ESSAYS ON ASIAN AIRPORTS' PRODUCTIVITY AND COMPETITIVENESS

A Dissertation

Submitted to the Faculty of the National Graduate Institute for Policy Studies (GRIPS)

in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY IN PUBLIC ECONOMICS

by

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December 2016

Abstract

In this dissertation I conducted two empirical studies under the framework of interactions of different interest groups in civil aviation industry. The first study deals with the interaction between policy maker and airport, namely the influence of one policy change on the operational efficiency of airports. The second study analyzed the interaction between passenger and airport. It reveals factors affecting passengers' choice on different airport.

The first study is about the effect of the Three Links agreement between mainland China and Taiwan which resumes the commercial airline services across the Taiwan Strait. I analyzed changes in the efficiency of Taiwanese airports with data envelopment analysis and Malmquist Index analysis. I found that airports in Taiwan with a direct China route would have a lower efficiency score but a higher Malmquist Index comparing to their counterparts. An overall improvement of Taiwanese airports' efficiency and shrinking of the gap between big airports and small airports are also observed.

The second study analyzed the competition patterns between Hong Kong International Airport (HKG) and Singapore Changi Airport (SIN) with regard to air route connecting Europe and Oceania. Hong Kong and Singapore have traditionally been Asia's busiest airports by international passenger traffic. While super-connectors in the Persian Gulf and Turkey are stimulating the growth of their base airports, analyzing passengers' trade-offs in choosing a transit airport in this route is vital for traditional Asian hubs' developing strategy.

Airport choice for multi-airport regions (MARs) has been studied for long but transit airport choice analyses for long-haul passengers remain limited. This study uses revealed preference data of passengers travelling between Europe and Oceania on July, 2015, who took a transit in HKG or SIN. The estimation of alternative-specific logit model indicates that frequency, fare and flight duration significantly

affect people's choice on transit airport. Case-specific attributes such as days-to-departure, round-trip affect passengers' choice behavior via airline companies' sales strategies.

Acknowledgements

I would like to express my sincerest gratitude to my supervisor, Professor Hozumi Morohosi, for his support, guidance and encouragement on my dissertation. Our weekly meetings have always been pleasant and fruitful. Many ideas in this dissertation actually flashed through my mind during our talking in Professor's cozy office. I would also like to thank my university National Graduate Institute For Policy Studies (GRIPS) for five years' of consecutive financial support, without which I would not have concentrated on my research here in Japan without worrying about expenditures.

Besides my main adviser, I would also like to thank the rest of my thesis committee: Professor Tetsushi Sonobe, Professor Makoto Tanaka, Professor Yoichi Arai and Professor Yuichiro Yoshida, for their insightful comments and suggestions during my qualification exam, candidate's seminar and the defense. The same goes to scholars of The Operations Research Society of Japan, and The Air Transport Research Society (ATRS), for their valuable remarks and advice during my presentations.

A special thank you goes to Mr. Faical Allou, Business Development Manager in Skyscanner for Business. Mr. Allou generously provided the data of purchasing records on Skyscanner.com for my study in Chapter 4. Without his kind support it would be impossible for me to conduct the second research.

Last but not the least, I would like to express my appreciation to my fellow classmates in the Policy Analysis Program and other programs in the sixth floor: Arif Rahman Sumon, Arnold Fang, Francis Mark Antonio Quimba, Francis Mwesigye, JB Tomas Busque, Jeffrey Ordaniel, Jerry Huang, Jing Lan, Kazuya Masuda, Krist Michael Chun-Yang Huang, Pascal Lottaz, Rhoda Ejalu, Siriporn Pittayasophon, Stefan Angrick, Tatsuya Ted Takeda, Trinh Quang Long, Xiangcai Meng, Xing Zhang, Yan Zhang, Ying Yao, Yoko Oishi, Yoko Sakai, Yuki Higuchi and Zarau Wandeline Kibwe. They have made my research and life in Tokyo fulfilled.

To my loved ones.

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[1]Provided by Travel Insight — Skyscanner Business.

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Chapter 1

Introduction

Civil aviation is a unique and fascinating sector of public transportation. The correlation between the growth of air transportation and GDP has been confirmed in numerous literature. Figure 1.1 reveals the growth rate of global GDP and that of global air passengers carried. The aviation industry shows the same trend with GDP but with a higher average growth rate around 5%, comparing to average GDP growth rate at around 2%. Also, in 2004 and 2010, aviation industry rebounded with a 10% plus growth rate from the early 2000s recession and financial crisis of 2008, while the scale of recovering in GDP growth is much flatter. The negative growth rate of air passenger in 2001-2002 was due to the influence of the September 11 terrorist attacks. Among different regions of the world, Asia Pacific is dynamic and promising in both economic growth and air transportation. Figure 1.2 shows the growth of GDP and air passenger in Asia Pacific in the same period. In 2001-2002, this region was not affected by the 9-11 attacks but in 2003 the civil aviation experienced the only negative growth year due to the spread of SARS. Since 2003, Asia Pacific aviation shows similar trend with global figures, with an even higher average growth rate near 10%. According to APA TFG (2012), the annual GDP growth rate of Asia Pacific region would be 5.9% in the year 2011-2022 and 4.8% in the year 2022-2032. The air

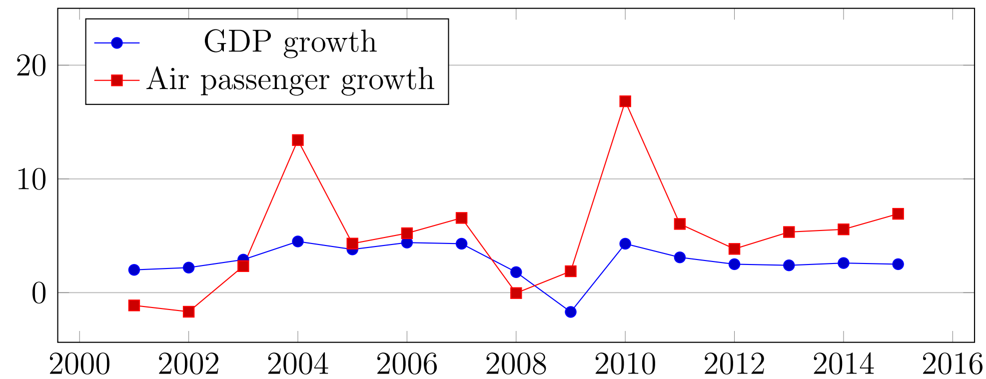


Figure 1.1: Global GDP and air passenger growth rate(%) 2001-2015

Source: The World Bank DataBank

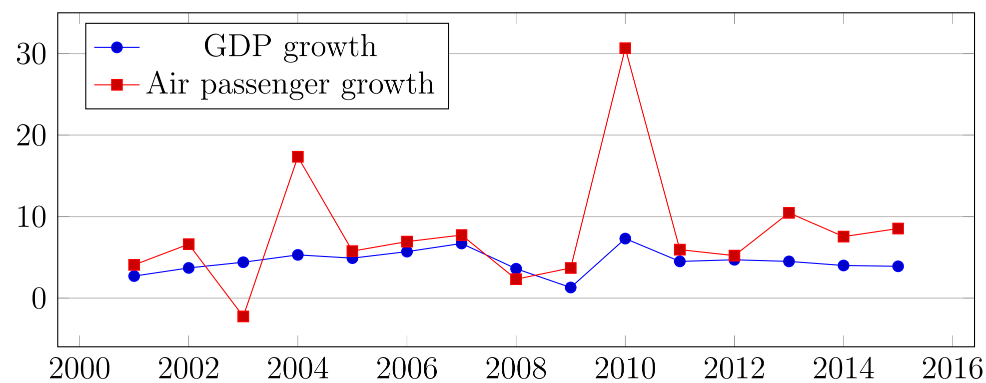


Figure 1.2: Asia Pacific GDP and air passenger growth rate(%) 2001-2015

Source: The World Bank Databank

passengers carried within Asia Pacific region are estimated at an annual growth rate of 5.9% and 5.0%, for the period of 2011-2022 and 2022-2032 respectively(APA TFG, 2012). This dissertation concentrates on the aviation issues in Asia Pacific region.

Although strongly affected by economic environment, civil aviation is much more complex comparing to other industries because of its unique features: enormous assets investment involved and a long payback period, constrained resources of airport slots, and policy issues on the freedom of the air. Government policy makers, airports and airline companies have similar but slightly different interests and interact with each other. As my main focus in this dissertation is airport, I illustrate how government policy makers, airline companies and passengers interact with airports in Figure 1.3.

Government

Policy makers' main target is to develop or to keep the hub status of gateway airport(s) of their own countries without losing sufficient attention to aviation safety. In order to achieve such goal, airport privatization is often adopted to stimulate cost effectiveness and to promote service level(Matsumura and Matsushima, 2012). One of the newest example is Kansai International Airport(KIX) and Itami Airport in Osaka, Japan. Their operational rights have been sold to a Japanese-French consortium, hoping to be extricated from the huge debt borne by KIX.

Another trend in aviation policy is the liberalization in the freedom of the air. Typical examples are open-skies bilateral or multilateral agreements advocated by the Unite States, and single aviation market within one united economic unit proposed by EU. United States have signed Open-Skies agreements with more than 100 partners (U.S. State Department, 2016). EU and ASEAN have accomplished the "European Common Aviation Area" in 2006 (Dobruszkes, Goetz and Budd, 2014) and "ASEAN Single Aviation Market" (ASEAN-SAM) in 2015 (ASEAN Briefing, 2015), as counterparts to the US-led Open Skies. A special case of air liberalization is the (re)open of direct flight between specific countries/regions. Opening of direct China-Taiwan flights and international flights to Myanmar are examples in Asia while direct American flights to Cuba and Mexico (Zacks Equity Research, 2015) are a recent example in mature market.

Airline

Emerging in the 1990s, Low Cost Carriers (LCC) have become a worldwide phenomenon during the 2000s, thanks to deregulation of air transport (Gross *et al.*, 2016). There are successful examples in North America (Southwest Airlines and WestJet) (Vowles and Lück, 2016), Europe (Ryan Air and EasyJet) (Conrady, 2016) and Southeast Asia (Lion Air, AirAsia Group and Jetstar Group) (Taumoepeau, 2016). Comparing to the 56% share of available seats by LCCs within Southeast Asia, the figure is only 11% for LCCs within Northeast Asia (CAPA Centre for Aviation, 2016). LCC in the Asia Pacific region still has strong growth potential with further deregulation in Northeast Asia and South Asia. Airport authorities have started to face the trade-off between decreased landing fee and additional traffic brought by LCCs. Although it is evaluated by Volkova (2010) that the former is larger than additional revenue, it remains an investment for the future to accommodate airport slots to LCCs, especially for small regional airports whose capacities are not fully utilized.

One of the most important issues between airlines and airports is the slot allocation at congested airports.

Passenger

Passengers are of great interest to both airports and airline companies as they are the main source of revenue. In addition to conventional air ticket fare, which has the landing fee included, and airport facility fee, the non-aviation revenue has taken a growing part of the total income of airports. According to ACI (2014), the non-aviation revenue makes up 44% of airport industry's total revenue. Especially in Asia Pacific and Middle East, the two regions with the fastest growth in airport revenue in 2013, the non-aeronautical revenue takes 46.5% and 48.3% of total revenue in 2013 respectively. (Calculated from data of ICAO (2013).)

The contribution to the revenue of airports makes passenger volume a major output indicator of airport. As construction for airport facilities has a long investment recovery cycle, it is vital for the airport authorities to make a correct market forecast for a long period in the future in order to optimize the input-output ratio.

In this dissertation I looked into two issues with regard to Asian airports. One is about the relationship between government policy and airport, the other one about the relationship with passenger demand for specific airports. In Chapter 3, I analyzed the *Three Links* agreement between mainland China and Taiwan, specifically about

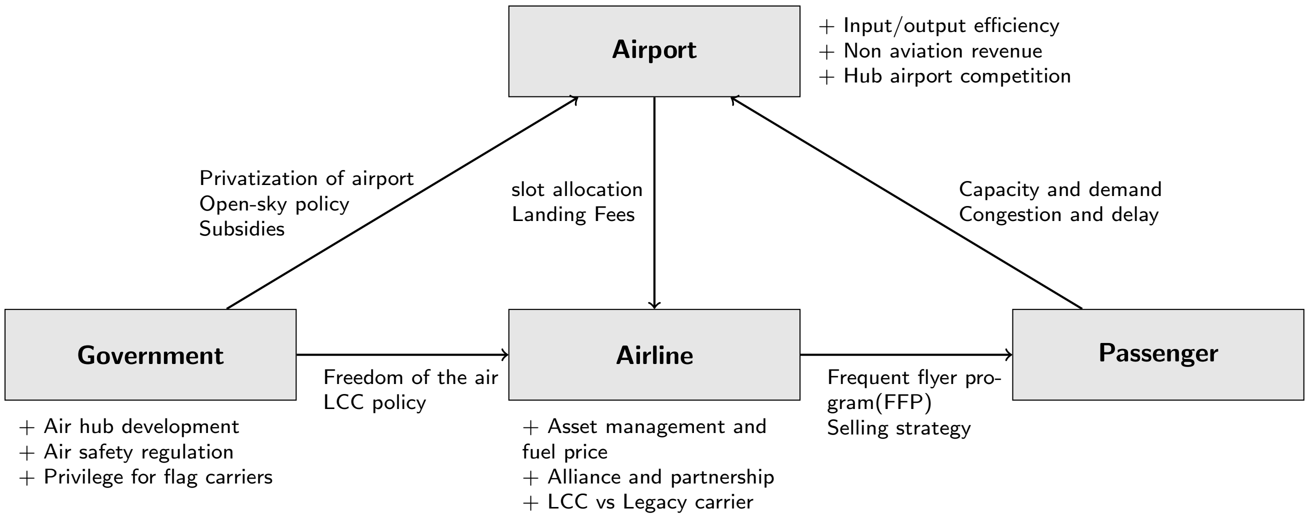


Figure 1.3: Issues(+) and interactions of stake holders in civil aviation

the influence it had on Taiwanese airports. In Chapter 4, I studied the competition between two gateway airports in Asia: Hong Kong International Airports and Singapore Changi Airport. A choice model is applied to distinguish passengers' demand between the two transit airports in the "Kangaroo Route"–the air route between Europe and Oceania. The following part of this chapter will be unfolded as follow: Section 1.1 and Section 1.2 will present backgrounds of the two main research topics. Section 1.3 includes the statement of the research questions of this dissertation and the purpose of the study. Lastly Section 1.4 summarizes the contribution of this dissertation in filling the gap of the existing literature.

1.1 Development of Cross-Strait Flights

The history of air routes across the Taiwan Strait dates back to the end of Chinese Civil War. The partition of Taiwan and mainland China led to an era of no any traffic relations between the two sides. In 1979, Standing Committee of the National People's Congress of China published *Message to Compatriots in Taiwan*, which was the first policy towards Taiwan by People's Republic of China. This document for the first time established the idea of three links. In 1987, with the lifting of Martial Law[1] in Taiwan, Taiwanese were allowed to go to mainland China to visit their families. Still there was no direct transportation, a transfer in Hong Kong was necessary.

With the warming-up cross-strait relations, flights connecting Taiwan and China emerged since 2003. At that time only Taiwanese Airlines were allowed to operate one-direction flights carrying only Taiwanese businessmen. A stopover at Hong Kong or Macau was still needed. In 2005, the stopover at Hong Kong was replaced by flying through Hong Kong FIR[2]. In addition, Chinese Airlines also took part in these chartered flights.

The humanity chartered flights from Taiwan to Sichuan, the stricken area of the 2008 earthquake, helped the cross-strait relation to move forward. By the second half of 2008, cross-strait weekend charters have been available on a more permanent basis. 6 Chinese carriers and 5 Taiwanese carriers operated cross-strait flights in 5 Chinese airports and 3 Taiwanese airports (Figure 1.4). In the next year, weekday charter flights became available, with much more Chinese destinations and carriers (Figure 1.5). One Taiwanese destination (Taichung Ching Chuan Kang Airport) was also added, before more Taiwanese airports opened in the following years. Since not all Taiwanese airports are opened for cross-strait flights, and not all the airports are opened in the same year, we are able to conduct an efficiency analysis based on a panel data on Taiwanese airports.

1.2 Development of "Kangaroo Route"

According to Australian National Dictionary Centre[3], the phrase "Kangaroo route" originally refers to the "air route between Australia and the United Kingdom via

[1] 1949/5/20-1987/7/15
[2] Flight Information Region
[3] Word of the Month: Kangaroo route. Retrieved August 3, 2016, from http://andc.anu.edu.au/sites/default/files/WotM%20July%20kangaroo%20route%202014.pdf

Figure 1.4: Route Map of the 2008 Cross-strait charters
(Source:Wikipedia Commons by Tsungyen Lee)

Figure 1.5: Route Map of Cross-strait charters 2008-2009
(Source:Wikipedia Commons by Tsungyen Lee)

a stopover in another country". Noticeably there are two certain conditions that must be satisfied in the definition. One is that the origin and destination have to be Australia and the UK, or the other way around. The second condition is that the flights must be hopping among airports in different countries. The latter is also where the name kangaroo route comes from. Qantas first operated this route in 1944[4].

In this dissertation, I broaden the definition of the term "Kangaroo Route" as follow:

Definition 1.2.1. Kangaroo Route
Kangaroo Route refers to air route connecting Europe and Oceania with at least one transit point en route.

This is a highly competitive route, as a result of the close economic connections between the two continents. The pioneer Australian carrier Qantas and Imperial Airways[5] were the main suppliers in this route in the first place. With limited range of aircraft during the early period, they had to make as much as 7 stopovers along the route (Figure 1.6). With the improvement of the capacity of modern aircraft, however, only one stopover is still needed in a typical "Kangaroo Route". Asian carriers, with their hub airports that used to be one of the stopovers of "Kangaroo Route", joined this market soon. Singapore Airlines, Malaysia Airlines and Thai Airways are the representatives. Traditionally, these carriers have been hopping via Southeast Asian hub, specifically Singapore, or Hong Kong in Northeast Asia. Up-and-coming players are gulf carriers in the middle east. In addition, with Qantas establishing a partnership with gulf carrier Emirates and shifting its stopover from Singapore to Dubai afterward, Dubai has replaced Singapore as the biggest transit airport in this market. While gulf carriers are still growing fast in international flights,

[4]https://en.wikipedia.org/wiki/Kangaroo_Route
[5]Predecessor of British Airways

China and Indonesia, both with a huge domestic market, are also starting to target "Kangaroo Route" in recent years. (Fickling, 2013; Flynn, 2013)

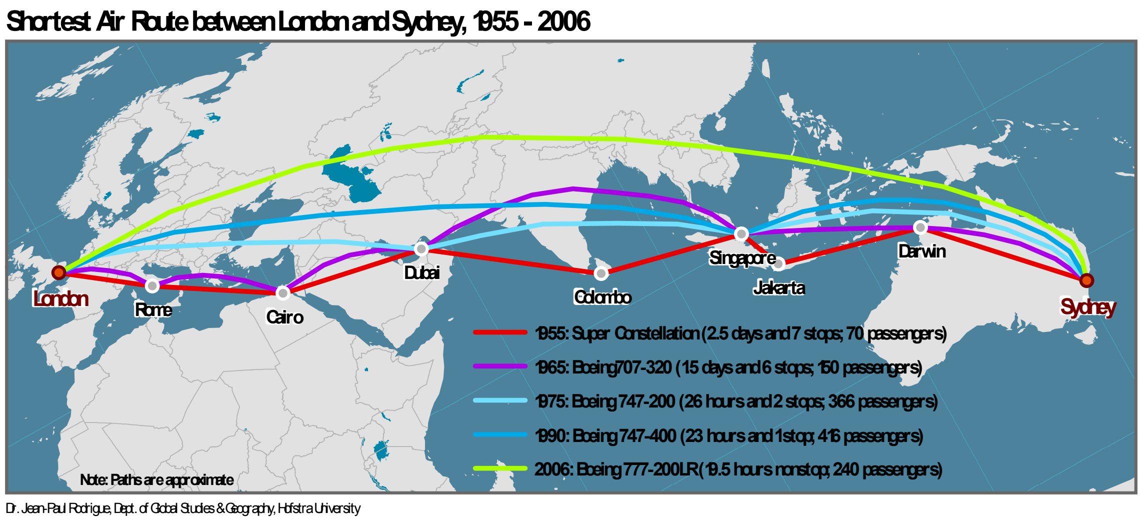


Figure 1.6: Evolvment of stopovers along the Kangaroo Route 1955-2006 (Author: Dr. Jean-Paul Rodrigue)

1.3 Research problems

With a focus on the two issue mentioned above, I am trying to answer the following 2 questions in empirical studies in Chapter 3 and Chapter 4.

Question 1

Does the Three Links agreement have a significant influence on the efficiency of Taiwanese airports? If so, in what direction? How would the effects differ between major airports and local regional airports?

7 years after the adoption of the agreement, the percentage of passengers to and from mainland China in total passenger volume of Taiwan's airports has reached 20% and surpassed the share of Taiwan's domestic passenger (Figure 1.7). Moreover, mainland China has become the biggest tourist source for Taiwan (and much more

than the second biggest source Japan[6]). There are considerable studies on the political and macro-economical influence of this landmark in cross-Taiwan strait relation. While Lau *et al.* (2012) investigated the implication of the Three Links Agreement on the composing of airports' destinations in greater China, this dissertation would be the first one to analyze the affect on efficiency of Taiwan's aviation industry.

I also place an emphasis on the difference of direct flights' effect on different level of airports in Taiwan. Taiwan has adopted a "one county one airport" policy that mainly subjects to election needs. With the adjustment of Taiwanese economy and the development of highway and high-speed railways, the small regional airports turn sluggish during the first decade of this century. I will discuss in Chapter 3 how the efficiency of these airports would change under direct cross-strait flights, comparing to gateway airports like Taoyuan International Airport and Songshan Airport serving Taipei. Both data envelopment analysis and Malmquist Index analysis are used in this Chapter.

Question 2

What are the major factors affecting passengers' route choice along the Kangaroo Route, regarding choice between Singapore and Hong Kong? How would this result provide reference for Asian countries' aviation policy on hub strategies?

In Chapter 4 I try to adapt the methodology in existing departing airport choice analyses to the choice of transit airports in a typical intercontinental route. With a focus on Asian airports, I choose Hong Kong International Airport and Singapore Changi Airport as the two alternatives of transit airport. In addition to conventional attributes like air ticket fare, flight duration and flight frequency at the transit airport, I include variables related to individual travel schedule in the choice model to reveal how the schedules of each passenger affect their route choice. The model used in this Chapter is alternative specific conditional logit model.

[6]Source: Tourism Bureau, M.O.T.C. Republic of China(Taiwan).

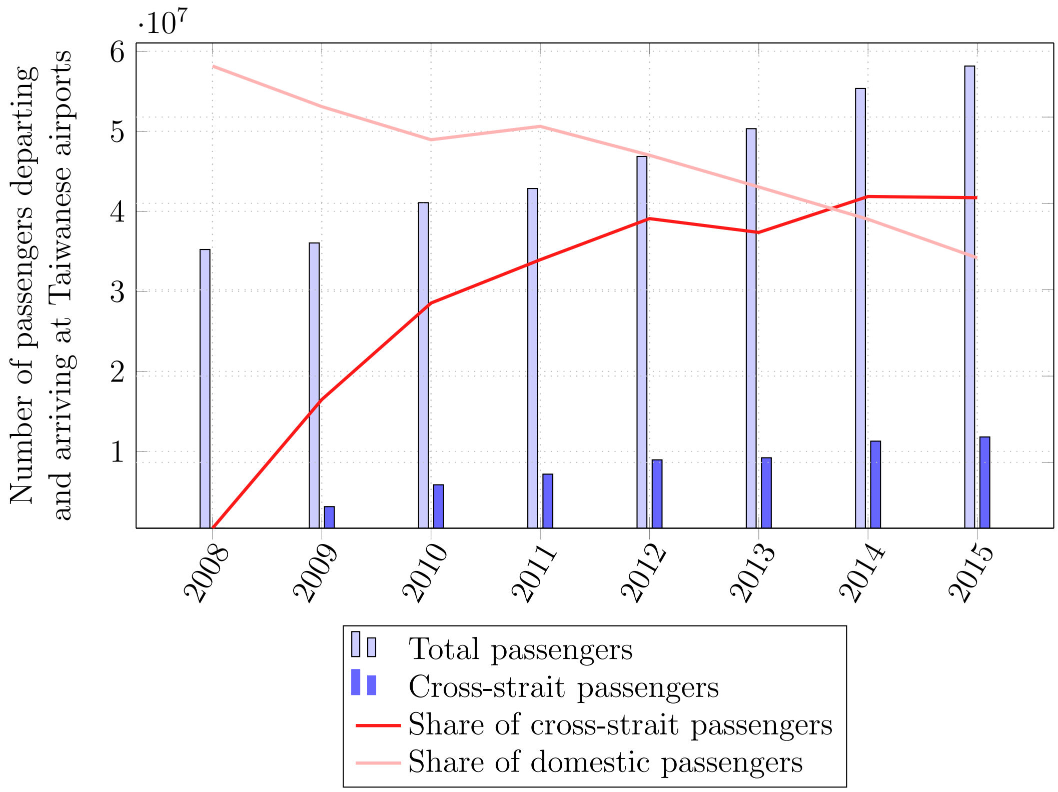


Figure 1.7: Population and share of cross-strait route passenger after 2008

Data source: Traffic of Civil Aviation by Airports: http://www.caa.gov.tw

1.4 Contribution

This dissertation analyzed two issues on the efficiency and competitiveness of typical Asian airports. The contribution of this dissertation is listed below.

Firstly, Chapter 3 fills the gap of existing literature on the policy change concerning direct flight over the Taiwan Strait(refer to Section 2.1). This is also the first study utilizing data envelopment analysis on the efficiency change after the Three Links agreement.

Secondly, Chapter 4 extends the current airport choice problem in a multiple airport region (MAR) to the choice of transit airport into long-haul flight market. Choice of transit airport is of more importance as it helps to maintain the transit airport's hub status, while the choice of departing airport only affects the revenue per se (Renard (2004)).

Last but not the least, Chapter 4 is to the best of my knowledge the first research in an air route choosing model, using a revealed preference data from an on-line travel search engine. The advantage of using revealed preference data over stated preference data will be discussed in the following relevant chapter.

Chapter 2

Related Work

2.1 Past work on cross-strait direct flight

Many of the past work about the direct transportation, including air transportation, appeared before the Three Links agreement. At the time when direct transport linkage between the two sides were not allowed, many scholars discussed the possibility and visions of future Cross-strait air transportation. Lin and Chen (2003) estimates the demand for air cargo transportation across the Taiwan Strait based on the assumption that direct air link connecting the two sides is inevitable. Two years before the agreement, Guo *et al.* (2006) enumerated the obstacles of economical, political, cultural and transportation that tourism across the Taiwan Strait were facing at that time and proposed direct transportation mode between mainland China and Taiwan without passing by the third city or country. Some other studies (Shon *et al.*, 2001) put the emphasis on the possible damages the direct flights may have caused on the status of Hong Kong Airport, which had been playing the role of China's gateway to the rest of the world, especially Taiwan. Hong Kong-Taipei has long been one of the world's busiest air routes, based on the disconnection between mainland China and Taiwan.

In contrast, papers that verify the effects of direct flights after the agreement are not as many, among which many discuss the possible benefits or losses it brought to carriers in Taiwan, China and Hong Kong (Chang *et al.*, 2011). Lau *et al.* (2012) summarized the cost reduction of major airlines operating cross-strait route and the competition carriers face. Influences on airports in greater China are also analyzed in a perspective of shares among different regional routes. Changes in efficiency of Taiwanese airports, which is the research object in next Chapter, are first analyzed in this paper in the connection to Three Links agreement.

2.2 Past work on the "Kangaroo Route"

Comparing to regional cross-Taiwan Strait routes, intercontinental "Kangaroo Route" receives more attentions, from both aviation industry and academia. The great air route not only impels the economic relations between Europe and Oceania (especially United Kingdom and Australia, the two member states of commonwealth), but also culture exchanges (Hubbard *et al.*, 2014). Because this route is a representative of highly competitive and lucrative long haul routes, Whyte and Lohmann (2015) uses it as a hypothetical example in his analysis on low-cost long-haul carriers, a market where current LCCs have barely stepped into.

Renard (2004) analyzed the behaviours of the passengers along the Kangaroo Route and described the competition between British Airways(BA)/Qantas(QF) and Singapore Airlines(SQ) as a competition between two kinds of air network models: point-to-point versus hub-and-spoke. SQ, as well as other Asian carriers with their own hub being the hopping airport, enjoys hub premium over BA or SQ, whose point-to-point merit does not exist in this special route where direct flight is not possible due to technical restrictions. Yang (2015) analyzed the pricing process and revenue management strategies of carriers operating Kangaroo Route. The influence transit airports have on pricing is discussed. However, none of the literature studies passengers' choice on transit airport along this route. Chapter 4 is carried out to fill this gap.

Chapter 3

Effects of Three Links Policy on Efficiency of Taiwanese Airports

3.1 Introduction

Taiwan is a small island off the southeast coast of mainland China, facing the Pacific in the other side, consisting of a main Taiwan Island and several offshore islands. Taiwan has a natural advantage in international aeronautic transportation in the Asia-Pacific region: it is only 90 minutes away from Hong Kong and even less time to Shanghai by air. The flight time it costs from Taipei to Seoul and Tokyo are 140 minutes and 180 minutes respectively. With 3 to 4 hours one can reach Bangkok and Singapore from Taipei easily, enough for a one day business trip. In its development history there used to be a huge aviation demand which came along with the Taiwanese economic taking off during the 1970s, when more than one third of the civil aviation airports in Taiwan were built. Partly because of this convenient location between East Asia and Southeast Asia, partly as a result of a great aviation demand in its economic development history, Taiwan has quite an extraordinary high level of airport density. In Figure 3.1 we list the airport density of major countries/regions around the world.

The information of commercial airports is collected from the official websites of each country's Civil Aviation Authority or the Department of Transportation. We can see that Taiwan ranks top in these selected countries/regions.

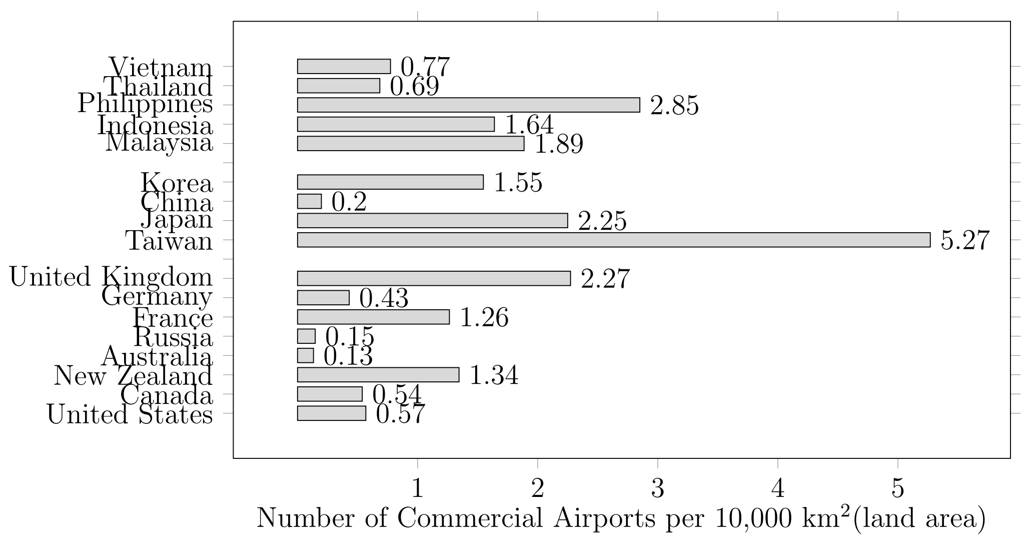


Figure 3.1: Worldwide Airport Density (as of June, 2015)

However the total aviation passenger number as well as cargo tonnage have been on the decline since the year 1997(with some exception years), along with the decelerated economic growth. The trend of Taiwanese aviation demand in these forty years is shown in Figure 3.2. This decline continues in domestic flights when THSR[1] opened for service in 2007. However, as we can see in Figure 3.2, despite the fact that the domestic aviation demand decreased rapidly after around 1996, the international aviation passengers number kept growing.

More importantly, Taiwanese airports experienced a big change last decade, when the "Three Links" agreement was signed between mainland China and Taiwan. "Three Links" stands for direct postal service, direct transportation and direct trade between mainland China and Taiwan, which put an end to the history of no traffic relations between PRC China and ROC Taiwan since the ending of the Chinese Civil War in 1949. The first chartered flight between mainland China and Taiwan

[1]Taiwan High Speed Rail. Currently runs from Taipei to Zuoying(Kaohsiung).

appeared in 2003, when the flights had to make a transit in Hong Kong or Macau, and the airplane could only make one-way flight during traditional Chinese festival periods. After the huge earthquake in Sichuan, China in May 2008, humanity chartered flights were permitted for Taiwanese relief supplies[2] and rescue teams[3] to be sent directly to the disaster area. Two months later on July 4th 2008, first weekend regular chartered cross-strait flight made its debut without stopping by Hong Kong[4], although a symbolic passing through the Hong Kong FIR(Flight Information Region) was still necessary. Finally at the end of 2008, the regular daily flights across Taiwan Strait without detouring over Hong Kong came into reality[5].

Since the implementation of the agreement the share of cross-strait flights has increased rapidly for airports in Taiwan(Figure 1.7). The effects for Chinese airports are much smaller due to a fast growing presence in other international routes as well as a huge domestic market. It would be interesting to see how the policy change by the Three Links affects the efficiency and productivity of airports from both China and Taiwan. We focus on the behavior of Taiwanese airports in this paper. From Figure 3.2 the year 2009 appears to be a watershed: the international aviation demand sped up and even the domestic aviation demand stopped decreasing and increased slightly in recent years. As a whole the total aviation demand of Taiwan finished its 10 years decreasing and returned to a strong increasing ever since. Despite of the influence of the financial crisis of 2007-2008 and the bankrupt of Lehman Brothers, which pulled

[2] "Chinese Airlines chartered cargo plane will make a direct flight to Sichuan in the afternoon to deliver relief supplies"(in Chinese). RTHK. May 15, 2008.
http://www.rthk.org.hk/rthk/news/expressnews/20080515/news_20080515_55_490111.htm

[3] "The Mainland agrees to receive 20 members of our Red Cross Society's relief team to join the relief effort — due to arrive in Chengdu by charter plane in the afternoon of the 16th" (in Chinese) The Red Cross Society of the Republic of China. May 15, 2008.
http://www.redcross.org.tw/RedCross/upload/main/00-2008hqrcyteam/970515.htm

[4] "Taipei, Beijing reach historic pacts" The China Post & agencies. June 13, 2008
http://www.chinapost.com.tw/taiwan/china-taiwan-relations/2008/06/13/160749/Taipei-Beijing.htm

[5] "Direct cross-strait links in place" The China Post. December 15, 2008
http://www.chinapost.com.tw/taiwan/china-taiwan-relations/2008/12/15/187643/p2/Direct-cross-strait.htm

down the growth rate of Taiwan's GDP to around -5%[6], along with the opening of THSR, both domestic and international passenger volume have better performance after 2009 than before. Our assumption in this paper is that the opening of direct China air route plays an important role. The efficiency difference is evaluated by the DEA efficiency scores and productivity change by Malmquist index. DEA scores measures the relative ratio of (weighted) output to input of a specific DMU(Decision Making Unit) while Malmquist index evaluates the productivity change of one DMU between two time periods. The detail will be discussed in section 3.2. We found that the overall efficiency and productivity increases after the Three Link agreement. At the same time, it is observed that the gap between efficiency of big airports like Taoyuan airport and small airports like Hengchun airports becomes bigger, according to the decomposition of Malmquist index.

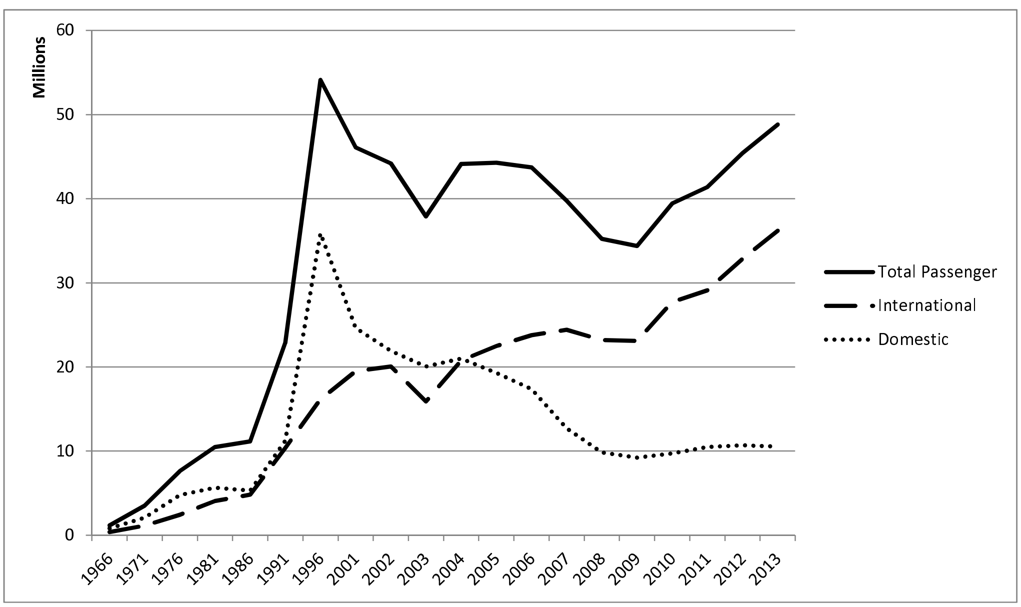


Figure 3.2: A Breakdown of Taiwan's Aviation Passenger

Data source: Traffic of Civil Aviation by Airports: http://www.caa.gov.tw

[6] "Taiwan GDP Growth Rate" http://www.tradingeconomics.com/taiwan/gdp-growth. Trading Economics

The remainder of this chapter unfolds as follows. In the next section we will introduce the development of DEA in airport benchmarking. Then in section 3.2.1, the methodology applied in this study will be introduced. In section 3.2.2 we are trying to measure (1) the efficiency of Taiwan airports; (2) the technical efficiency change (TEC) and the frontier shift (FS) of Taiwan airports over the years 2004 to 2011. Furthermore, we are going to analyze the relationship between this policy change and the efficiency (DEA score) and also productivity change (Malmquist Index) of airports. A second stage panel data regression will be adopted to check the correlation between the efficiency of Taiwanese airports and endogenous factors, especially the Three Links Agreement between China and Taiwan. The results and conclusion, as well as policy suggestions, will constitute the last section.

3.1.1 Literature review

The efficiency of airports has long been measured and evaluated in a wide variety of contexts. Among those methods DEA is one of the most widely used one. In fact, in the appendices of Liebert and Niemeier (2013)'s survey of empirical studies on the productivity and efficiency of airports , only 4 studies employ price-based index approaches, 20 papers applied parametric approaches(SFA:Stochastic frontier analysis, is the main approach), while 37 papers use non-parametric approaches. Among those non-parametric papers 30 apply DEA purely and 6 compare DEA results to those of other methods. The DEA method is chosen in many empirical studies because of its advantage in dealing with the naturally complex relation among multiple inputs and outputs of the DMUs, which is difficult to deal with other methodologies. In DEA models, there is no assumption on a functional form for the DMUs and the production process is seen as being operated in a black box. For example, when measuring Taiwan's domestic airport efficiency, Yu (2004) applied DEA with one undesirable output (airplane noise) and the population of local prefecture where the airport locates is introduced as an environmental variable. The economical cost of the airplane noise or the mechanism it affects airports' operation is not necessary in DEA, and the weight of each input/output is decided individually.

In the field of airport benchmarking there is a significant amount of studies done by various researchers. Yoshida and Fujimoto (2004) calculated both the CRS and VRS efficiency scores of Japanese airports in year 2000. In the second stage he conducted a Tobit regression to test the connection between the efficiency scores and two factors indicating the characteristics of each airport. Malmquist index analysis are conducted by Barros *et al.* (2010) on the productivity of Japanese airport over a span of nine years. Abbott and Wu (2002) analyzed both the total factor productivity (Malmquist Index) for 12 Australian airports and technical efficiency (DEA efficiency score) for Australian and international airports. Malmquist Index is decomposed into technical efficiency change and technological change, technical efficiency change is further decomposed into pure technical efficiency and scale efficiency. A second stage regression is also applied. Ha *et al.* (2013) investigated the impact of airline concentration on airport efficiency with a sencond stage tobit regression, with regard to airports in Northeast Asia.

For the efficiency of Taiwan airports, the previous studies are quite limited. Some research compared the efficiency of global airports where TPE (Taoyuan International Airport) is included as one of the research objects. For example, Oum and Yu (2004) measured and compared the Variable Factor Productivities (VFP) of 76 major airports including TPE, utilising the data from the 2003 ATRS global airport benchmarking report. VFP is chosen in this study because of the lack of information on the capital input of each airport and the distortion caused by government subsidy on airport capital expansion projects. TPE is also included in Yang (2010)'s research on 12 international airports of the Asia-Pacific area from 1998 to 2006. DEA and SFA are both used in his study and relations between the results of the two methods are discussed. Lin and Hong (2006) calculated the DEA efficiency scores for 20 airports around the world by both CCR and BCC model. Besides the undesirable output study, (Yu, 2004), Yu *et al.* (2008) applied Malmquist-Luenberger productivity index and window approach to a panel data of four domestic airports of Taiwan, for a period from 1995 to 1999. Yu (2010) also conducted a cross section research on 15 domestic airports of Taiwan in the year 2006, using a slacks-based measure network DEA (SBM-NDEA) model.

In the Taiwan airport case, we not only want to obtain efficiency scores for each airport, but also more importantly, we are eager to identify possible influence on the efficiency and productivity of Taiwanese airport by Three Link agreement. At first, we would like to distinguish the performance of Taiwanese airports before and after the specific year when a China route was opened. If we want to know how the efficiency and productivity of DMUs changes during a specific time period, the Malmquist Index is a proper indicator which is calculated based on DEA efficiency scores of each year. Two-stage Malmquist Index analyses are rarely seen in airport benchmarking. Fung *et al.* (2008) evaluated the efficiency scores and Malmquist productivity for 25 Chinese airports during year 1995-2004. In the second stage, however, they did not use a regression but only showed the ODF[7] by groups to explain the relation between airports' productivity and other factors such as the location or ownership of airports. In this paper SBM DEA and Malmquist index model are applied for all the Taiwanese airports for a time span across the signing of Three Link agreement, also a second stage regression is conducted to verify the effect on efficiency and productivity of airports by China air routes or other characteristic factors.

[7]Output Distance Functions, the terminology they adapt for the DEA efficiency score.

3.2 Data and Models

3.2.1 Data

The data of 18 airports used in this study are collected from the website of the Civil Aeronautics Administration, Republic of China[8]. The biggest Taoyuan International Airport is operated by state-owned cooperation. All the rest 17 airports are administrated under the Civil Aeronautics Administration ifself. It is a balanced panel data from year 2004 to year 2011. This is the longest time period given data availability and the fact that Hengchun Airport started its operation in the new terminal since Dec. 2003 and that Pingdong Airport finished its run in the year 2012. Considering data availability, I choose three orthodox variables each for input and output. The annual volume of passenger, cargo and taking-off and landings are output variables. Terminal area, runway area and apron areas are input variables. Labor input is not included in this study as we focus on the capital input productivity. The descriptive statistics for these input and output variables are shown in Table A.1 in the Appendix.

As we can see in this table, there is a giant gap in the inputs and outputs among these airports, while the changes along the 8 years in each airport are not so significant. If we look at the input variables in the year 2011, we can find that the terminal area of Taoyuan International Airport accounts for nearly 80% of the total terminal area of the 19 airports. Correspondingly, its apron area accounts for more than half of the total. For the runway area it is not so extreme, but still Taoyuan runway accounts for 20% of the sum. The situation, as expected , is similar in the output section, where 42%, 60%, and 94% of the taking-off and landing, passenger volume and cargo volume are delivered by Taoyuan International Airport.

Taking a deeper glance at the output data we could also find some interesting trends for different airports. For example, the passenger number of Taoyuan Inter-

[8]http://www.caa.gov.tw/big5/content/index.asp?sno=186

national Airport increases steadily until 2008, possibly due to the opening of THSR and the global recession resulted from the bankruptcy of Lehman Brothers. Both passenger volume and cargo volume recovered in 2010 though, when Taiwan economy expanded remarkably at a 23-year high of 10.8%[9]. For the second biggest Songshan Airport located within Taipei city which mainly operates domestic flights, the recovery in 2010 are not so strong as the previous one. The passenger number fluctuates around 4 million per year, no bigger than 2008 level. Kaohsiung Airport is the second biggest international airport in Taiwan, which has a decreasing passenger volume even before the crisis. However the recovery since 2010 seems to be strong comparing to other airports. Passenger volume of Taichung Airport and Kinmen Airport grows rapidly despite of the crisis in 2008, passenger volume in Magong Airport recovers immediately since 2009. The four airports in main Taiwan island, namely Tainan, Taitung, Chiayi and Hualien, are examples of a rapidly decreasing passenger volume, the recoveries are slow and seem to be difficult for them. The passenger volume trend graphs for these typical airports are listed in Figure 3.3 and Figure 3.4.

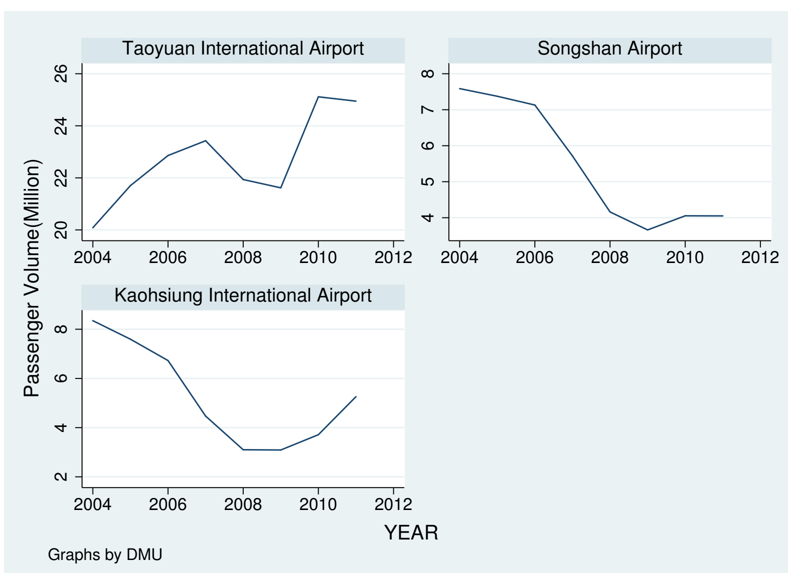


Figure 3.3: Passenger Volume Trend for the Three Biggest Airports in Taiwan

[9]National Statistics, Republic of China(Taiwan)

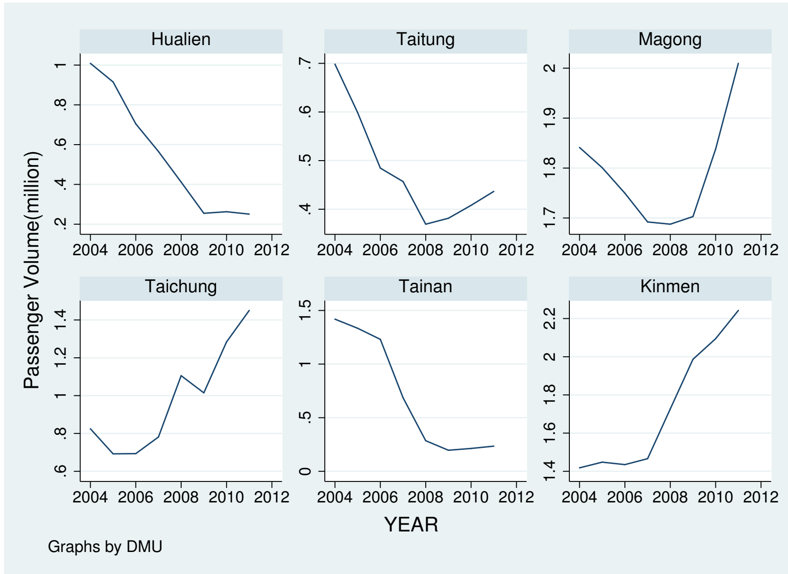


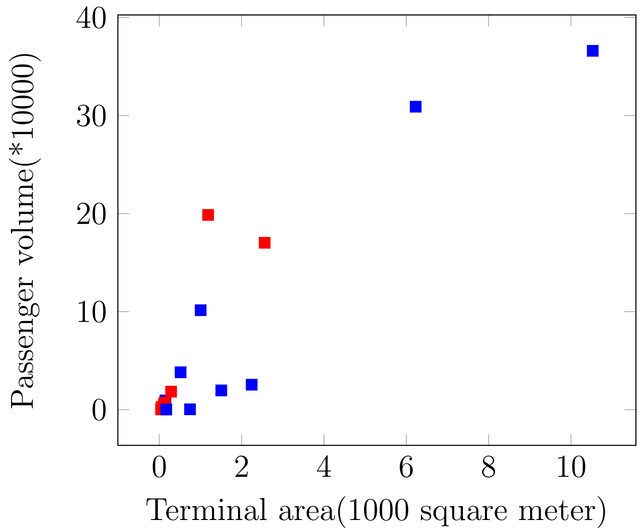
Figure 3.4: Passenger Volume Trend for some Typical Airports in Taiwan

3.2.2 Models

We assume variable return to scales, which is realistic for the airport case. Figure 3.5 shows a scatter plots for the main input and output variables in 2009 for all Taiwanese airports except for Taoyuan International Airport as a result of its large scales in both terminal area and passenger volume comparing to the rest. Offshore islands airport are marked with red squares. The scatter indicates a decreasing return to scale in this single input/output producing process. It is reasonable to assume variable return to scale for all the inputs and outputs. Furthermore, an input-oriented model is chosen because our research focus is on the necessary infrastructure of airport in accordance with demand level. In other words, aviation demand is regarded as exogenous variable here. We are trying to find out the most efficient allocation for the airport capital investment inputs, in order to give a reference to policy makers in making the right decisions.

The original input oriented model is a *radial* DEA model, where a proportional change of inputs and/or outputs is dealt with. There is another *non-radial* DEA

Figure 3.5: Terminal area/Passenger volume of Taiwanese airports in 2009



model too. According to Cooper *et al.* (2007), a *non-radial* input-oriented slacks-based model(SBM) deals better with input slacks(excesses). In the case of this paper, all the inputs for Taiwanese airports do not change in the same scale. For example, there exists a minimum requirement for the length and width of the airstrip even in an airport with small passenger volume. On the other hand, we could increase the efficiency score by adjusting the size of the terminal building accordingly with the number of terminal users more flexibly. This kind of input slack would not affect the ordinary CCR efficiency score, though. So the SBM is applied to take into account all input slacks in DEA calculation (Tone, 2011).

Suppose there are n DMUs for which the efficiency score is calculated. For each DMU there are m inputs and s outputs. For a specific year, $\mathbf{X}$ and $\mathbf{Y}$ are the input and output matrices respectively. s_i^- is the slack of input i for DMU o and $\boldsymbol{\lambda}$ is a non-negative vector $\boldsymbol{\lambda}= (\lambda_1, ..., \lambda_n)^T$. The efficiency value θ_o^t for DMU o at time t is obtained by solving the following problem:

$$\theta_o^t = \min_{\lambda, s^-} \quad (1 - \frac{1}{m} \sum_{i=1}^{m} s_i^- / x_{io}^t) \tag{3.1}$$

subject to

$$x_o^t = X^t \lambda + s^-$$

$$y_o^t \leq Y^t \lambda$$

$$e\lambda = 1$$

$$where \qquad \lambda \geq 0, s^- \geq 0$$

$$e = [1, 1, ...1]$$

As we are eager to know the historical trend of Taiwanese airports' performance and how it is affected by the China factor and other charicteristic variables, we apply Malmquist index calculation afterward for the productivity measurement, based on the efficiency score result of non-radial input-oriented SBM model above. Malmquist input index is developed into a productivity measurement by Färe, Grosskopt and Lovell(Fare *et al.*, 1994) from the original idea of Malmquist(Malmquist, 1953).

$$M_o = \left[\frac{\theta_o^t(x_o^{t+1}, y_o^{t+1})}{\theta_o^t(x_o^t, y_o^t)} \frac{\theta_o^{t+1}(x_o^{t+1}, y_o^{t+1})}{\theta_o^{t+1}(x_o^t, y_o^t)} \right]^{\frac{1}{2}} \tag{3.2}$$

Here $\theta_0^t(x_o^t, y_0^t)$ calculates the above input-oriented VRS model (3.1), comparing the production of DMU o at time t to the productivity frontier at time t. $\theta_o^t(x_o^{t+1}, y_o^{t+1})$ calculates the input-oriented VRS envelopment model, comparing the production of DMU o at time $t+1$ to the productivity frontier at time t, respectively.

Additionally Malmquist Index can be decomposed into two parts: catch-up and frontier-shift. Catch-up effect indicates the change in relative efficiency of a specific DMU from period t to period $t+1$; Frontier-shift effect indicates the change in the frontier technology around a specific DMU from period t to period $t+1$.

Table 3.1: SBM-I-V Efficiency Score

DMU	2004	2005	2006	2007	2008	2009	2010	2011
Taoyuan	1	1	1	1	1	1	1	1
Kaohsiung	0.769353	0.804921	0.763018	0.875124	1	0.753767	0.714564	0.623997
Songshan	1	1	1	1	1	1	1	1
Hualien	0.58435	0.555488	0.479275	0.385938	0.283289	0.19006	0.189618	0.182221
Taitung	0.694452	0.714841	0.697383	0.540035	0.44977	0.534609	0.539313	0.535436
Magong	1	1	1	1	1	1	1	1
Taichung	1	0.73207	0.732061	0.634835	0.610309	0.560486	0.639007	0.691158
Tainan	0.799096	0.781894	0.730039	0.447778	0.247333	0.16782	0.163063	0.170801
Chiayi	1	1	1	1	0.389674	0.425881	0.398026	0.398361
Qimei	1	1	1	1	1	1	1	1
Wang'an	1	1	1	1	1	1	1	1
Lanyu	0.819752	0.988219	1	1	1	1	1	1
Lyudao	0.653847	0.671599	0.653019	0.677558	0.682305	0.651903	0.629085	0.676846
Kinmen	1	1	1	1	1	1	1	1
Beigan	1	1	1	0.584962	0.599952	0.642481	0.649289	0.663155
Pingtung	1	0.173222	0.151087	0.135798	0.124331	0.120765	0.122052	0.122052
Nangan	0.830747	0.748032	0.639415	0.579531	0.609117	0.587884	0.533432	0.589865
Hengchun	0.344335	0.341614	0.328735	0.327072	0.326696	0.316496	0.326199	0.326159

$$M_o = CU * FS$$

$$CU = \frac{\theta^{t+1}(x_o^{t+1}, y_o^{t+1})}{\theta^t(x_o^t, y_o^t)} \tag{3.3}$$

$$FS = \sqrt{\frac{\theta^t(x_o^t, y_o^t)}{\theta^{t+1}(x_o^t, y_o^t)} \frac{\theta^t(x_o^{t+1}, y_o^{t+1})}{\theta^{t+1}(x_o^{t+1}, y_o^{t+1})}} \tag{3.4}$$

where CU stands for catch-up effect and FS stands for frontier-shift effect.

3.3 Results

We use DEA-Solver(Version 10.0) to calculate the DEA efficiency score and Malmquist index. The results are listed in section 3.3.1 to 3.3.3. The second-stage regression results and test results in section 3.3.4 are obtained via Stata.

3.3.1 Input-oriented VRS SBM

Results of input-oriented VRS model are shown in Table 3.1. Those with full efficiency are shown with white cells and dark cells indicate low efficiency.

Taoyuan, Songshan, Magong, Qimei, Wang'an and Kinmen are the 6 airports with full efficiency for the whole time period. Except for the two capital airports (Taoyuan and Songshan Airports), the rest are all off-shore island airports.

Kaohsiung, the second biggest airport enjoys a full efficiency in year 2008 but faces decreasing efficiency behave since 2009.

Hualien, Taitung, Tainan and Chiayi are the 4 airports facing a decreasing in efficiency since 2008. They are all small airports on the main Taiwan island.

3.3.2 Malmquist index

Malmquist indices in Table 3.2 we see more light area (increasing productivity) in the right hand side of year 2008 and more dark area (decreasing productivity) in the left hand side. It shows more clearly that after 2009 almost every airport in Taiwan enjoys an increase in productivity, especially Kaohsiung, Songshan, Magong and Taichung airports, which all have direct flights to China.

Among these airports a special example is Songshan Airport. Being the first airport in Taiwan and the only airport within Taipei city, Songshan Airport used to be the sky gateway into Taiwan until 1979 when Taoyuan International Airport[10] started operation as one of the "Ten Major Construction Projects" in Taiwan and at the same time replaces Songshan Airport as the only international airport of Taipei. However thanks to the "Three Link" agreement, Songshan Airport opens its international routes again to Hongqiao Airport of Shanghai in 2010. As part of Taiwanese President Ma Yin-jeou's "Golden Aviation Circle in Northeast Asia" campaign[11], the flight

[10]Named Chiang Kai-shek International Airport from 1979 until 2006.

[11]"Direct flights from Taipei's Songshan Airport to Seoul's Gimpo Airport to begin in March. Taiwan's president continues to carry out his 'golden routes' " CNN Travel 15 November 2011

services between Songshan Airport and Haneda Airport of Tokyo resumed operation in the same year. And in 2011 the flight service between Songshan Airport and Gimpo Airport of Seoul also started operation. As a result of the newly opened China routes and other northeastern Asian routes, Songshan Airport's decreasing trend due to the decreasing demand for domestic flights abated in 2009 and since 2010 Songshan Airport embraces strong increase ever since.

Table 3.2: I-V Malmquist Index

Malmquist	04=>05	05=>06	06=>07	07=>08	08=>09	09=>10	10=>11
Taoyuan	0.970455	1	1	0.89846	1.020901	1.063923	1
Kaohsiung	0.966457	0.809812	0.799871	0.698511	0.740948	1.2323	0.996388
Songshan	0.552371	0.603279	0.490991	0.466601	0.835447	1.238678	1.361529
Hualien	0.8858	0.825454	0.804369	0.799473	0.701664	1.029555	0.960294
Taitung	0.949908	0.962843	0.787122	0.872472	1.136283	1.040366	1.02285
Magong	0.950492	1.010626	0.97148	0.979018	0.902955	1.274775	1.152318
Taichung	0.690981	0.960663	0.884156	1.043512	0.885757	1.220758	1.114377
Tainan	0.896155	0.909021	0.622626	0.572991	0.716769	1.00805	1.051322
Chiayi	0.865841	0.91396	0.5734	0.391761	1.06138	0.946415	1.019584
Qimei	1.073039	1.006904	0.994883	1.008695	1.014983	0.978614	0.99857
Wang'an	1.000527	1.044849	0.994917	1.000017	1.030529	0.97055	0.998791
Lanyu	1.101359	1.110826	0.997029	0.934062	1.243842	1.144537	1.000018
Lyudao	0.975225	1.019262	1.049688	0.997696	1.020449	0.948005	1.07085
Kinmen	1.071665	0.990474	1.148917	1.292277	1.0934	1.064796	1.048295
Beigan	0.730759	0.950789	0.477362	1.036779	1.062957	1.028248	1.016207
Pingtung	0.15486	0.887884	0.891436	0.92334	0.977228	0.999884	1
Nangan	0.845858	0.867175	0.921815	1.077861	0.984109	0.920374	1.098163
Hengchun	0.988481	0.997418	0.994539	0.998913	0.997499	1.000126	0.999767
Average	0.870568	0.937291	0.855811	0.888469	0.968172	1.061664	1.050518

3.3.3 Decomposition of Malmquist Index

Figure 3.6 illustrates the Catch-up Effect, Frontier-shift Effect as well as the Malmquist index of all the airports in the specific time period. In the original Malmquist index graph it looks more like chaos where the increasing trend is not so clear, although we can still tell that more values before the year 2008-2009 is below 1 while more values afterward is above 1.

http://travel.cnn.com/seoul/visit/direct-flights-taipeis-songshan-airport-seouls-gimpo-airport-begin-march-487057

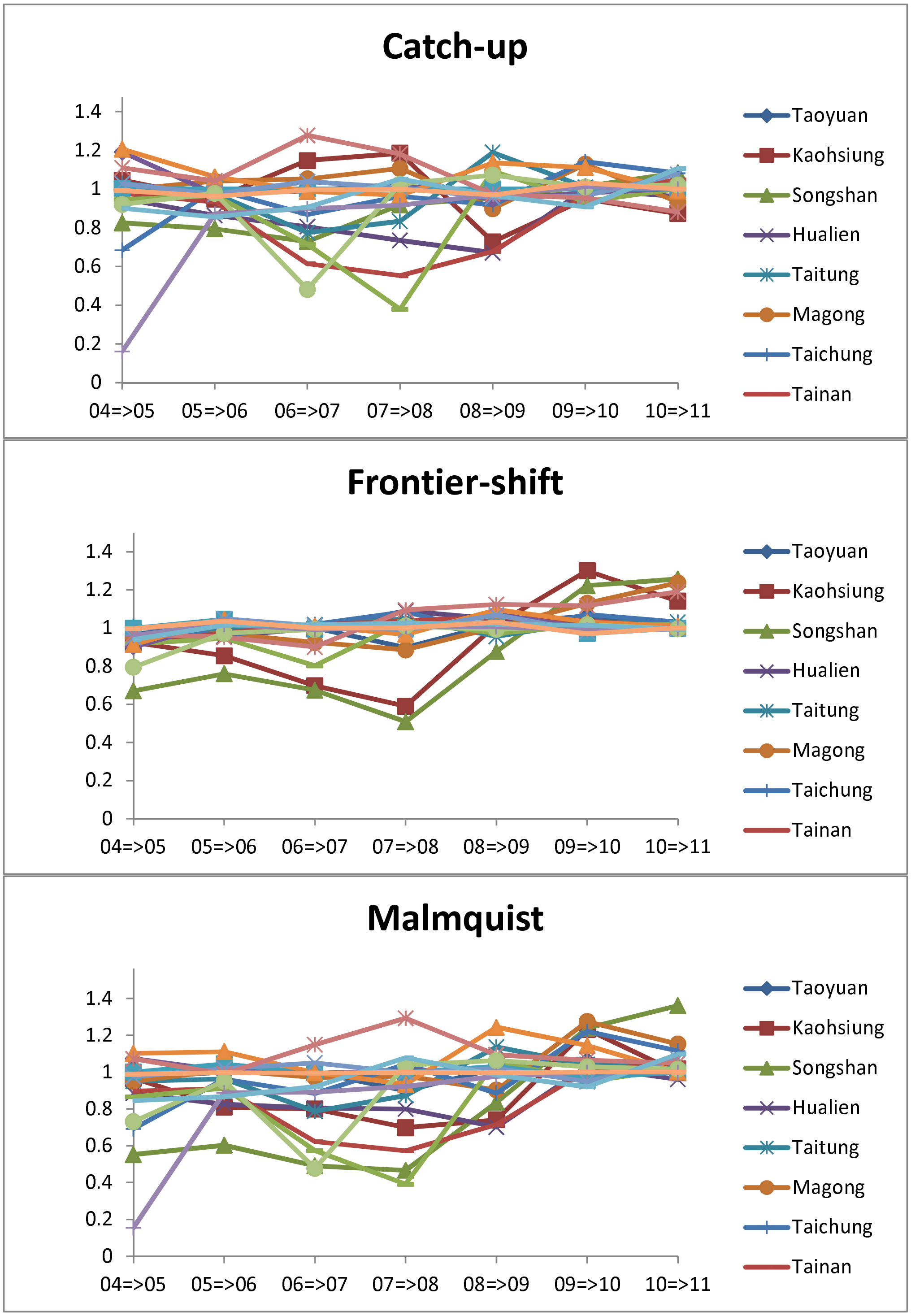


Figure 3.6: Malmquist Index, Catch-up Effect and Frontier-shift Effect

In the Frontier-shift Effect graph we could understand this radical change more clearly: almost every DMU has a Frontier-shift Effect value less than one while most of them enjoy a value above one after 2008-2009 period. By contrast, the graph of Catch-up Effect shows a different trend. The values are disperse before the year 2008-2009, where the smallest value is around 0.2 and the biggest value exceeds 1.2. After the year 2008-2009, however, the values are congregate with a distance around 0.2 between the biggest value and the smallest ones.

3.3.4 Second-stage regression

At this stage we use regression models to verify the correlation between several characteristic factors and the efficiency and productivity scores we obtained in the previous sections. At first we run the following fixed effect, random effect to test the factors affecting airports' DEA efficiency scores:

$$DEA_{it} = \mathbf{X}_{it}\beta + \alpha_i + U_{it} \tag{3.5}$$

The $\mathbf{X}_{it}$ regressors here include the following dummy variables: CN indicates whether the airport operates a direct China route or not; OFF indicates whether the airport locates on an offshore island(1) or on the main Taiwan island(0); INT shows at least one international route is connected to this airport; ML suggests whether this airport is also used by the military force. The Mega and Mini variables are used to measure the passenger size of the airport. An airport is classified as "Mega" airport if the passenger volume exceeds 10 million and "Mini" airport if its passenger volume is less than one million. In a fixed effects model OFF, ML and Mega are excluded from $\mathbf{X}_{it}$ because these variables are time-invariant. Relatively, in a random effects model we could include all these variables with the assumption that α_i is not correlated with $\mathbf{X}_{it}$.

In the Hausman and Taylor model, however, the restriction of no correlation between α_i and $\mathbf{X}_{it}$ could be relaxed without losing those time-invariant regressors. Hausman Test is applied to verified which regressor is correlated with the individual effect α_i.

$$W = [\hat{\beta}_{FE,k} - \hat{\beta}_{RE,k}]/[se(\hat{\beta}_{FE,k})^2 - se(\hat{\beta}_{RE,k})^2]^{(1/2)} \tag{3.6}$$

The test results for CN, INT and Mini variables are 0.443, -1.175 and 1.529, which all have a p value larger than 0.05. The Hausman Test for the overall model shows consistent result of a chi-squared value at 2.52 and a p value at 0.47. As a result, random effects model is preferred. We list both the results in Table 3.3, with a pooled Simar Wilson efficiency analysis model. Because of the data generating process of DEA which produces many "1"s for full efficiency units, we listed regression results in Table 3.4 for a data set without full efficiency units. The results are similar to those of Table 3.3 except for some minor modifications in the significance of Mini in the fixed effect model and sign of the coefficients of China route in the random effect model. The regression without full efficiency units appears to be more consistent referring to each other.

In Table 3.3 we find negative relationship between the DEA efficiency score and the dummy variable CN. This might be an unexpected outcome before further exploring. Table 3.5 shows us the regression result for Malmquist index. At a significance level of 5%, the dummy variable CN has positive correlation with the improving of productivity of Taiwanese airports. International route also brings positive effect to Malmquist index, with a larger coefficient and a bit higher significance. On the other side, in pooled OLS and random effect model off-shore island airports show a strong positive gap with the airports on the main Taiwan island.

From the regression result of Malmquist index, the airports with a direct China route do increase faster than their counterparts. Why is the CN variable negatively

Table 3.3: Regression Results for DEA Efficiency Scores

	(1) Pooled Simar & Wilson	(2) FE	(3) RE
CN	-0.1505**	-0.134**	0.128**
	(0.054)	(0.004)	(0.005)
OFF	0.3065***		0.302**
	(0.000)		(0.004)
INT	0.1827***	0.00988	0.0382
	(0.051)	(0.876)	(0.520)
ML	-0.0099		0.0200
	(0.046)		(0.848)
Mega			0.343
			(0.120)
Mini	-0.2891***	-0.129	-0.211**
	(0.059)	(0.134)	(0.003)
Constant	0.6593***	0.863***	0.747***
	(0.000)	(0.000)	(0.000)
Observations	126	126	126
Adjusted R^2	0.467	-0.089	
rho		0.723	0.593

p-values in parentheses
* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

related with the DEA score then? An overview of the data structure gives us a possible answer. Eight Taiwanese airports were opened from 2009 to Chinese routes. Taoyuan and Kaohsiung are permitted for regular flights while Songshan, Hualien, Taitung, Taichung, Kinmen and Magong are for chartered flights. Although capital airports Taoyuan and Songshan, along with offshore island airports Kinmen and Magong show full efficiency along this period, we should notice that smaller airports in Taiwan island like Hualien, Taitung and Taichung are also appointed to Chinese routes. Although they do show a progress in their efficiency, as we observed in the Malmquist index, their absolute values of DEA efficiency scores are lower than their counterparts. In addition Kaohsiung airport does not seem to be successful even after the agreement. As a result we see the negative sign in the regression reult of DEA efficiency score.

Table 3.4: Regression results for DEA Efficiency Scores without full efficiency DMUs

	(1) Pooled Simar & Wilson	(2) FE	(3) RE
CN	-0.141***	-0.204***	-0.197***
	(0.000)	(0.000)	(0.000)
OFF	0.304***		0.251*
	(0.000)		(0.028)
INT	0.177***	-0.000422	0.0389
	(0.000)	(0.993)	(0.387)
ML	-0.00584		-0.0209
	(0.927)		(0.843)
Mini	-0.272***	-0.222***	-0.254***
	(0.000)	(0.000)	(0.000)
Constant	0.640***	0.748***	0.705***
	(0.000)	(0.000)	(0.000)
Observations	69	69	69
Adjusted R^2	0.547	0.275	
rho		0.811	0.661

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.5: Regression results for Malmquist Index

	(1) OLS	(2) FE	(3) RE
CN	0.0994*	0.124*	0.105*
	(0.043)	(0.010)	(0.028)
OFF	0.208***		0.215***
	(0.000)		(0.000)
INT	0.106*	0.212**	0.121*
	(0.032)	(0.002)	(0.021)
ML	0.0474		0.0434
	(0.219)		(0.357)
Mega	0.0456		0.0216
	(0.562)		(0.825)
Mini	0.0516	-0.149	0.0389
	(0.257)	(0.096)	(0.444)
Constant	0.743***	0.961***	0.746***
	(0.000)	(0.000)	(0.000)
Observations	126	126	126
Adjusted R^2	0.180	0.035	
rho		0.621	0.0902

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.3.5 Regression for decomposed Malmquist indexes

Table 3.6 and table 3.7 reveal the regression results for decomposed Malmquist indexes. These results are in accordance with the intuition we got from Figure 3.6. All of the changes come from frontier-shift effect, where China route, International route, offshore location and mini size airports have a significantly positive development among all the variables listed. International route other than China has weaker influence than China route in random effect model but a slightly stronger effect in fixed effect model, while in OLS model this variable is not significant.

Table 3.6: Regression results for Catch-up Effect

	(1) OLS	(2) FE	(3) RE
CN	-0.234 (0.913)	0.0156 (0.994)	-0.190 (0.928)
OFF	-1.537 (0.389)		-1.395 (0.512)
INT	-1.617 (0.454)	0.142 (0.963)	-1.306 (0.572)
ML	1.477 (0.387)		1.488 (0.472)
Mega	1.744 (0.617)		1.503 (0.726)
Mini	1.480 (0.462)	-0.277 (0.946)	1.432 (0.523)
Constant	1.220 (0.670)	1.962 (0.515)	1.107 (0.731)
Observations	126	126	126
Adjusted R^2	-0.016	-0.190	
rho		0.166	0.0850

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.7: Regression results for Frontier-shift Effect

	(1) OLS	(2) FE	(3) RE
CN	0.0761*	0.0923**	0.0781**
	(0.012)	(0.003)	(0.009)
OFF	0.0893***		0.0914***
	(0.000)		(0.001)
INT	0.0585	0.115**	0.0623*
	(0.054)	(0.007)	(0.045)
ML	0.0564*		0.0567*
	(0.019)		(0.028)
Mega	0.0374		0.0339
	(0.441)		(0.523)
Mini	0.0988***	0.0351	0.0987***
	(0.001)	(0.539)	(0.001)
Constant	0.821***	0.912***	0.819***
	(0.000)	(0.000)	(0.000)
Observations	126	126	126
Adjusted R^2	0.111	0.001	
rho		0.416	0.0330

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.4 Conclusion and following work

According to the results of DEA efficiency scores and Malmquist index, along with the regression result for both of them, we try to shed a light on the effect of direct China routes on the efficiency of Taiwanese airports. As discussed in the previous section, China route variable is negatively related to DEA efficiency scores due to the selection process of appointed airports. It is likely that economic benefit is not the only reason to open a specific airport because in order to support Taoyuan Airport's strategic target to be a hub airport in the Asia-Pacific region the best strategy is to open none but Taoyuan International Airport. In that scenario more traffic would be attracted to the gateway airport of Taiwan and increase its destinations and frequency which help to attract transit passengers in the hub competition. On the other hand the China route variable shows positive effect on Malmquist index. After the Three Links agreement, the overall productivity of Taiwanese airports increases. Particularly for the smaller local airports with annual passengers less than one million, although with a lower efficient score, have gained significant development with regard to frontier shift effect.

How to enhance the competitiveness of Taoyuan which is already behind many other Asian airports, and how to stimulate the efficiency of small local airports which are indispensable for local residents, these are the two important topics facing Taiwan civil aviation authorities. This might as well explain the negative correlation with DEA efficiency score and positive correlation with Malmquist index for the China route variable. Local airports on the Taiwan Island are chosen as part of the destinations of cross-strait flights even if they have lower efficiency score than not only the international airports in Taipei and Kaohsiung but also the offshore islands airports. Increasing load factor of offshore flights from small local airports as well as blossoming local tourism are positive rewards for this policy design.

As the final remark we point out that traditionally Tobit regression was used due to the interval of the DEA scores being between 0 and 1. However, John McDonald argues that since DEA efficiency score is a fractional data instead of being generated by a censored process, Tobit model may not be appropriate. An ordinary least square is consistent in this situation (McDonald, 2009). Meanwhile, others argue that a fractional regression model is the best fit for analyzing DEA scores in the second stage (Ramalho *et al.*, 2010).

Additionally, Simar and Wilson (2007) argues that conditional DEA efficiency calculation followed by a second-stage regression on environmental variables would be meaningless if a "separability test" is not passed. In a recent paper Daraio *et al.* (2016) offers an implementable way of conducting such a test for the separability condition before regressing the estimated efficiency on environmental variables. I could not include result of this separability condition test in my dissertation due to time constraints. I would like to include separability test in my future study though, and perhaps a conditional efficiency estimation in the case that the condition does not hold would be applied while second-stage regression would be not appropriate.

Chapter 4

Transit airport choice for "Kangaroo route"

4.1 Introduction

The favorable economy conditions, the descending oil price, the popularizing of Low Cost Carriers(LCC) as well as the deregulation of civil aviation sector in recent years have been stimulating people's air travel demand. The increasing travel demand has reached the capacity limitation of some major airports so that passengers face the choice of different airports in multiple airport regions(MAR). Therefore many studies are conducted on people's departure airport choice in MARs. On the other hand, the transit airport of their trip, or the route he or she chooses, has not been paid enough attention to.

This paper reports on a model of transit airport choice on the "Kangaroo route": the air routes between Europe and Oceania[1]. Although direct flights has become possible in most of the city pairs among North America, Europe and Asia, this tradi-

[1] Originally Qantas named its London-Sydney route as Kangaroo Route not only because Kangaroo is the representative animal in Australia but also because multiple stops are necessary along this route.

tional route remains unreachable for current civil aircraft. While Qantas is proposing a new direct flight between London and Perth with the newest Boeing 787-9 from 2018,[2] considering the in-flight problems such as economy class syndrome that may occur during the long journey, and the market share of Perth in Australia, a one-stop flight will still be the main option in this market.

This study is based on a transaction data of air tickets connecting European cities and Oceanian cities on July, 2015, provided by Skyscanner, which includes only the records with one-stop at HKG or SIN. In this paper, we suppose that HKG and SIN are the only two options for passengers travelling in this route. This assumption can be highly arguable especially that Dubai has become a larger player in kangaroo route since Qantas moved its transit stop from Changi to Dubai (CAPA, 2013). However, from the perspective of a choice model, the existence of Dubai would barely affect people's choice between HKG and SIN, so that the independence of irrelevant alternatives (IIA) is not violated.

The next section contains a review of the literature on airport choice modelling, mostly for MARs. Most researches on airport choice are in a North American or European context, utilizing stated preference(SP) survey data, while few contribution is based on revealed preference(RP) data. The methodologies of past studies are compared in section 4.2. The following section describes the data and variables used in current study. The source of each data is also introduced. The econometrics model and the matching method is discussed in section 4.4. Estimation results and discussions are presented in the final section.

[2]Mitchell Bingemann, "Qantas in talks on network reach of Dreamliner fleet," http://www.theaustralian.com.au, (June 3, 2016).

4.2 Airport Choice: a literature review

Selected literature on airport choice is summarized in Table 4.1. As we mentioned above, literature on airport choice is mainly about airport choice within multi-airport regions (MARs). Most of them are in a North American context. Innes and Doucet (1990) discussed airport choice in the northern half of the province of New Brunswick, Canada; More papers focus on either east coast of the United States (Blackstone *et al.*, 2006) or the west coast (Hess and Polak, 2005; Ishii *et al.*, 2009), most of which utilized the 1995 Airline Passenger Survey conducted in San Francisco Bay area. Some more general models for the airport choice in the United States are constructed using SP data. (Hess, 2007; Hess *et al.*, 2007) Europe also sees the studies of airport choice in MARs like the Great London area (Hess and Polak, 2006), which is the biggest MAR in the world. Researches are also conducted in Germany (Wilken *et al.*, 2007), Campania (de Luca, 2012) and Marche and Emilia-Romagna (Marcucci and Gatta, 2011) in Italy.

Airport choice analysis is not so popular in Asia as it is in North America or Europe. With self collected survey data on passengers in Hong Kong International Airport (HKIA), Loo (2008) analyzed the airport choice in the Hong Kong-Pearl River Delta. As a mature aviation market, relatively large amount of researches are conducted on passengers' route choice in Japan. Hanaoka (2003) discussed the transit airport choice for Japanese passengers who travel from a regional domestic airport to overseas destinations. However, literature on international transit airport choice model are rarely found, to the best of our knowledge. Matsumoto and Lieshout (2016) on the other hand, analyzed the route choice problem with a focus on the effort of network development by South Korean carriers.

Although most of the past studies use SP data, RP data is more realistic in analyzing consumers' behaviour, since SP data can have "larger perception and reporting errors" (Bradley and Kroes, 1992). In this study we use RP data which captures the real transaction conducted in one of the most famous(especially in UK, European and Australian market) on-line travel search engine, skyscanner.com.

Table 4.1: Representative studies on airport choice

Area	Study	MAR	Data
North America	Innes and Doucet(1990)	New Brunswick, Canada	Travel-agency-conducted curvey
	Blackstone, Buck and Hakim(2006)	Philadelphia region	Airport-conducted survey
	Hess and Polak(2005)	San Francisco Bay area	1995 Airline Passenger Survey by MTC[3]
Europe	Hess andPolak(2006)	Great London area	1996 Passenger Survey by CAA[4]
	Luca(2012)	Campania, Italy	Self-conducted survey
	Marcucci and Gatta(2011)	Marche and Emilia-Romagna, Italy	Self-conducted survey
	Wilken, Berster and Gelhausen(2005)	Germany	2003 German Air Travel Survey
Asia	Loo(2008)	Hong Kong-Pearl River Delta area	Self-conducted survey
	Hanaoka(2003)	Japanese local prefectures	International Air Passenger Survey by MLIT[5]

[3] Metropolitan Transport Commission
[4] Civil Aviation Authority
[5] Ministry of Land, Infrastructure and Transport of Japan

Table 4.2 compares past literature's methodologies in analyzing airport choice of MARs. Popular models used in airport choice within MARs are multinomial logit (MNL) model (Marcucci and Gatta, 2011; Hess and Polak, 2006; Loo, 2008) and Cross-Nested Logit (CNL) model (Wilken *et al.*, 2007). Multinomial Probit model is used to overcome the independence of irrelevant alternatives (IIA) problem (Blackstone *et al.*, 2006). Mixed Multinomial Logit (MMNL) model helps to deal with random taste variation (Hess and Polak, 2005). Results of MNL, CNL, MMNL and Hierachical Logit (HL) model are compared by Luca (de Luca, 2012).

Table 4.2: Comparison of estimation results of past studies

Study	Model	Coefficients			
		Access time/cost	Frequency	Duration	Fare
Innes and Doucet(1990)	Binary Logist Model			-0.36019	
Blackstone, Buck and Hakim(2006)	Multinomial Probit(MNP)				
Hess and Polak(2005)	Mixed Multinomial Logit(MMNL)[6]	-1.8916	1.8333		-0.043
Hess andPolak(2006)	Multinomial Logit(MNL)	-1.283	0.5641	-2.2963	
	Nested Logit(NL)[7]	-1.1807	0.5446	-2.1002	
	Cross-Nested Logit(CNL)	-0.9863	0.2495	-1.5373	
Luca(2012)	MNL	-0.31	0.27	-0.047	-0.46
	CNL	-0.25	0.35		-0.47
	MMNL[8]	0.47	0.36		1
	Hierachical Logit(HL)	-0.13	0.54		-0.28
Marcucci and Gatta(2011)	MNL	-0.13552	0.21476		
Wilken, Berster and Gelhausen(2005)	CNL[9]	-0.02767			
Loo(2008)	MNL	-0.0177	0.0153		-0.0003
Hanaoka(2003)	MNL		0.68/0.488[10]	-0.4006	

[6] Results from different segment
[7] Nesting by airport
[8] Expectations of coefficients
[9] Results for intercontinental private travel segment
[10] Frequency for domestic/international route

4.3 Data and variables

Unlike past literature including those we listed above, we use revealed preference data instead of the traditional stated preference survey data. While survey data is generally easier to obtain than behavioral data in a realistic setting, there are several drawbacks with stated preference data. Systematic tendency might be corrected with pre-designed statistical models, but the reliability and validity of the data rely on the questionnaire design and the interviewee's individual and national bias. State dependence, a typical weakness of stated preference data, could significantly contribute to common method bias. (De Jong *et al.*, 2012) Revealed preference data, on the other hand, could eliminate such bias since participants made their choices in the real world.

We use transaction records of travelling between Europe and Oceania with one stop in HKG or SIN on July 2015 from Skyscanner.com. Detail explanation of these records are listed in Appendix B. After excluding all those with no price information, routes that only one of SIN or HKG has access to, records with children tickets, non-economy classes and routes that have more than 2 stopovers, the sample includes a total of 6673 observations for Europe-Oceania routes and 11907 observations for Oceania-Europe routes. We use only flight records in this one particular month to avoid possible seasonal variation. Figure 4.1 and Figure 4.2 show the 10 airports in Europe and 7 airports in Oceania that both SIN and HKG have direct flight to. The size of each circle represents the number of trips starting from that airport in our sample and the green sector represents the ratio of passengers choosing HKG as their transit stop. Additionally SIN has three more destinations in Europe (ATH, CPH and BCN) and Australasia (DRW, OOL and CHC) while HKG only has advantage in Pacific islands like Guam and Fiji. From the figures we can confirm that SIN is the major choice for transit in these kangaroo routes. Only around 1/4 of passengers from European airports choose HKG and the ratio is even lower for passengers from Oceanian airports.

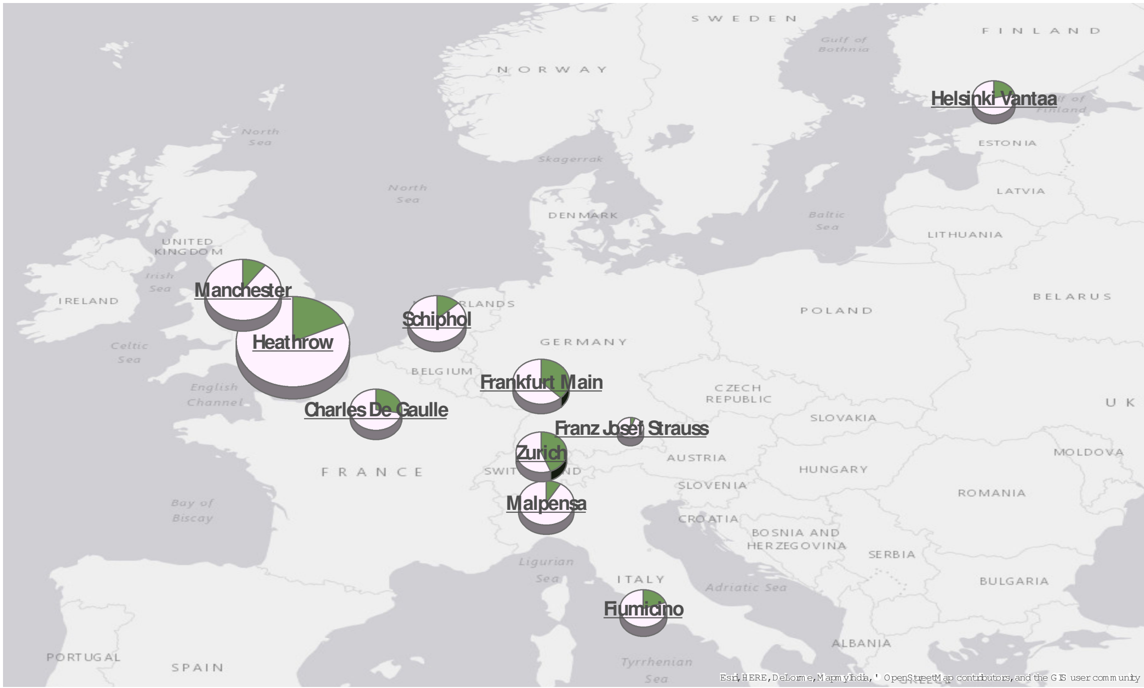


Figure 4.1: Passenger ratio between HKG(green) and SIN from Europe

Although HKG has a much smaller share in this route comparing to SIN, we may have a comprehensive understanding of the status of the two mega airports referring to Figure 4.3. This figure presents the annual passenger traffic of HKG and SIN for the period from 2009 to 2015. HKG has been handling more passengers than SIN in recent 7 years. This gap narrowed from 2009 to 2012 when SIN recorded three consecutive years of double-digit expansion. From 2013 to 2015 however, Changi witnessed a sluggish demand and a slow-down in their growth, while HKG experienced an accelerated growth in passenger traffic approaching 8% in 2013. Changes in transit traffic actually played an important part in these two airports' passenger traffic changes. In 2013, Qantas moved the stopover of its A380 "Kangaroo route" (Sydney/Melbourne-London) from Singapore, its long offshore international hub, to Dubai, which has been taking over SIN's share in this route with the rising of Gulf carrier Emirates. Another "Kangaroo route" via SIN, Sydney-Frankfurt, was discontinued in the same

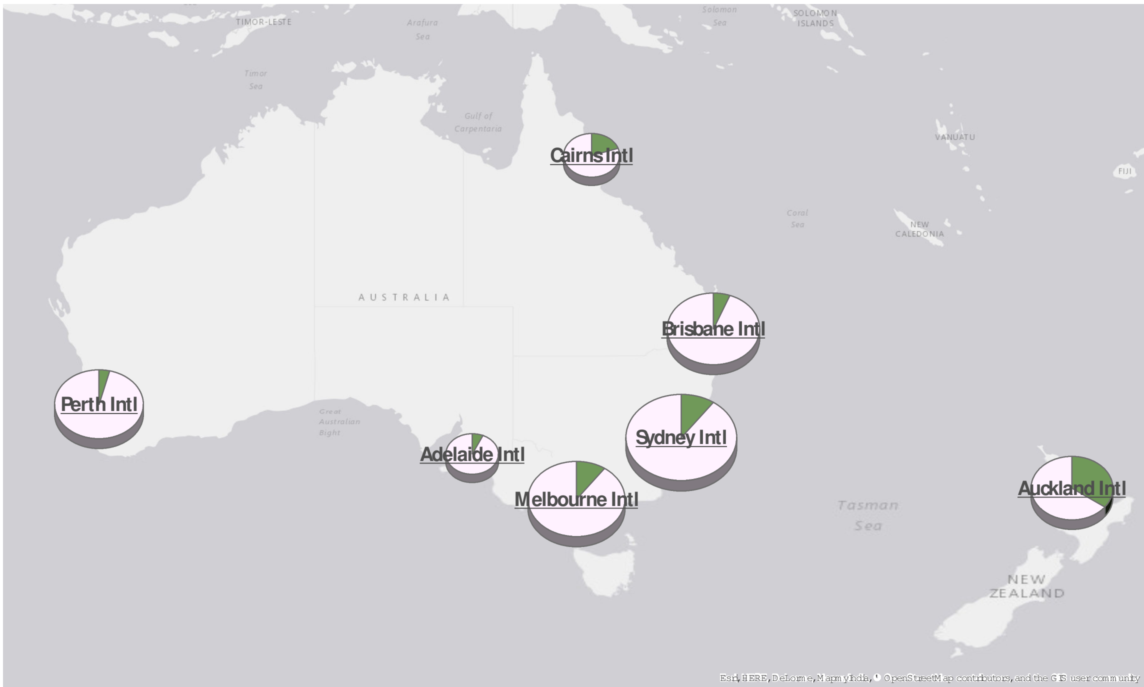


Figure 4.2: Passenger ratio between HKG(green) and SIN from Oceania

year[11]. HKG's growth in 2015, on the other hand, was driven mainly by the rapidly growing transfer/transit passenger, which amounts to approximately half of HKG's total passengers. [12].

4.3.1 Alternative specific variables

Referring to existing literature, we choose three alternative-specific attributes in this model. *Fare* is the actual amount of money paid for the tickets by the user in US dollar. *Duration* is the amount of total flight time (one-way) measured in minutes, including time spent at the transit stop. At last we collect data of the two transit airports in July 2015 from flyteam.jp, a Japanese website that keeps the historical records of timetables of worldwide airports. The data shows number of direct flights between two airports per week during July, 2015. We only count regular flights that

[11]© CAPA, "Singapore Changi traffic growth to slow as Qantas drops hub and AirAsia closes base", http://centreforaviation.com, (April 15, 2013).

[12]HKIA Media Centre, "HKIA Reports Steady Traffic Growth in First Half of 2015", https://www.hongkongairport.com/eng/media/press-releases/pr_1181.html, (July 19, 2015).

operate more than two weeks in July, 2015. The number of direct flights connecting SIN and HKG with Europe and Oceania as well as the carriers are listed in Table 4.3 and Table 4.4 below. Sum of both flights to airport of origin and airport of destination is introduced as the third attributes *frequency*. For routes with more than one stopovers in addition to SIN or HKG, for example LHR-SIN-BNE-WLG, the segment with fewer flight between SIN-BNE and BNE-WLG is counted as the frequency of flights to the airport of destination.

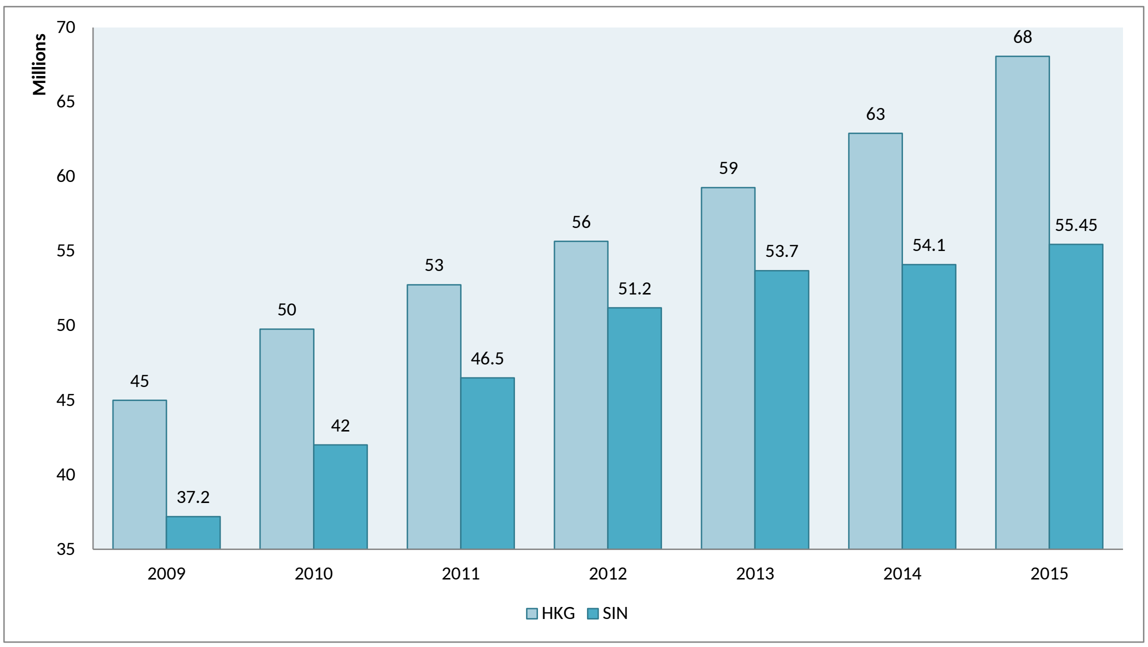


Figure 4.3: Passenger traffic for HKG and SIN since 2009

4.3.2 Case specific variables

Information available in this data set which is related to the decision maker are days-to-departure, length-of-stay[13], isota[14], platform, nationality, city, and the currency he/she uses.

With no theory or intuition that the last three categorical variables would affect passengers' transit choice, we have the first four variables as the case-specific variables

[13]For round-trip travellers only.
[14]OTA: online travel agency

Table 4.3: Regular flights connecting SIN/HKG to Europe

Airport	Airline	Singapore	Airline	HongKong
London	BA	14	Cathay	35
London	Singapore Airlines	28	BA	7
London			Virgin Atlantic	7
Manchester	Singapore Airlines	7	Cathay	4
Paris	Singapore Airlines	7	Cathay	10
Paris	Air France	10	Air France	7
Frankfurt	Singapore Airlines	14	Cathay	7
Frankfurt	Lufthansa	7	Lufthansa	7
Munich	Singapore Airlines	7	Lufthansa	7
Milano	Singapore Airlines	6	Cathay	7
Rome	Singapore Airlines	5	Cathay	7
Amsterdam	Singapore Airlines	7	Cathay	7
Amsterdam	Garuda	3	KLM	7
Amsterdam	KLM	7		
Zurich	Singapore Airlines	7	Swiss International Airlines	7
Zurich	Swiss International Airlines	7	Cathay	7
Helsinki	Fin Air	7	FinAir	9

Table 4.4: Regular flights connecting SIN/HKG to Oceania

Airport	Airline	Singapore	Airline	HongKong
Melbourne	Singapore Airlines	28	Cathay	21
Melbourne	Jetstar	5	Qantas	7
Melbourne	Qantas	7		
Melbourne	Emirates	7		
Brisbane	Singapore Airlines	21	Cathay	11
Brisbane	Emirates	7	Qantas	7
Brisbane	Qantas	7		
Perth	Singapore Airlines	28	Cathay	10
Perth	Jetstar Asia	13		
Perth	Qantas	5		
Perth	Scoot	7		
Adalaide	Singapore Airlines	7	Cathay	4
Sydney	Singapore Airlines	31	Cathay	28
Sydney	Scoot	7	Qantas	7
Sydney	Qantas	13		
Sydney	BA	7		
Cairns	Silk Air	1	Cathay	4
Auckland	Singapore Airlines	7	AirNZ	7
Auckland	Air New Zealand	7	Cathay	7

in our model. *Days-to-departure* captures how many days ahead of the trip the passenger bought the tickets. *Length-of-stay* measures how many days they spend in the destination before the return flight. *Isota* is a dummy variable with the value 1 when the transaction is done through an on-line travel agency, 0 otherwise (through the carrier's website directly for example). For platform we generate a dummy variable mobile with the value 1 when the booking is done via a mobile phone, 0 when it is done through a PC.

We consider that days-to-departure is correlated with trip type (business or leisure), passenger's preference, as well as airline companies' selling strategies. The last feature can be observed in the distribution of tickets by *Days-to-departure* of the two transit airports (See Figure 4.4 and 4.5), which are dominated by their flag carriers respectively. From the figures we can see that SIN is the leader in this market and HKG is a follower. SIN, which is dominated by Singapore Airlines (SIA), tends to sell more tickets about three months ahead to European travellers while for Oceania travellers more seats are kept within one month before the trip. HKG as a follower, which is dominated by Cathay Pacific, shows an opposite trend to SIN in selling periods for the two directions.

4.4 Estimation

4.4.1 Alternative-specific conditional logit model

We use alternative-specific conditional logit (McFadden's choice) model (McFadden, 1973) for the transit airport choice problem. Cameron and Trivedi (2005), along with Long and Freese (2006) introduced regression models for discrete nominal outcomes. Conditional logit model is widely used in the analysis of travel demand. In alternative-specific conditional logit model (ASCLM), both regressors varying across different

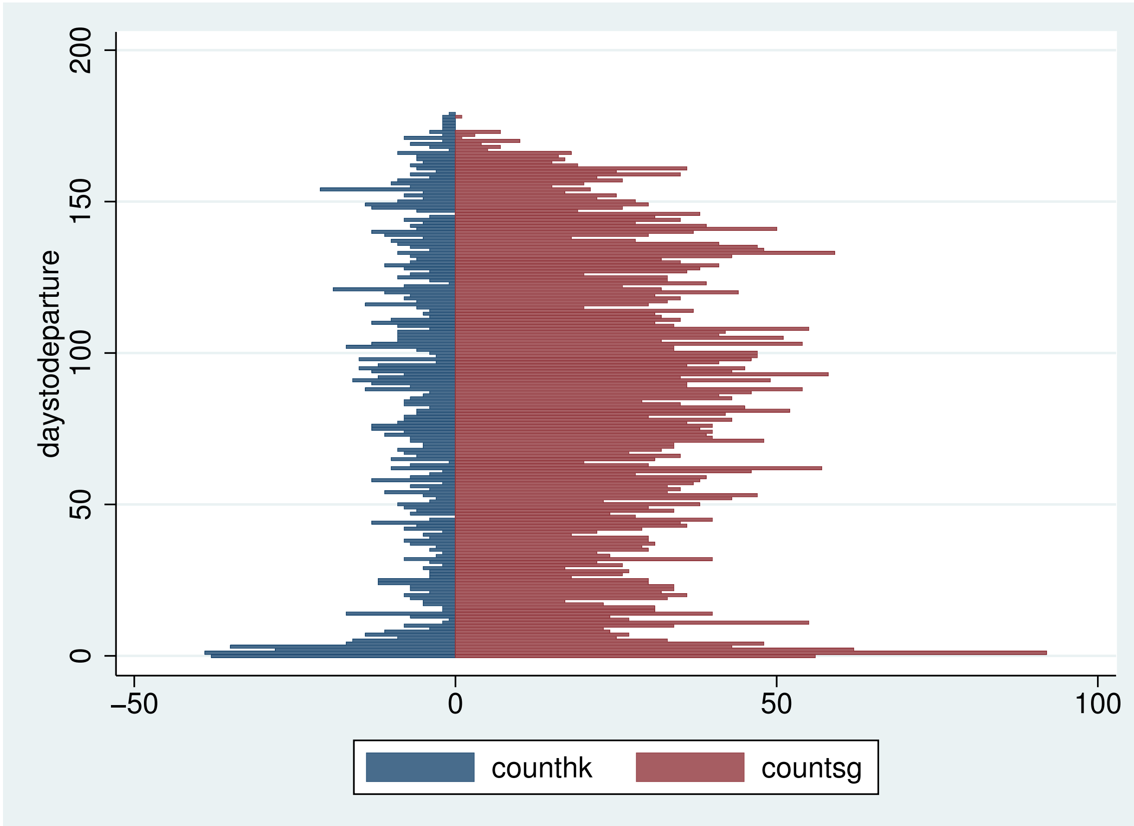


Figure 4.4: Europe-Oceania tickets by days-to-departure

alternatives and regressors varying across different cases (while being constant across alternatives) are included.

Assume that X_{im} is the alternative specific attributes of alternative $m \in J = \{\text{HKG, SIN}\}$ for individual i, while $\mathbf{z}_i$ is the case-specific variable for individual i. In ASCLM, the predicted probability of choosing alternative m out of possible choice set J is

$$\Pr(y_i = m|\mathbf{z}_i, X_i) = \frac{\mathrm{e}^{U_{im}}}{\sum_{j\in J} \mathrm{e}^{U_{ij}}} \tag{4.1}$$

where X_i is the matrix of all the alternative specific attributes for individual i. The utility from alternative m for individual i would be

$$U_{im} = X_{im}\beta + \mathbf{z}_i A_m + \sigma_{im} \tag{4.2}$$

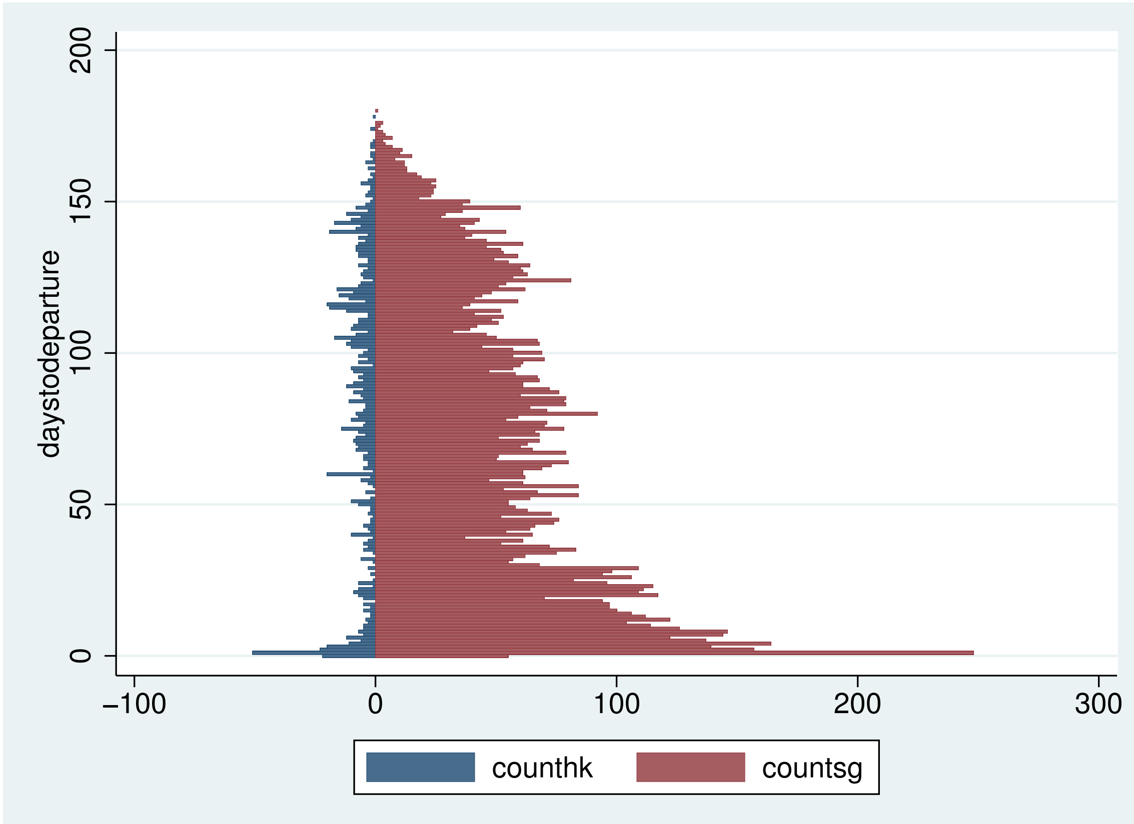


Figure 4.5: Oceania-Europe tickets by days-to-departure

where β and A_m are the coefficients to be estimated for alternative-specific variables and case-specific variables respectively.

4.4.2 A matching method for the alternative choice

One apparent drawback of using the actual transaction data, comparing to survey data, is that only information on the actual chosen route is available. In other words, we do not have the information on the alternative choice. In our case, we do not know about the available price and schedule with a stopover at Hong Kong a passenger could have chosen if his final choice is transiting at Singapore. In the RP data, only the alternative chosen is available. To generate the alternative-specific variables X_{im} that decision maker did not choose we use a simple mapping method. First we sort all the original data from newest to oldest, with regard to redirect time from Skyscanner to the ticket supplier's website. Then the first transaction data of the other airport below is employed as the alternative choice. Both the price and total flight time are included in the newly generated alternative variables.

Table 4.5 illustrates how this mapping method works. We extract decision makers labelled 1 to 8 who flew from London Heathrow to Auckland. For passenger 1 who chooses the route via HKG, we find the nearest transaction record of the same origin and destination via SIN below, which is passenger 3. We assume that the set of fare and duration of passenger 3 to be the alternative choice for passenger 1. Passenger 4's information is used as a reference for passenger 3 in a similar manner. We map the references to all the records in our sample except for the oldest one in each origin-destination pair, for which we have no choice but to use the nearest record above as the reference. In our example, we use information of passenger 7 and 8 for each other.

Table 4.5: An example of the mapping method

id	redirect time	fare	departure	arrival	duration	freq_eu	freq_oc	stop
1	2015/04/19 6:06	1170.95	20:15	10:00	1605	49	14	HKG
2	2015/04/19 6:06	1170.95	20:15	10:00	1605	49	14	HKG
3	2015/04/18 18:15	1229.95	20:40	22:20	2320	42	14	SIN
4	2015/04/18 15:23	1750.56	22:20	10:00	1480	49	14	HKG
5	2015/04/18 15:16	1750.56	22:20	10:00	1480	49	14	HKG
6	2015/04/18 14:27	986.96	13:35	22:20	2745	42	14	SIN
7	2015/04/18 14:26	986.96	13:35	22:20	2745	42	14	SIN
8	2015/04/18 8:37	791.86	12:25	12:05	2200	49	14	HKG

Since transaction before current decision maker's redirect time is used as the reference of the alternative choice, we name this mapping method *backward mapping*. *Forward mapping*, with which we use future transaction as a reference, is also conducted and we will compare the results in the next chapter.

4.5 Results

4.5.1 Estimation result using backward mapping

Table 4.6 presents the overall estimation results for the "Kangaroo route" in both direction. We list the estimation coefficients in column 1 and 3, while the odds-ratios are reported in column 2 and 4 respectively. Frequency is the most important factor affecting passengers' transit route choice between Europe and Oceania. This result is agreed by Jorge-Calderón (1997), who states that frequency is a major factor influencing passengers' demand to a hub airport. One more extra flight will increase the odds of being chosen by 1.27% for Europe-Oceania and 5.3% for Oceania-Europe. Fare has significant negative effect on transit airport choice. An extra one dollar cost would decrease the odds by 0.12% for Europe-Oceania and 0.02% for Oceania-Europe. Passengers prefer shorter duration when travelling from Europe to Oceania, while it is not significant for those travelling from Oceania to Europe.

Days-to-departure affects passengers' transit airport choice in different direction for the two routes. Comparing to purchasing the ticket within one month from departure, those bought 2 (3) months ago have a 46% (41%) higher odds choosing SIN when travelling from Europe. Passengers from Oceania have a 31% (60%) lower odds choosing SIN when booking the tickets within 3 (4) months, respectively. The difference might comes from the airline companies' selling strategies as we saw in Figure 4.4 and Figure 4.5. Passengers' route choice is somehow constrained by the available seats airline companies offer at that time. Passengers booking round-trip tickets are more likely to choose HKG. This can be explained by the fact that Cathay Pacific Airways usually offer round-trip tickets similar or even cheaper than one-way tickets.

The analyses after this comparison would focus on the routes from Europe to Oceania, since the ratio of HKG in the route from Oceania to Europe is too small to make a comparison.

Table 4.6: Regression table for routes connecting Europe and Oceania

	Europe-Oceania-raw		Europe-Oceania-or		Oceania-Europe-raw		Oceania-Europe-or	
Alternative-specific								
fare	-0.0012***	(0.000)	0.9988***	(0.000)	-0.0002**	(0.004)	0.9998**	(0.004)
duration	-0.0003***	(0.000)	0.9997***	(0.000)	0.0001	(0.240)	1.0001	(0.240)
freq	0.0126***	(0.000)	1.0127***	(0.000)	0.0516***	(0.000)	1.0530***	(0.000)
Case-specific(for SIN)								
Days-to-departure								
2.months	0.3810**	(0.004)	1.4637**	(0.004)	0.0788	(0.519)	1.0820	(0.519)
3.months	0.3407**	(0.005)	1.4059**	(0.005)	-0.3699***	(0.001)	0.6908***	(0.001)
4.months	0.1482	(0.138)	1.1598	(0.138)	-0.9068***	(0.000)	0.4038***	(0.000)
roundtrip	-0.9131***	(0.000)	0.4013***	(0.000)	-0.3492***	(0.000)	0.7053***	(0.000)
isota	-0.6855***	(0.000)	0.5038***	(0.000)	1.0545***	(0.000)	2.8705***	(0.000)
mobile	0.1337	(0.214)	1.1430	(0.214)	-0.1016	(0.309)	0.9034	(0.309)
Constant	2.2704***	(0.000)	9.6832***	(0.000)	1.3843***	(0.000)	3.9920***	(0.000)
Observations	13346		13346		23814		23814	

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.5.2 Comparison across one-way and round-trip passengers

Based on the assumption that one-way ticket holders and round-trip ticket holders have different preference in choosing their air route, we divide the sample into the two categories. Table 4.7 gives the comparison of the estimation results. Fare, duration and frequency have similar effects for both round-trip and one-way passengers in this route. The influence seems to be stronger for one-way passengers' while round-trip passengers' are more affected by case-specific variables. Trip schedule attributes (case-specific) are not significant for one-way passengers while days-to-departure and length-of-stay affect people's choice between HKG and SIN significantly.

This difference is correlated with types of passengers buying different types of tickets. Temporary visitors, usually with fixed travel dates, tend to buy round-trip tickets. They do not have so many choices in fare, duration or frequency, comparing to medium or long term visitors, and are more bound by their travel schedules. The medium to long term traveller who buy one-way tickets on the other hand are usually more flexible in travel schedule and therefore have more choice in all the alternative-specific aspects.

Table 4.7: Results for Europe-Oceania route comparing round-trip and one-way

	Roundtrip-raw		Roundtrip-or		Oneway-raw		Oneway-or	
Alternative-specific								
fare	-0.0005***	(0.000)	0.9995***	(0.000)	-0.0073***	(0.000)	0.9927***	(0.000)
duration	-0.0003***	(0.000)	0.9997***	(0.000)	-0.0005*	(0.010)	0.9995*	(0.010)
freq	0.0159***	(0.000)	1.0160***	(0.000)	0.0188**	(0.005)	1.0190**	(0.005)
Case-specific(for SIN)								
Days-to-departure								
2.months	0.4598**	(0.003)	1.5838**	(0.003)	-0.3686	(0.274)	0.6917	(0.274)
3.months	0.3466*	(0.014)	1.4142*	(0.014)	-0.0251	(0.933)	0.9752	(0.933)
4.months	0.0157	(0.893)	1.0158	(0.893)	-0.3348	(0.198)	0.7155	(0.198)
Length-of-stay								
2.months	0.0057	(0.956)	1.0057	(0.956)				
3.months	-0.3740**	(0.001)	0.6880**	(0.001)				
isota	-0.7166***	(0.000)	0.4884***	(0.000)	0.1752	(0.623)	1.1915	(0.623)
mobile	0.1449	(0.240)	1.1559	(0.240)	-0.2079	(0.464)	0.8123	(0.464)
Constant	1.4986***	(0.000)	4.4754***	(0.000)	1.2636**	(0.003)	3.5380**	(0.003)
Observations	7528		7528		5818		5818	

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.5.3 Forward mapping and closer reference

As I mentioned before, I also estimated a choice model using forward mapping references, which uses the nearest purchasing record of the other route later than the original record. It is controversial which mapping method is more close to reality: When a passenger is browsing all the available combinations of air fare and route, he or she may have seen the offer of another route which appears earlier than his or her consumption while a "future" offer may not be seem by the passenger. In this perspective, a backward mapping method is more realistic. However, a "past" offer may have been already bought by another passenger before he or she made their decision. Thus the "past" offer is actually not available to the passenger any more. In this perspective, a forward mapping method is preferred. We list results of both methods to test the robustness of our findings. The results for forward mapping method are listed in Table 4.8. For the round-trip records, the iteration turns out to be not concave so I adopt a difficult option which uses a different stepping algorithm in the non-cave region.

Surprisingly, fare has a positive effect for choice of transit airport in this model for round-trip passengers, although not significant for all the passengers. This result is in contradiction with the former one. Choice of the direction of reference does have affected the coefficients of fare. To understand this, we'd better check the feather of air fare in our data set. Usually, air fare would be cheaper if you buy the ticket earlier. In our data set, however, the air fare shows a downward trend along the time-line. It does not seem nature to us before we take a look at the historical jet fuel price. According to IATA (2016), jet fuel and crude oil price always change simultaneously. From April 2015 to July 2015, when most of the purchasing is done in our data set, the crude oil price was reduced from nearly 60 dollars per barrel to 46.83 dollars (Macrotrends, 2016). As fuel cost usually takes the biggest share in long haul flights, the decreasing oil price may explain the decreasing air fare in our data set, and thus the positive sign for the coefficient of fare, because the "unselected" reference appears later than the selected one, so it is generally cheaper.

Table 4.8: Regression table for Europe-Oceania route using forward mapping

	Roundtrip-raw		Roundtrip-or		Mix-raw		Mix-or	
Alternative-specific								
stop								
fare	0.0014***	(0.000)	1.0014***	(0.000)	-0.0000	(0.779)	1.0000	(0.779)
duration	-0.0000	(0.849)	1.0000	(0.849)	-0.0002**	(0.002)	0.9998**	(0.002)
freq	0.0149***	(0.000)	1.0150***	(0.000)	0.0128***	(0.000)	1.0129***	(0.000)
Case-specific(for SIN)								
Days-to-departure								
2.months	0.7852***	(0.000)	2.1929***	(0.000)	0.5312***	(0.000)	1.7010***	(0.000)
3.months	0.4658**	(0.001)	1.5933**	(0.001)	0.4106***	(0.000)	1.5077***	(0.000)
4.months	0.0834	(0.483)	1.0869	(0.483)	0.1927*	(0.040)	1.2125*	(0.040)
Length-of-stay								
2.months	-0.1269	(0.227)	0.8809	(0.227)				
3.months	-0.5268***	(0.000)	0.5905***	(0.000)				
isota	-0.7303***	(0.000)	0.4818***	(0.000)	-0.7056***	(0.000)	0.4938***	(0.000)
mobile	0.1329	(0.292)	1.1421	(0.292)	0.1360	(0.195)	1.1457	(0.195)
roundtrip					-1.2764***	(0.000)	0.2790***	(0.000)
Constant	1.6073***	(0.000)	4.9895***	(0.000)	2.7006***	(0.000)	14.8886***	(0.000)
Observations	7446		7446		13148		13148	

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The results of forward mapping confirms our findings about negative correlations between passengers' transit airport/route choice and flight duration, as well as the positive correlations with flight frequency. However, the relationship between air fare and transit airport choice seems to be mainly decided by the direction of our mapping references. Both backward mapping and forward mapping are one-direction mapping methods that may cause systematic bias. To mitigate this disturbance, Table 4.9 reveals the results adapting a closer mapping method. In this mapping method I choose the closest transaction record of another route, no matter it was before or after the original record, to be the reference. In this way, the setting for my mapping method becomes more realistic and the trend of oil price now does not affect our regression result since the direction of the references are now random. In fact I also tried a complete random design for the mapping direction and I found similar results as the one listed below.

Table 4.9: Closer mapping for Europe-Oceania route

	Roundtrip-raw		Roundtrip-or		Mix-raw		Mix-or	
stop								
fare	0.0001***	(0.001)	1.0001***	(0.001)	-0.0001***	(0.001)	0.9999***	(0.001)
duration	-0.0002*	(0.016)	0.9998*	(0.016)	-0.0002***	(0.000)	0.9998***	(0.000)
lnem	-0.0036	(0.947)	0.9964	(0.947)	-0.0808	(0.094)	0.9224	(0.094)
freq	0.0142***	(0.000)	1.0143***	(0.000)	0.0101***	(0.000)	1.0102***	(0.000)
SIN								
1b.months	0.0000	(.)	1.0000	(.)	0.0000	(.)	1.0000	(.)
2.months	0.7494***	(0.000)	2.1158***	(0.000)	0.6822***	(0.000)	1.9781***	(0.000)
3.months	0.5584***	(0.000)	1.7479***	(0.000)	0.5413***	(0.000)	1.7182***	(0.000)
4.months	0.2935**	(0.002)	1.3411**	(0.002)	0.3943***	(0.000)	1.4834***	(0.000)
1b.months	0.0000	(.)	1.0000	(.)				
2.months	0.0237	(0.800)	1.0240	(0.800)				
3.months	-0.1711	(0.115)	0.8428	(0.115)				
roundtrip					-1.2177***	(0.000)	0.2959***	(0.000)
isota					0.0207	(0.847)	1.0209	(0.847)
mobile					0.1219	(0.197)	1.1296	(0.197)
Constant	0.5014***	(0.000)	1.6510***	(0.000)	1.6486***	(0.000)	5.1998***	(0.000)
Observations	8414		8414		14332		14332	

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The variable *lnem* is a dummy variable suggesting a late night flight which departures or lands after 20:00 or an early morning flight which departures or lands before 9:00.

So far our sample only contains flights that only stop once at SIN or HKG. I try to include multiple stopovers records, which is of importance to take into account, given the fact that some cities in New Zealand like Wellington and Queenstown, or Australian cities like Canberra could not support a direct flight to Asia, both in a passenger demand and a runway capacity perspective. Passengers from these cities have to make at least two stopovers going to Europe (At least before Singapore Airline's "Capital Express" that offers direct flight to Canberra from September 2016).

Also for destinations with direct flight to either HKG or SIN, for example Barcelona Airport with direct flight to SIN and Fiji's Nadi International Airport with direct flight to HKG, it would be enlightening to include these observations to identify the disadvantage brought about by one more stopover. However, while applying closer reference, the variable multiple stopovers does not seem to be significant in passengers' route choice.

4.6 Summary and future work

4.6.1 Conclusion and summary

This study have adopted discrete choice model for transit airport choice analysis based on an on-line transaction data of airline tickets. It reveals the factors underlying people's choice behavior when travelling along the "Kangaroo Route", both those related to the characteristics of the routes themselves and those related to passengers' own schedule and purchasing habits. Frequency are found to be the most influential factor and then fare and duration of the flights. These results are in accordance with past researches and our expectations. With the case-specific attributes we explore the relationship between passenger's choice preference and their purchasing time and trip schedules. We hope the results would shed some light on how airline companies' selling strategy would affect their potential demand.

According to our data, HKG is still a small player in the "Kangaroo route" comparing to SIN, the traditional stopover for British Airways and Qantas, not to mention the current dominant player Dubai Airport. However, HKG is also paying an attention to this market. Hong Kong's flag carrier, Cathay Pacific has been strengthening its network in Europe. Out of 9 newly opened destination from 2010, 6 are European airports. Hong Kong Airlines, on the other hand, is focusing on the Australasia market. All the three new destinations for Hong Kong Airlines are in Australia and New Zealand[15]. With higher frequency we expect the market share of HKG in "Kangaroo routes" would increase in following years. Hopefully the results of this study would provide a reference for the airports and airlines who determine to strength their power and share in this market. SIN is also trying to regain signification in Australasian market since 2012. SIA Group (including SilkAir, TigerAir and Scoot) has increased its flights to Australian cities by over 40% by 2016[16]. In addition, SIA is planning to build a "Capital Express" connecting to Canberra and Wellington, from September 2016[16].

4.6.2 Future work to be done

One possible question for the discrete choice model is that we do not have the information on all the possible choice an agent faces. For example it is likely that someone compared the ticket price and schedule of both on-line websites (including skyscanner) and air-ticket agencies, before making up her mind, while we only have information from skyscanner.com. Fox (2007) discussed this choice-based sample problem.

[15]CAPA analysis, "Chinese airlines' long haul growth tilts the balance of power in Asia, as southeast Asia shrinks", http://centreforaviation.com/analysis, (June 10, 2016).

[16]CAPA Analysis,"Singapore Airlines Capital Express Part 1: Canberra, Wellington Airport outlook boosted by new route", http://centreforaviation.com/analysis, (January 26, 2016).

In this study we use actual transaction RP data to be more accurate on the result. However, in the transaction data we could not obtain information on passengers' personal characteristics such as income or purpose of travel, which are generally available in the survey data. These factors are conventional case-specific variables. We hope that they will be included in future studies combining both transaction data and survey data.

Chapter 5

Policy implications and conclusion

5.1 Policy implications

A new destination with tremendous potential market like China is a perfect chance for Taiwanese airports to get back on track of improving efficiency. As a smaller market, Taiwanese government faced a trade-off between the enhancement of the hub status of Taoyuan International Airport and restoration of the demand for local mainland airports when signing the direct flight agreement with China. The result turned to be that Taoyuan's hub status is to some extent sacrificed for the activating of local travel demand and economy. This is a de facto result, referring to the result we got in Chapter 3, although the slot constraint in Taoyuan Airport could also be an important reason. Cross strait flights are clearly more of a point-to-point route instead of hub-and-spoke network which Taoyuan desired in pursuing the hub status, given recent trend of increasing long haul routes by Chinese carriers.

Nonetheless, the result of the direct flight's influence on Taiwanese airports is an example of how deregulation would boost local aviation. The warming cross-strait relations stimulated Taiwanese airports' efficiency with growing mainland Chinese tourists flying to Taiwan and increasing of both destinations and frequency for Taiwanese airports. This warm relation might not last forever, though. With the Democratic Progressive Party (DPP) coming into power in 2016, the cooling down relations across the Taiwan Strait has seen a decline in both the destinations and frequency in cross-strait routes. Although a re-disconnection across the Taiwan Strait does not seem realistic, the limitation and restrictions on Chinese tour groups to Taiwan would have caused serious damage to both the aviation sector and tourism industry in the island, after years of prosperity brought by direct transportation to mainland China.

Although the case of a closed air market, even to a specific country like the China-Taiwan case, is rare in current Asia Pacific aviation market, we can still apply the results to countries like Myanmar or North Korea. The former opened up its sky as part of the liberalization after the political reform in early 2012 (CAPA, 2016). Number of foreign carriers landing at Myanmar has increased from 13 in 2012 when it opened to the world to 22 two years later(THIHA (2014)). North Korea is still against the operation of foreign airlines except for limited service from Air China. Outside of Asia, United States and Cuba signed an arrangement regarding resuming scheduled air service between the two countries, which was interrupted since 1961 due to the Cold WarBureau of Economic and Business Affairs (2016). I expect similar influence the arrangement would have on Cuba's airports.

With regard to the Kangaroo Route, the findings in Chapter 4 would possibly help both the airport authorities as well as airline companies in making their strategic decisions regarding long haul markets. The game players are among partnering British Airways and Cathay Pacific, Qantas and Emirates, and new comers including Etihad Airways and Qatar Airways in the Middle East, and China Southern Airlines and Garuda Indonesia in the Far East. It is vital for the carriers to grasp passengers' demand in specific market and how sensitive are they to changes in air fare, flight duration and frequency in the transit airport. They selling strategies are expected to be made on the basis of such information. More direct destinations in the target region and high frequency would be a major impetus in the competition. This in turn proves the necessity of the partnership mentioned in the previous paragraph.

For the airport authorities, it is conceivable that the forecast of not only point-to-point passenger but also transit/transfer passenger would be crucial in making construction plans for future capacity. Particularly for Guangzhou Baiyun Airport and Jakarta Soekarno-Hatta International Airport, who are ambitious in substituting Dubai and Singapore as the main transit hub airport in the Kangaroo Route, the result of this dissertation offers a general guideline for the legacy carriers on how to fix the schedule and price to attract current passengers of Emirates or Singapore Airlines, and thus the landing fee or possible subsidies from corresponding airports.

5.2 Conclusion and summary

Air transportation is an important sector in economic activities. It not only directly contributes to GDP and employment, generates global trade and investment, stimulates tourism, but also helps to improve people's quality of life (Air Transport Action Group, 2005). With the deepening of air transport liberalization, the emergence of LCC, and the growing demand of Chinese outbound travellers, Asia is expected to experience strong growth in civil aviation.

This dissertation keeps an eye on issues concerning the productivity and competitiveness of selected Asian airports. Chapter 3 finds an overall improved productivity for Taiwanese airports after the opening of direct flight to mainland China, with unbalanced effects on airports of different scale. While negative effect is found associated with the China route variable, the panel data proves that it has positive effect on the improvement of productivity along the corresponding period.

While the opening of Taiwan airports of different levels to China destinations distracts the benefit it may have brought about to the gateway Taoyuan International

Airport, it on the other hand helps the small local airports in Taiwan to shift their production possibility frontier upwards. Efficiency of offshore island airports also improved during the period. It turns out to be more a fair policy decision than an most efficient one.

Chapter 4 looks into passengers' travel demand along the air route connecting Europe and Oceania. A choice model is adopted to distinguish attributes affecting people's choice between HKG and SIN when choosing the transit airport. Comparing to stated preference survey data, the revealed preference on-line transaction data I used in this study lacks the alternative information that is necessary in the choice model. A backward and a forward mapping method are applied to generate reference alternative for each decision maker.

Similar effects from flight frequency, fare and flight duration are unfolded in our model as in the choice of departure airports in multi-airport regions. Flight frequency is found to have the biggest positive effect on choice of transit airport. The air fare and flight duration are found to have negative effects with backward mapping method. In forward mapping method, however, flight duration is no long significant for round-trip travelers, and air fare seems to have a positive effect. This contradiction is answered by the trend of air fare in our data set witch is influenced by a decreasing jet fuel price from April to July 2015.

I also noticed that different selling strategies would affect passengers' choice in different routes. For European passengers traveling to Oceania, early booking has a positive correlation with choice of SIN. For Oceanian passengers travelling to Europe, on the contrary, early reservations tend to go for HKG. This result could be explained by different selling strategies of Cathay Pacific and Singapore Airlines on specific market.

Appendix A

Descriptive Statistics for Chapter 3

Table A.1: Descriptive Statistics for Inputs and Outputs Variables

YEAR		Runway	Apron	Terminal	TL	Passenger	Cargo
2004	mean	114,645	129,730	46,023	28,048	2,450,917	101,286
	max	420,600	1,398,843	583,647	148,938	20,100,000	1,701,020
	min	19,435	3,070	432	186	2,040	5
	sd	98,480	329,761	136,610	42,751	5,042,799	399,768
2005	mean	114,792	131,115	52,564	26,639	2,459,321	101,044
	max	420,600	1,398,843	693,647	152,614	21,700,000	1,705,318
	min	19,435	3,070	432	156	1,622	1
	sd	98,471	329,277	162,011	41,865	5,330,858	400,826
2006	mean	114,489	136,593	52,564	25,750	2,429,171	100,531
	max	420,600	1,398,843	693,647	157,703	22,900,000	1,698,808
	min	18,009	3,070	432	194	2,422	0
	sd	98,774	333,333	162,011	41,690	5,532,507	399,284
2007	mean	116,511	136,919	51,713	23,416	2,209,580	94,928
	max	420,600	1,398,843	678,673	160,120	23,400,000	1,605,681
	min	18,055	4,300	432	198	2,503	1
	sd	98,257	333,259	158,533	40,065	5,531,961	377,392
2008	mean	116,553	142,406	72,931	19,888	1,957,575	88,181
	max	420,600	1,498,453	1,044,658	145,993	21,900,000	1,493,120
	min	18,009	4,300	432	200	2,708	0
	sd	98,217	355,491	243,988	35,248	5,125,683	350,928
2009	mean	116,488	131,856	73,363	18,648	1,910,119	80,302
	max	420,600	1,309,536	1,044,658	139,399	21,600,000	1,358,304
	min	18,009	4,300	432	168	2,036	0
	sd	98,280	313,420	243,881	33,436	5,045,354	319,204
2010	mean	115,288	131,878	74,506	20,023	2,191,971	103,774
	max	420,600	1,309,536	1,063,141	156,036	25,100,000	1,767,075
	min	18,009	4,300	432	158	2,143	0
	sd	98,170	313,411	248,200	37,240	5,862,169	415,385
2011	mean	116,465	137,345	79,967	21,397	2,299,387	96,572
	max	420,600	1,407,365	1,143,651	163,200	24,900,000	1,627,462
	min	18,009	4,300	432	156	2,293	0
	sd	98,301	335,116	267,050	39,321	5,855,174	382,342
Total	mean	115,654	134,730	62,954	22,976	2,238,505	95,827
	max	420,600	1,498,453	1,143,651	163,200	25,100,000	1,767,075
	min	18,009	3,070	432	156	1,622	0
	sd	95,935	322,451	203,851	38,252	5,294,296	372,402

Appendix B

Description for records used in Chapter 4[1]

Table B.1: Skyscanner record description

Field	Description
date	Search date
dayofmonth	Search date
weekday	Search date
outbounddate	travel date
outbounddayofmonth	travel date
outboundweekday	travel date
inbounddate	return date
inbounddayofmonth	return date
inboundweekday	return date
originairport	departure airport
origincitycode	departure city code
origincountry	departure country code
destinationairport	arrival airport (final destination)
destinationcitycode	arrival city code (final destination)
destinationcountry	arrival country code (final destination)
carriercode	marketing carrier
carriertype	low cost / full service
adults	nb of adults in the group
children	nb of children in the group

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[1]Provided by Travel Insight — Skyscanner Business.

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Field	Description
seats	sum of the 2 above + infant
daystodeparture	travel date - (”minus”) search date
dayslengthofstay	travel date - (”minus”) return date
originalcurrency	currency displayed
pricegbp	price in GBP
priceusd	price in USD
cabinclass	cabin class
platform	mobile / desktop / api
isota	is OTA? Or airline.com
usercity	City from where the search was made
usercountry	Country from where the search was made
userregion	Region (code to distinguish regions in large countries such as the US) ”subdivision” in http://www.geonames.org/countries/
pk_exitid	internal number
origdestcitycode	market
redirectdatetime	The date and time of redirecting from skyscannner to ticket-offer sites
numberofstopsout	Number of stops on the outbound
durationout	Duration of the whole leg as HH:MM (hours: minutes), adjusted by time difference
departuredatetime	Departure time of the outbound
arrivaldatetime	Arrival time at the destination of the oubound
from_out	Departure airport (outboung leg) - IATA code
to_out	Arrival airport (outboung leg) - IATA code
stop1_takeoff	Departure time from the first stop
stop1_duration	Duration of the first stop
stop1_out_to	Stop 1 arrival airport
stop1_out_from	Stop 1 departure airport
stop2_takeoff	Departure time from the 2nd stop
stop2_duration	Duration of the second stop
stop2_out_to	Stop 2 arrival airport
stop2_out_from	Stop 2 departure airport
stop3_takeoff	Departure time from the 3rd stop
stop3_duration	Duration of the third stop
stop3_out_to	Stop 3 arrival airport
stop3_out_from	Stop 3 departure airport
numberofstopsback	Number of stops on the inbound
durationback	Duration of the whole leg as HH:MM (hours: minutes), adjusted by time difference
departuredatetimeback	Departure time of the inbound
arrivaldatetimeback	Arrival time at the destination of the inbound

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Field	Description
from_in	Departure airport - IATA code
to_in	Arrival airport - IATA code
stop1_takeoff_b	Departure time from the first stop
stop1_duration_b	Duration of the first stop
stop1_in_to	Stop 1 arrival airport
stop1_in_from	Stop 1 departure airport
stop2_takeoff_b	Departure time from the 2nd stop
stop2_duration_b	Duration of the second stop
stop2_in_to	Stop 2 arrival airport
stop2_in_from	Stop 2 departure airport
stop3_takeoff_b	Departure time from the 3rd stop
stop3_duration_b	Duration of the third stop
stop3_in_to	Stop 3 arrival airport
stop3_in_from	Stop 3 departure airport

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