to vigorously develop.

- Managerial pattern was carried out in according with national policies.
- Three major airports are still inadequate in the layout of network routes, the convergence of flights schedule and flights wave.
- Small and medium-sized airports originally exists weaknesses in passenger and cargo business.
- Unscientific planning on construction has been improved little by little.
- It is obvious that the number of airports in eastern are much more than in western
- The utilization of large airports is higher than most small and medium-sized airports
- A large majority of airports are facing financial challenge
- enhancing non-aeronautical income is an important factor for increasing total revenue
- Chinese airports have emphasized the construction of system step by step instate of the infrastructure construction.
- The distribution and quantity of airports in China is imbalanced and especially the airports in western region can not meet the entire demand.
- Comparing with international hub airports, they still lack a lot of efforts.
- Non-aeronautical income should be improved.
- The regulation on various aspects of Chinese airports is still stringent by reason of national policy.
- Because of the policies of airports were carried out by civil Aviation Administration of China, the source of construction fund is mainly depend on government, the regulation is still stringent.
- Economies of scale and less “peak” operation indicated that the efficiency of large airports is higher than other small and medium-sized airports.
- Imbalanced economic development directly caused imbalanced development of airports, namely, the development of airports could not catch the economic development.
- Profitability is still a big problem for the airports.
- The policy in aviation industry is still incomplete and conservative.
- A large part of airports lack long-term planning on construction.
- Small and medium-sized airports should attract short-haul regular routes to copy with the stiff issue of poor efficiency caused by shortage of routes.
- The evidence indicated Chinese airports have been focusing on the basic construction and ignored the managerial development.

- The regulation on various aspects of Chinese airports has been deregulated step by step.
- Majority of Chinese airports ignored the non-aeronautical revenue.
- Economic effect resulted in the imbalanced development among airports.
- The distribution of airports and the development of airports between eastern and western region and between large airports and small and medium-sized airports are imbalanced.
- Chinese airports should focus on the managerial construction instate of massive infrastructure construction and strive to cultivate service concept.
- Backward marketing strategies of airports contributed to a big challenge in profitability.
- The construction of the airports needs a scientific planning and evaluation.
- Profitability is still big challenge for the Chinese airports.
- Although the construction level of small and medium-sized airports are relatively backward, the facilities of large major airports were advanced, so it can not simply say Chinese airports are mainly concentrated on the infrastructure construction.
- The development in passengers and cargo business as well as non-aeronautical is balanced at large airports.

- **Suggestive aspect:**
  - The construction of the airports in the western region has to combine the elements of the density of population and economic level.
  - With the cooperation between the western and eastern economic zone have been strengthened, the expansion of the airport in the western region would contribute to local economic development.
  - Market-driven operating will influence the security of airports and provided that the traditional managerial pattern could not be overcome after merger, it would have many unexpected consequences, there is no more need to mention increasing efficiency.
  - The security issue always is a prerequisite for improving efficiency.
  - After specific period such as Beijing games, airport should concern that how to maintain its efficiency with big expansion project.
  - Aeronautical revenue should at least be 75% in total revenue of airports.
  - Chinese airports should increase non-aeronautical revenue positively.
  - Passenger and cargo should be improved synchronously, however, there is no need to establish regular routes if the throughput of them are low at airports.

- Airports should create a win-win situation with airline.
- According to the state of economic development, there is not need to accelerate the construction and expansion in western regions.
- The management within inter-organization should be improved.
- Market-driven operating is beneficial for improving efficiency so that to enhance competitiveness of airport.
- Expanding airports in the western region could guarantee the basis air traffic to carry out and ensure the demand for aviation to be met completely.
- With economic development of China, large airports also need expansion even though there is no specific period such as Olympic Games.
- Carrying out merger among airports could achieve recourses sharing so that could promote efficiency each other.
- Airport has its public effect, thus airport will decrease the focus of aeronautical if airport concentrate much more on non-aeronautical business.
- Implementing merge could advance the unified management of airports.
- Assuring security of airport is an important prerequisite to promote efficiency.
- According to the management model, most local hub airports and small and medium-sized airports might refer to the listed airports.
- The expansion of large airports would loss its part of efficiency after specific period by reason of lower utilization comparing with before.
- Chinese airports should change the managerial concept of state-owned enterprise
- Facing with poor efficient airports, airport should try to develop non-aeronautical business or based on the development needs of the local, there is also possibility to close them down.
- Airports could share the resources and information so that to improve efficiency if implementing merge among airports.
- Airports should decrease flight delay and possible efficient risk, meanwhile strive to improve service.
- It is prudent to provide capacity as forecast by economic growth and according to local catchment area.
- A good example is the introduction of competition for provision of ground handing services which tends to lower costs to the airline customers.

- Delegation of operational decision to the “front line” can improve response times and customer service levels.
- According to the specific period, such as Beijing, what will be demand after Beijing games? How can facilities be used at the airport?
- Speeding cargo development is vital to trade and economic growth.
- Increasing non-aeronautical revenue is vital.
- Reducing possible risk such as queue time and check-in time can first and last impression of a city and form the basis of customer’s perception of service.
- Passenger and cargo should be developed synchronously, and the ratio of aeronautical business should be better at 75%.
- Improving management is the first prerequisite for promoting efficiency of airports.
- Amplifying the capital, economic of scale will help improve the efficiency.
- The revenue ratio could not be changed during short time.
- From a holistic perspective, the cargo business is still weak.
- Changing traditional operating model is a prerequisite for the development of airport, which means that airport should create it selves feature.
- The management within inter-organization should be improved.
- Market-driven operating can improve airports’ overall efficiency, but airports have to avoid to copy this idea due to the management of airport should have a social effect.
- The expansion of three large airports was in line with the scientific evaluation, even if the end of the specific period such as Olympic Games, the airport itself will not cause too much waste and idle issue.
- Enterprises management system would contribute to airport security problem
- Implementing merge could advance the unified management of airports.
- Despite there are not big games, the three large airports also are required to expand.
- Deregulation would contribute to the problems in security of airports so that efficiency could be assured.