Valuation of Aviation Externalities:

a case study in Bangkok, Thailand

by

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ABSTRACT

Aircraft noise, for the first time in Thailand, has gained public attention as a significant environmental issue since Bangkok's Suvarnabhumi Airport opened in 2006. Residential areas around the airport are expanding rapidly while local residents are protesting about the noise from the new airport which suggests a tension between economic benefits and environmental problems at the airport.

This thesis sets out to obtain valuation of aviation externalities at Suvarnabhumi airport using the stated choice method. It is the first study to obtain and compare valuations from perspectives of the polluters (Thai air passengers) and the polluted (residents) at the same airport. Furthermore, this is the first study to obtain a valuation of local impacts from aircraft operations and from air passengers. It starts by investigating perceptions and awareness of the benefits and costs of aviation activities among Suvarnabhumi's residents and passengers using focus groups and questionnaires. It then employs the stated choice method to elicit willingness-to-pay (WTP) and willingness-to-accept (WTA) values of aviation externalities.

The results found that the perceived environmental problems at Suvarnabhumi airport are in line with the literature mainly involving aircraft noise and its effects. This study also found that the development of the airport and surrounding area, while creating business and employment opportunities, has also created traffic and flooding problems. In terms of air pollution from aircraft, residents' concerns are confined to local impacts from aircraft. Thai air passengers were found to be more concerned with engine pollution than noise. These findings were reflected in the values obtained.

Two stated choice designs were used to elicit values. The first rerouted the aircraft flight path away from residents' homes thus reducing aircraft noise and pollution in the area. This design also included travel time to place of work or to the shops. The rerouting attribute was not statistically significant. However, the travel time attribute reveals that residents were willing to accept 14.23 baht a month to have their travel time to work or shopping increased by 1%.

The second design was used to obtain and compare values between Suvarnabhumi's residents and air passengers. In this design, attributes for aircraft noise, local air pollution and carbon emissions were included. Residents' willingness to pay to reduce aircraft noise by 1% is 104.76 baht/year whereas passengers are willing to pay less, at 70.63 baht per year. Air passengers place a higher value on local air pollution than the residents. Passengers are willing to pay 97.72 baht to reduce local pollution by 1% per year, whereas

residents' willingness to pay is 45.36 baht. Lastly, passengers' WTP to offset carbon is 473.26 baht per flight, whereas residents' carbon offset coefficient is not statistically significant. The obtained values are well within the range of existing studies on aircraft noise and carbon emission valuations.

Findings from this study suggest that current mitigation measures at Suvarnabhumi airport are still inadequate. There are areas where the situation is likely to get worse given the rapid growth in aviation activities and urban development at the airport. The values from this study may be used to help form the basis of fairer and more transparent compensation system alongside an operational mitigation policy to address aviation impacts. On the passenger side, the stated willingness-to-pay to reduce the impact gives an opportunity for the Thai aviation industry to promote an environmentally friendly behaviour among the travelling public.

ACKNOWLEDGEMENTS

I consider myself an aviation enthusiast and it all began at the very first moment I stepped aboard a Thai Airways Boeing 737-400 on my first flight in 1995 when I was 10. As I sat down, I decided that this is something I love and want to know more about. Ever since then, I've spent countless days plane spotting from my house terrace and was not aware that aircraft noise and pollution were serious issues. I've studied aviation in various aspects including aviation history, management, technology but I then realised that I've never studied the environmental aspect of aviation which is an inspiration for me to pursue a research degree and write this thesis. It gives me a chance to examine the aviation industry from an entirely different angle which has been an eye-opening and a worthy experience.

The completion of this thesis is owed to a number of kind and generous minds. Firstly, I wish to thank my supervisors; Professor Abigail Bristow, Dr Lucy Budd and Dr Alberto Zanni. I thank Professor Abigail for using her unrivalled expertise in aviation noise and stated choice method to guide and supervise me throughout this research. After all, it was one of her papers on stated choice and aircraft noise that inspired this thesis. I thank Dr Lucy for using her excellent aviation expertise to provide an invaluable input on my work and also for patiently correcting my twisted English. It has been an absolute pleasure meeting and working with a true aviation expert like her. I wish to thank my third supervisor, Dr Alberto for spending time to explain technical side of stated choice method to me and for helping me with the experimental design of the SC cards. Without him, it would have been much harder, if not impossible, to finish this thesis.

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I'm most indebted to my mother Dr Duangdean Cheramakara who introduced me to the world of aviation by taking me on the first flight and have always been supportive of my aviation interest and this study. I thank my father for also always supporting my interests and occasionally go as far as acting as 'a civil aviation authority in residence' by banning me from flying certain aircraft types and airlines that he deems unsafe. I also wish to thank my brother who acts as my personal 'Minister for Information Technology' by assisting me on many trivial IT issues mostly owing to my ignorance.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Problem Statement

As the fastest mode of transportation, commercial aviation enables tourists to explore the world, business people to conduct business internationally and goods to be transported worldwide. In short, the industry is beneficial to the global economy. Thailand, as a major tourist destination and a developing economy which has seen growing numbers of foreign businesses investing in the country, is increasingly reliant on air transport (NESDB, 2013; Department of Tourism, 2013). However, in addition to its economic benefits, the aviation industry produces negative externalities to the environment and human health through engine emissions and noise as well as airport activities generating airport waste and emissions from ground handling and surface access vehicles. While recent the growth of the Thai aviation industry plays a part in contributing to the national Thai economy, these externalities should not be overlooked.

This study looks into the case of Bangkok's Suvarnabhumi airport development and its impacts on the environment. The airport is the largest in terms of traffic and passenger handled in the country and it is the 16th largest airport in the world in terms of passenger numbers (ACI, 2013). The airport was opened in 2006 and went through a rapid increase in aviation movements from 42.8 million in 2006 to 51.46 million in 2013 (DCA, 2014). The case of Suvarnabhumi airport presents a unique opportunity to study the impact particularly in the context of tensions between socio-economic benefits and environmental costs in a developing economy. The airport was built in a relatively rural area to minimise the impact from the aircraft activities where local population were mostly engaged in agricultural activities in a quiet environment. However, the airport growth, hence the ensuing environmental impact, was underestimated. Additionally, areas surrounding Suvarnabhumi airport have seen a rapid rate of urbanisation which has an impact on local resident's' livelihoods.

The airport provided potential benefits in terms of job and business opportunities, comparatively cheap housing development and good transportation links to city centre (with a direct rail-link and an expressway). This resulted in rapid increase in population in the area (The Nation, 2005). At the same time, significant changes in noise levels have caused disruption to resident's welfare and have generated strong opposition to the airport operation with several on-going protests. It was the first time Thailand had experienced protests about noise problems (Chalermpong, 2010) and put aviation's impact on the environment into the spotlight. Although aircraft noise is the main focus of protests by residents, aviation-related

activities at Suvarnabhumi airport cause other impacts as well including pollution at both the local (from increased road traffic to and from the airport and the aircraft emissions during take-off and landing) and the global level along with other social and cultural impacts on residents.

Airports of Thailand plc. (AOT), the airport operator, has been attempting to address the environmental impact by land purchase and paying compensation to those affected by noise but these schemes have been controversial as these measures were perceived by affected residents as being unfair, not transparent and inadequate and were coupled with problems with perceived corruption and delayed compensation (The Nation, 2005; Manager, 2013). One reason for the controversy is that compensation is based on an outdated noise and pollution forecast data from 2005 which was created before the airport started its operations (Team Consulting Engineering and Management, 2005). Apart from this pre-opening data on noise and local air pollution, there are no up to date information available from which to assess the environmental impact of Suvarnabhumi Airport.

The perceived unfairness along with the lack of empirical data on Suvarnabhumi's impacts opens an opportunity for this study to address the impacts by measuring them through a valuation based on the perception of those who have been impacted by the airport, namely, the residents. This includes both positive and adverse impacts. This study needs to assess the socio-economic benefits brought to the local area such as improvement in transport infrastructures, urbanisation, and better opportunities to earn income and compare them with the adverse impacts particularly from aircraft noise, local air pollution from both aircraft and traffic, and social and cultural impacts on residents' livelihoods.

Furthermore, there has yet to be a study that compares the impact of aviation's environmental externalities in monetary terms between the polluter (airline passengers) and the polluted (airport residents). It is therefore important to identify and assess the environmental impact of the Thai aviation sector and obtain a monetary valuation from the two groups. Examining environmental damage valuations from both affected residents and air transport users will enable relevant authorities to assess the views in terms of impact from the affected (residents) and polluting (air passengers) parties more accurately. Once the problems and their extent have been identified, appropriate mitigation measures and policy recommendations to address these environmental problems can be proposed.

1.2 Aims and Objectives

Aims

1) To investigate Thai air transport users and local residents' perception and awareness of commercial aviation's externalities.
2) To obtain a valuation of aviation environmental externalities in Thailand from the perspectives of air transport users and residents who are directly affected by air transport operations.
3) To use the results to compare with other airports in terms of impacts and policy to address aviation externalities.

Objectives

1) Investigate Thai air transport users' awareness of the environmental problems caused by aviation.
2) Study residents living near Bangkok's Suvarnabhumi Airport awareness and perceptions of aviation's environmental externalities.
3) Obtain a valuation of aviation externalities through residents' willingness to pay to reduce the impact from aviation activities.
4) Examine Thai air transport users' willingness-to-pay to offset the environmental damage caused by commercial aviation.
5) Assess the acceptability of offsetting charges from the viewpoint of Thai air transport users.
6) Compare the Suvarnabhumi situation with other airports in terms of problems and valuation.

1.3 Structure of Thesis

This thesis is divided into three main parts consisting of 13 chapters. This chapter has introduced the background of the research by discussing the research aims and significance of the study. The first part (Chapters 2 - 4 inclusive) reviews relevant literature relating to the background context of the problem and the state of the aviation industry in Thailand. Chapter 2 discusses the status of aviation industry in Thailand and the Thai economy. Chapter 3 examines the impact of the aviation industry and the environment in general. It also summarises the operational and economic measures that are being used to mitigate the environmental impact of aviation. Chapter 4 discusses the environmental impact at Bangkok's Suvarnabhumi Airport and the mitigation measures currently in use.

The second part (Chapters 5 – 9 inclusive) details the planning and design for this study. It begins with a review of environmental valuation methods and relevant literature focusing on aviation externalities to select the most appropriate method for this study, Stated Choice (SC). It then turns its attention to the planning and design stage of this research. Chapter 7 reports on the results from a focus group study which was used to inform the Stated Choice attribute and level designs which are then described in Chapter 8. Chapter 9 then describes the implementation process of the SC study.

The last part of this thesis presents the findings and results of the questionnaire (Chapter 10) and the Stated Choice exercise (Chapter 11). A discussion of the results is provided in Chapter 12 before the conclusions of the research are presented in the final chapter.

Pound Sterling (GBP) and Thai Baht (THB) are the main currencies used in this study. The exchange rate used was correct as of September 2013 and was £1 to 50.39 Baht (Bank of Thailand, 2013). For historical and other currency exchange rates, this study uses data provided by the World Bank (2014)

2. THAI AVIATION INDUSTRY OVERVIEW

During the past decade, the commercial aviation industry in Thailand has experienced significant change. These changes include the liberalisation of the domestic airline market which resulted in the end of Thai Airways International's (THAI) dominance in the domestic market, the introduction of Low Cost Carriers (LCCs) and the opening of Bangkok's Suvarnabhumi International Airport in 2006 as a replacement for the capacity-constrained Donmuang International Airport. The new airport is being used to promote Bangkok and Thailand as a major aviation hub for Asia. Further change is occurring to the international regulations that govern aviation, especially within the ASEAN (Association of South East Asian Nations) market.

Recently, the Thai industry has suffered from negative factors that have affected demand, including outbreaks of epidemic disease (SARS, Bird Flu, and Swine Flu), economic recessions, fuel price rises, and an on-going political crisis in Thailand which resulted in the complete closure of Bangkok's two airports from late November to early December 2008 causing chaos to the industry and economy (BBC, 2009). A subsequent protest in May 2010 resulted in rioters burning and blocking off the main business district in Bangkok and burning down commercial buildings (BBC, 2010). Subsequent sections of this chapter provide an overview of the Thai Aviation industry in terms of its trends and the factors affecting the industry both positively and negatively.

2.1 Market Liberalisation of the Thai Aviation Industry

2.1.1 Domestic Aviation Market Liberalisation

In 2001, Royal Thai Government liberalised the country's domestic aviation market by allowing airlines to compete freely. Prior to market liberalisation, only one designated airline was allowed to fly on each route (Leephungdham, 2004). This regulation prevented all forms of airline competition and passengers were left with no choice of airline operator. According to Thai Department of Civil Aviation (DCA) statistics for 1999 (DCA, 2009), THAI Airways International (hereafter THAI) was the major player in the domestic market flying from Bangkok to 17 out of 22 regional airports in the country. This left PB Air and Bangkok Airways serving three and two regional airports direct from Bangkok, respectively (Kuldilograt, 2002). PB Air was a small carrier flying regional routes and Bangkok Airways was earning income by operating flights to its own airports in Samui and Sukhothai. In 2000,

two new start-up airlines, Air Andaman and Phuket Airlines, began serving some regional routes. This was the result of THAI's decision to gradually withdraw from the domestic market and allow regional routes to be transferred to the two start-up carriers (Kongsamutr *et al*., n.d.)

Table 2.1: Thai Domestic Air Routes with Competition (August, 2013)

Route	THAI/Thai Smile	Bangkok Airways	Thai Air Asia	Nok Air	Orient Thai Airlines
Bangkok-Phuket	✓	✓	✓	✓	✓
Bangkok-Chiang Mai	✓	✓	✓	✓	✓
Bangkok-Had Yai	✓		✓	✓	✓
Bangkok-Chiang Rai	✓		✓		✓
Bangkok-Udon Thani	✓		✓	✓	
Bangkok-Surat Thani	✓		✓	✓	
Bangkok-Ubon Ratchathani	✓		✓	✓	
Bangkok-Nakhon Si Thammarat			✓	✓	
Bangkok-Trang				✓	✓
Bangkok-Samui	✓	✓			
Bangkok-Krabi	✓		✓		

Adapted from Thailand Airline Timetable (2013)

Since the liberalisation of the domestic market, passengers have up to five choices of airline on a route. Table 2.1 shows that there are two routes which are served by five airlines, one with four airlines, three routes with three airlines and four routes with two airlines, giving a total of 11 city pairs with competition. The remaining 20 city pairs are operated by a single airline (Thailand Airline Timetable, 2013). The competition is highly concentrated on high-density routes such as Bangkok to Chiang Mai, Phuket, and Had Yai which are regional commercial centres and tourist destinations. In most cases, passengers can opt to fly with either Full Service Carriers (FSC) or Low Cost Carriers (LCC) (except Bangkok-Trang and Bangkok-Nakhon Si Thammarat which are exclusively served by LCCs whereas Bangkok-Samui is exclusively served by FSCs THAI and Bangkok Airways).

Furthermore, The Thai Government changed the airline ownership law in 2004 to allow a foreign entity to hold up to 49% of a Thai airline's shares from previous limit of 30% (Kongsamutr *et al*., n.d.). This led to the launch of Thai Air Asia, the Thai subsidiary of Malaysia's LCC Air Asia in which Thai investors hold 51% of shares and the remaining 49% is held by Air Asia Malaysia (Thai Air Asia, n.d.). The relaxation of the foreign ownership restriction could see more air carriers enter the market in the future.

2.1.2 Liberalisation of the International Aviation Market

In the international aviation market, the Thai Government plays its part by negotiating air traffic agreements with other countries. As of 2007, Thailand had air service agreement with 98 countries, 90% of which are capacity predetermined agreements where the two governments agree upon a predetermined number of seats and/or flight frequencies per week (DCA, 2007).

As a member of ASEAN (the Association of South East Asian Nations economic cooperation group), Thailand uses its membership to expand its aviation market. In 2002, ASEAN members ratified the "ASEAN memorandum of understanding on air freight agreement" (DCA, 2007) which is an open skies agreement for the air cargo sector within ASEAN that allows free movement of air freight traffic of less than 100 tonnes a week. This is a part of progressive liberalisation of the ASEAN aviation market which aims for a total liberalisation in 2015. Until then, ASEAN members are encouraged to engage in bilateral or multilateral liberalisation agreements. Thailand has since entered into liberalisation agreements with Singapore and Brunei (DCA, 2007). Once the full ASEAN liberalisation comes into effect, Thailand and ASEAN member states could anticipate further growth and competition in the aviation sector within the region.

2.2 Air Traffic Statistics

Table 2.2: Thailand's Air Traffic Statistics (Domestic and International)

Year	Passengers	Cargo (Tonnes)	Aircraft Movements
1998	33,055,833	Not available	320,596
1999	34,656,209	Not available	343,275
2000	37,948,719	933,613	278,472
2001	39,108,367	907,421	283,980
2002	41,349,559	1,019,003	297,024
2003	38,475,771	1,009,097	293,652
2004	49,795,440	1,123,633	366,570
2005	49,526,984	1,195,122	388,914
2006	54,736,770	1,233,741	413,293
2007	59,790,818	1,291,439	457,547
2008	57,898,932	1,253,424	427,519
2009	57,570,010	1,115,096	395,692
2010	62,260,970	1,391,938	433965
2011	71,462,504	1,405,803	494,091
2012	82,544,477	1,438,355	571,427

Source: DCA (2012), Airports of Thailand (2013)

Table 2.2 illustrates three indicators that measure the growth of the Thai aviation industry. The number of air passengers has increased from 33 million in 1998 to 82.5 million in 2012 or an increase of 149.71% during the period. Since 1998, the industry has reported a decline in passengers in 3 periods. In 2003, passenger numbers were reduced by 2.8 million from the previous year, owing in part to the effects of the SARS outbreak (World Health Organisation, 2003) that caused international travel demand to decline. A small decline of 0.5% was reported in 2005. Another decline was experienced in 2008 when there were 1.9 million fewer people travelling by air compared to the previous year. This was a result of on-going political problems and mass demonstrations leading to the closure of Bangkok's Airports coupled with the global economic recession that worsens the situation (Airports of Thailand, 2012). The year 2004 saw the strongest growth of 29.4% which was the year that three Thai low cost airlines began their operations (Kongsamutr, *et al*., n.d.). Recent growth in 2012 was also very strong with the number of passengers increasing by 15.51% in comparison with the previous year.

Air traffic movements in Thailand show a different pattern to those of air passenger numbers and cargo growth. In 1998, the DCA reported 320,596 aircraft movements whereas the latest figures from 2012 show 571,427 aircraft movements, an increase of 78.24% from 1998. From 2000 to 2003, aircraft movements fell below 300,000 as THAI withdrew from regional domestic services and progressively transferred traffic rights to Air Andaman, PB Air and Phuket Air. From 2003 onwards, aircraft movements have been on an increasing trend and rose to the highest recorded in 2012 with 571,427 movements. Air cargo also experienced steady growth of 54.63% during the period from 933,613 tonnes to 1,438,355 tonnes.

2.3 Bangkok and Thai Aviation Industry

As the capital and the most-populous city in Thailand with an official population of 8.8 million (Department of Provincial Administration, 2009), Bangkok has a significant share in country's aviation activities. All Thai airlines, except Kanair, base aircraft at either Suvarnabhumi or Donmuang Airport. The former is the main hub airport opened in 2006 as a replacement for Donmuang. The airport serves all international flights and most domestic flights whereas Donmuang is served by three domestic airlines; Nokair, Orient Thai and Thai Air Asia. International flights to and from Donmuang were resumed in 2012 by Thai Air Asia (Airports of Thailand, 2012).

Table 2.3: Bangkok Airports Traffic Statistics

Year		Passengers	Cargo (Tonnes)
Donmuang Airport	2000	29,616,432	867,942
	2001	30,623,366	841,150
	2002	32,182,980	956,790
	2003	30,175,379	950,136
	2004	37,960,169	1,058,145
	2005	38,985,043	1,140,836
Two Airports	2006*	42,800,437	1,181,889
Suvarnabhumi Airport	2007	46,015,321	1,232,473
	2008	43,646,725	1,195,666
	2009	40,500,224	1,045,194
	2010	42,783,967	1,310,146
	2011	47,910,904	1,321,853
	2012	53,002328	1,427,577
	2013	51,463,151	1,279,531

* The figures for 2006 are from the two airports as Suvarnabhumi began operation later in that year.

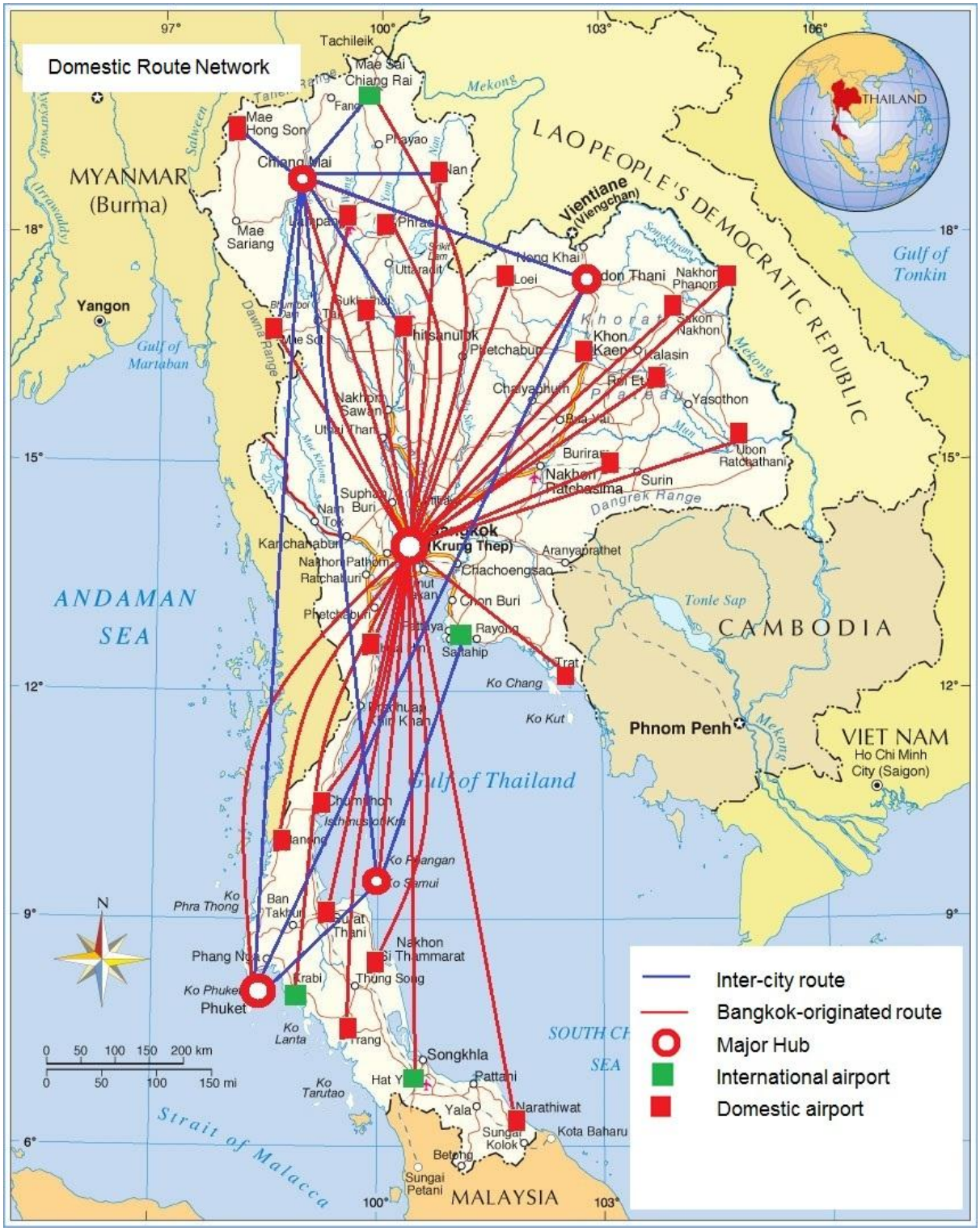
Source: Adapted from Airport Council International (2013), Airports of Thailand (2014)

Table 2.3 shows the passenger and cargo statistics at Bangkok's Suvarnabhumi and Donmuang airports. The growth pattern is similar to that of the country overall. Ranking data from Airport Council International (ACI, 2013) shows that Bangkok's Suvarnabhumi airport is the 16th and 19th largest airport in the world for passengers and cargo respectively. In 2000, the equivalent scores were 26th and 23rd largest airport. This illustrates Bangkok's relative growth. In terms of regional presence, Suvarnabhumi is the 5th largest passenger handling airport in Asia in 2011 (ACI, 2013) after Beijing (78.68 million), Tokyo Haneda (62.58 million), Hong Kong (53.33 million) and Jakarta (52.53 million). For air freight tonnage, Bangkok is in seventh place in Asia after Hong Kong (3.6 million tonnes), Shanghai (2.6 million tonnes), Inchoen (2.4 million tonnes), Singapore (1.9 million tonnes), Taipei (1.5 million tonnes), and Beijing (1.4 million tonnes).

On the national level, Bangkok is the most important hub in the country and has by far the largest share of aviation activities. DCA statistics (2013) shows that air passenger and aircraft movements are similar in terms of traffic share whereby air passengers using Bangkok's airports account for 73% of total airline passengers and 69% of all air traffic movements in Thailand. Air cargo is an area where Bangkok is even more dominant - 96%

of the country's air cargo is processed in Bangkok leaving only 4% being processed at other Thai airports.

Figure 2.1: Domestic Route System



Adapted from: Phukettravelling.com (2014)

Figure 2.1 shows the domestic route network of the winter schedule 2013. Bangkok has the largest number of routes in the country. There are four others hubs in the country which are Chiang Mai in the north, Udon Thani in the northeast and Phuket and Samui in the South. Traffic. Most of the domestic traffic originated or arrived in the capital. Table 2.4 shows the traffic statistics reported by Airports of Thailand (2014) which suggests that most of the aviation activities are concentrated in Bangkok's two main airports (68 million passengers in comparison with only 11 million passengers in Phuket which is the second largest traffic outside Bangkok). Bangkok remains an important point for people from all parts of the country to connect the international flights.

Table 2.4: List of Major Airports in Thailand (2013 statistics)

	Location	Passengers	Cargo (Tonnes)	Movements
Suvarnabhumi	Bangkok	51,463,151	1,279,531	297,616
Donmuang	Bangkok	16,479,227	18,363	144,108
Phuket	South	11,342,491	34,622	72,589
Chiang Mai	North	5,563,921	18,293	43,366
Hat Yai	South	2,552,411	13,626	17,551
Udon Thani	Northeast	1,325,523	2,827	11,375

Source: Airports of Thailand 2014

2.4 Air Carrier Operators

2.4.1 Full Service Carriers (FSC)

As of September 2013, there were 10 Thai airlines operating. THAI is the largest operator with a fleet of 96 aircraft. THAI is a member of the Star Alliance global airline network. The airline operates 61 international and 12 domestic routes (Thailand Airline Timetable, 2013). The company is a state enterprise with the Thai Government holding 51% of shares through the Ministry of Finance. The remaining 49% of shares are held by various investors with shares traded on the Stock Exchange of Thailand (THAI, 2012). During 2012, the airline carried 18.7 million passengers and its revenue composition indicates that 86.2% of revenues are from international operations and 12.4% come from domestic operations (THAI, 2012)

Bangkok Airways is the second largest FSC with a fleet of 18 aircraft. A unique feature of the airline is that it built and owns three airports in the country; Samui, Sukhothai, and Trat. It serves eight domestic routes and eight international routes (Bangkok Airways, 2013).

2.4.2 Regional Airlines

Nokmini and Kanair are two regional carriers flying low-density domestic routes. All regional routes are operated without competition (see Table 2.1). Kanair is a regional operator operating out of Chiang Mai in Northern Thailand with Cessna Caravans. Nokmini is originally an air taxi operator which later offers scheduled services. It has marketing alliance agreement with Nok Air whereby passengers can book tickets from Nok Air and travel with Nokmini. The airline currently operates various regional routes out of Donmuang with a fleet of Saab 340s and ATR-72s in conjunction with Nok Air (Thailand Airline Timetable, 2013).

2.4.3 Low Cost Carriers (LCCs)

Since market liberalisation, Thailand's aviation market has been opened to competition. The regulatory reform allows new airlines to start operations and compete for passengers. Consequently, three LCCs were established in the country. All three are subsidiaries of other airlines.

Thai Air Asia commenced operations in February 2004 and is the largest LCC in Thailand. It has a fleet of 19 aircraft and flies to 11 domestic and 15 international destinations. The airline is a subsidiary of Malaysia's Air Asia. The carrier has a total of 40 Airbus A320s on order which implies a major expansion plan in the near term (Thai Air Asia, n.d.). The second largest LCC is Nok Air, a subsidiary of THAI which holds 39% of Nok Air's shares. The airline started operations in July 2004 and currently operates a fleet of seven Boeing 737-400s and two ATR72-200s for domestic services on 12 routes (Nok Air, 2010). Orient Thai is the third LCC. It began operations in 2003 and now has a fleet of six Boeing 737s.

2.4.4 Other Airlines

Orient Thai Airlines is a charter airline and the owner of One-Two-Go. The airline earns revenue from charter operations with a fleet of four 747 Classic aircraft. It also operates a low cost division introduced in section 2.4.3. The second charter airline is Business Air which operates a fleet of three Boeing 767s carrying tourists between Thailand and South Korea. The airline started its operations in November 2009 (Business Air, 2010). The last carrier is K-mile Air which is the only cargo airline operating in Thailand. DCA (2009) reports that the

airline has two Boeing 727s with flights to Hong Kong and Malaysia. The airline is a subsidiary of Transmile Air Cargo of Malaysia.

2.4.4 Foreign Airline Operators

During the winter 2012/2013 schedule, there were 94 foreign airlines operating to Thailand. Eleven airlines were operating exclusive cargo flights, nine others were operating both passenger and cargo flights. The remaining 74 airlines operated passenger flights only, nine of which were low cost carriers. The largest foreign passenger operator in terms of traffic movements to/from Thailand is Air Asia with 134 movements per week followed by China Airlines, Malaysia Airlines and Singapore Airlines with 90, 84 and 82 movements per week respectively. Japan Airlines and Cargolux were the largest cargo operators, each operating 16 movements a week (DCA, 2012). In terms of its global network, Thailand is served by 21 airlines from Europe, 15 from Africa and the Middle East, 4 from North America and 54 from Asia.

2.5 Recent Developments and Issues in Thai Aviation Industry

2.5.1 Low Cost Carriers

Table 2.5: Bangkok-Phuket Air Fare

Airline	Price (baht)	Free Flight change	Seat Allocation	Free Baggage Allowance	In-flight Meals	Frequent Flyer Points
THAI	3,015	✓	✓	20kg	✓	✓
Bangkok Airways	1,990	✓	✓	20kg	✓	✓
Thai Air Asia	1,693	X	X	X	X	X
Nok Air	1,999	X	✓	15kg	X	✓
Orient Thai	1,450	X	✓	20kg	✓	X

* Fare for 16 SEP 2013 (Checked on 2 SEP 2013) inclusive of all taxes and surcharges

Since domestic airline competition has been allowed, Thailand has seen the introduction of three LCCs which have changed the nature of Thai aviation market. The most prominent example is the high concentration of operators on high-density routes such as Chiang Mai, Had Yai and Phuket. However, the market presence of LCCs in smaller markets is limited

and the DCA has issued regulations requiring airlines to fly to at least one regional airport (Kongsamutr *et al*., n.d.). LCCs give air transport users more choice of airlines, frequencies, and price on the more popular routes. The introduction of LCCs in Thailand during 2003-2004 resulted in a marked increase in air passenger traffic and air traffic movements. In 2004, passenger numbers grew by 11.32 million or 29.4% and air traffic movements increased by 25%. It also resulted in the change of air fare structure in Thailand whereby THAI and Bangkok Airways introduced a new fare structure instead of having one fare per route (THAI, 2009). Table 2.5 shows the difference in online fares (assessed on 2nd September 2013) charged for a one-way flight from Bangkok to Phuket travelling on the morning of 16th September 2013.

International LCCs also play a role in Thailand with a total of nine operators. Although the number of LCCs represents a small proportion of overall flights, Air Asia of Malaysia is the largest foreign operator in Thailand.

2.5.2 Suvarnabhumi Airport Capacity Problem

The airport opened in September 2006, initially as a replacement for Donmuang Airport. The Thai government has a policy to make the airport a major aviation hub of Asia with an aim to promote tourism and exports to international markets (Airports of Thailand, 2012). The government hopes to use the airport and more relaxed aviation market regulation to promote its hub status. Nevertheless, the airport itself has suffered from passenger congestion. Though the airport was designed to handle 45 million passengers annually, in 2007, when the airport handled 39.5 million passengers, the airport was already experiencing passenger congestion. In March 2007, Donmuang Airport had to be reopened for domestic scheduled flights to relieve some of the congestion at Suvarnabhumi. As a result, Nok Air, One-Two-Go and some of THAI's domestic flights moved back to Donmuang (Airport of Thailand, 2009). The implication is that the newly built airport is unable to sustain aviation industry growth. The Airports of Thailand annual report (2013) states that the second phase of expansion is in progress with the construction of the second terminal and two additional runways that will allow airport to accommodate 60 million passengers per annum. The expansion was initially scheduled to be completed in 2014 with a budget of 77.9 billion baht but it has yet to start as of March 2014. In 2013, DCA (2014) statistics shows 51.4 million passengers which exceeds the design capacity by 6.4 million and demonstrated that the expansion is imperative. In fact, the airport has been continuously exceeding its designed capacity since 2011 when it handled 47 million passengers.

There have been attempts to relieve the traffic by allowing international flights to use Donmuang airport since 2012 which results in Thai Air Asia moving its operations to Donmuang. Nevertheless, traffic growth quickly replaced the void left by Thai Air Asia and the airport was still handling 6.4 million passengers over capacity.

2.6 External Factors Affecting Thai Aviation Industry

2.6.1 Political Instability

On-going political problems in Thailand have had a direct impact on the aviation industry. The problem started from a military coup d'état in 2006 that led to a power struggle between two political groups; the supporters of the ousted Prime Minister Thaksin Shinnawatra led by the National United Front of Democracy Against Dictatorship (UDD) and the royalist supporters led by People's Alliance for Democracy (PAD). The political crisis had a negative impact on both business and tourism in Thailand and it caused a fall in demand for air transport in Thailand. One major political event which had a direct impact on the aviation industry was when PAD protestors blocked the entrance to Donmuang and Suvarnabhumi causing both airports to be closed from 25th November to 5th December 2008 (Airports of Thailand, 2009). The situation worsened again in April 2009 during the Thai New Year holiday when violence broke out among UDD protestors resulting in riots in Bangkok (BBC, 2009). In 2010, the on-going political conflict resulted in city-wide rioting and clashes between the army and the UDD protesters. On 19 May 2010, UDD protestors burnt down major department stores, the stock exchange, a TV station, and a number of other buildings in Bangkok. A state of emergency was declared and several countries warned its citizens against visiting Thailand (BBC, 2010). Political instability severely damaged the tourism industry which translates into lower demand for air transport. However, the situation has since improved and tourists have been returning to Thailand.

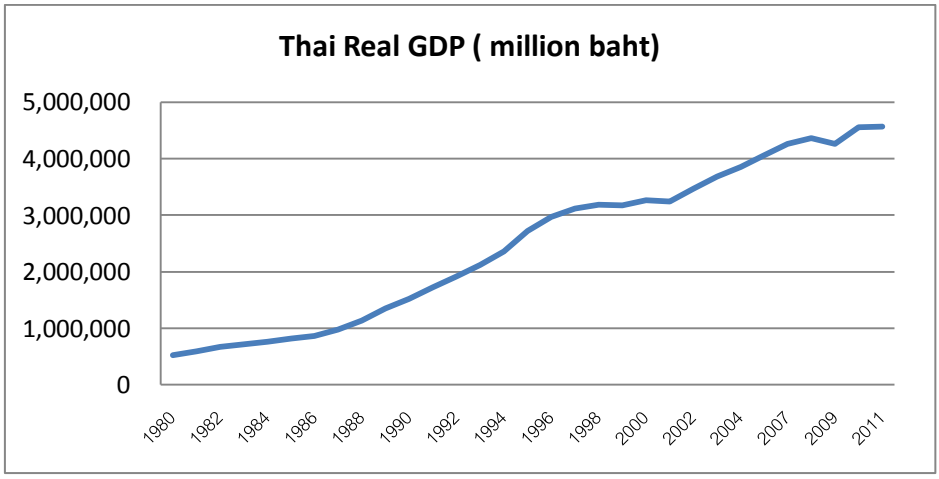
2.6.2 Economic Conditions

Figure 2.2 shows that the Thai economy has been growing rapidly since 1980. Thai Gross Domestic product was 5.2 trillion baht in 1980 and had grown to 45.7 trillion baht in 2011 (National Economic and Social Development Board, 2013) in real terms (taking inflation into consideration). During the late 1990s, Thailand was suffering from a financial crisis. Since the early 2000s, the economy has been on a growing trend. Should the trend continue it will

lead to further increases in demand for air transport as there will be more trade in products and more demand for tourism and business travel.

An area of concern lies within the current global economic recession that could undermine the growth of the industry as the Thai economy is highly dependent on international trade and tourism. Department of Tourism (2013) reported that there were 22.35 million foreign tourist visiting Thailand in 2012 which had increased by 16.24% from 19.23 million in 2011.

Figure 2.2: Real GDP of Thailand (Using 1988 as a base year)



Source: National Economic and Social Development Board (2013)

Oil price is also an important factor that can affect the aviation industry. According to IATA Fuel Monitoring (2010), the jet fuel price started to rise in March 2007 and reached its peak at 180 dollars/barrel on July 2008 before falling back to below 60 dollars/barrel in April 2009. Since then, the price of jet fuel price has again been increasing. IATA reports that the jet fuel price was 120 dollars/barrel as of 4th April 2014. The fluctuations and increase in oil price have an inevitable effect on airlines and passengers. THAI resorts to fuel hedging as part of its strategy to minimise risk from fuel price volatility (THAI, 2009). Information regarding other Thai operators' hedging strategies is not unavailable. In certain cases, a fuel surcharge has been introduced, thereby increasing the financial burden on consumers.

2.7 Forecasts

As forecasts for air traffic growth in Thailand are not available, forecasts for Asia and worldwide growth (see Table 2.6) are used to provide information on potential growth. Aviation growth in Asia for both passenger and cargo segments is predicted to be above the world average. Boeing forecasts that during the next two decades, air passenger numbers in

Asia will grow by 6.5% a year and cargo by 5.8%. The projected growth in demand for air transport is in line with the economic growth trend discussed in the previous section.

Table 2.6: Air Traffic Growth Forecasts (2012-2032)

	Global Growth		Asia Pacific Growth	
	Passenger	Cargo	Passenger	Cargo
Airbus* (2012-2031)	4.7%	Not available	5.4%	Not available
Boeing*(2013-2032)	4.1%	5.0%	6.4%	5.8%

Source: Adapted from Airbus (2012), Boeing (2013).

2.8 Conclusions

The aviation industry in Thailand has gone through several changes in market conditions which have contributed to considerable industry growth. The liberalisation of the domestic airline market which allows domestic carriers to operate freely and the introduction of LCCs in Thailand have had a positive impact on the market. Furthermore, the opening of Suvarnabhumi Airport has helped to increase the capacity for aviation activities whereas the growth in the Thai economy has driven further demand for air transport. However, there are obstacles that threaten this growth. These include outbreaks of epidemic disease (SARS, Bird Flu, and Swine Flu), volatile jet fuel prices, and on-going political instability in the country. Crucially, continuing growth in aviation in Thailand particularly in Bangkok will only bring social and economic benefits but will also impose a range of negative effects and environmental costs. Chapter three examines the nature of these environmental externalities and the measures that are available to control them and/or mitigate their effects.

3. ENVIRONMENTAL EFFECTS OF COMMERCIAL AVIATION

3.1 Introduction

Commercial aviation both creates benefits for society and imposes a range of environmental and social costs. It facilitates economic growth by transporting business and leisure passengers along with goods around the world. Being the fastest mode of transportation, aviation promotes globalisation by connecting the world (Derudder and Witlox, 2008). These benefits, however, come at a cost to the environment and society. Aircraft engines emit pollution into the atmosphere during flight whereas on the ground they generate noise and toxic emissions that affect the environment and quality of life of people living near airports. Airport operations such as ground support equipment and surface access traffic entering and leaving airports also release harmful emissions (Perl *et al.*, 1997). This chapter explores each effect by firstly examining aviation noise problems that include annoyance, health effects. The chapter then proceeds to cover the effects of aircraft emissions by dividing them into local and global categories. The former will cover aircraft emissions during the landing and take-off cycle along with emissions from ground service equipment and traffic around the airport. Global effects will be addressed by introducing the atmospheric effects of aircraft emissions. Finally, aviation environmental impacts at Suvarnabhumi Airport and measures to mitigate the impact at a local level will be discussed in the last section.

3.2 Aircraft Noise

This section aims to examine the impacts from aircraft noise by first reviewing the sources of noise emission. It then investigates the impact of air traffic noise by reviewing the annoyance. The impacts of aircraft noise on human health are investigated in terms of both direct and indirect effects. Lastly, other effects from aircraft noise will be considered.

3.2.1 Noise Emissions

The origin of aircraft noise comes from engine and aerodynamic noises (such as rotor noise from helicopters and air flow over the airframe). Engine noise is the primary source of noise from commercial aircraft. The intensity and propagation of aircraft noise depends upon distance from the source, aircraft altitude, temperature, humidity, turbulence, the ground characteristics of the noise path and weather conditions (Bugliarello *et al.,* 1975).

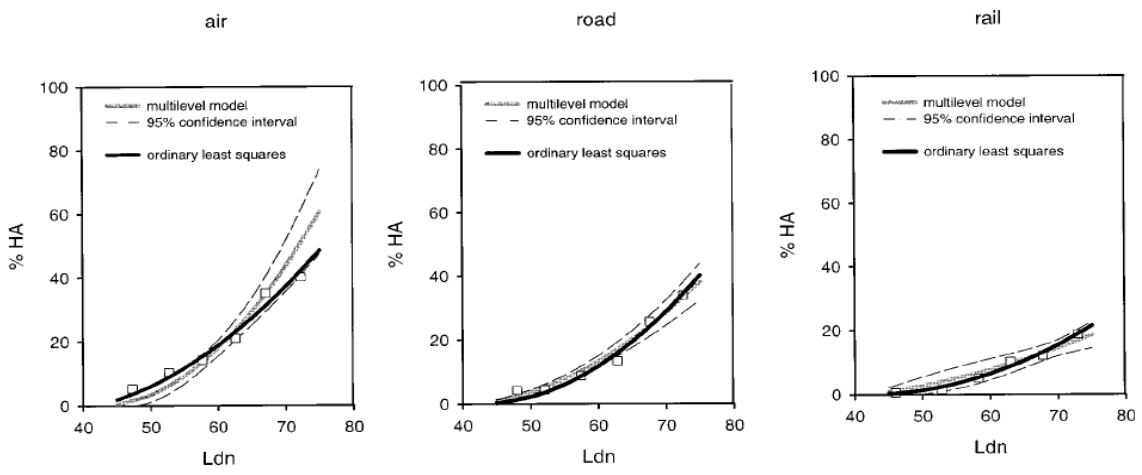
3.2.2 Annoyance

Aircraft noise annoyance is one of the undesirable effects of the aviation industry. Babisch *et al* (2009) define annoyance as “general negative feelings” such as disturbance, dissatisfaction, displeasure and nuisance. A study of transport noise annoyance by Ouis (2001) suggests that human noise reception is influenced by acoustic and non-acoustic factors. Acoustic factors include pressure levels, exposure duration, noise spectrum frequencies, and level of pitch fluctuation. Non-acoustic factors may include the time of the day, past experience and individual psychological and physiological states. Noise exposure could either result in distraction in activity or annoyance.

Quantifying the level of annoyance from noise exposure is complicated as each individual’s degree of annoyance is different (Miedema and Oudshoorn, 2001; Morrell, *et al*., 1997; Ouis, 2001). The variation of annoyance is examined by Guski *et al.* (1999) who found that the level of annoyance is related to subjective emotions (considered as pleasure or displeasure) that result from noise disturbance (such as communication disruptions), attitude towards noise, and knowledge of noise effects (such as health effect from aircraft noise). Similar results are reported by Morrell, *et al*., (1997) who found that annoyance is more pronounced in those who suffer from sleep disturbance, communication interference and individuals with problems of noise sensitivity, fear of aircraft accidents and concern about the human health impact of aircraft emissions. Socio-economic background can also have an impact on perception of noise annoyance. Thomas and Lever (2003) suggest that aircraft noise annoyance perception can be affected by resident’s wealth, attitudes, culture and lifestyle. The increasing employment opportunity in the area around the airport makes those who are less affluent to be more tolerant to aircraft noise.

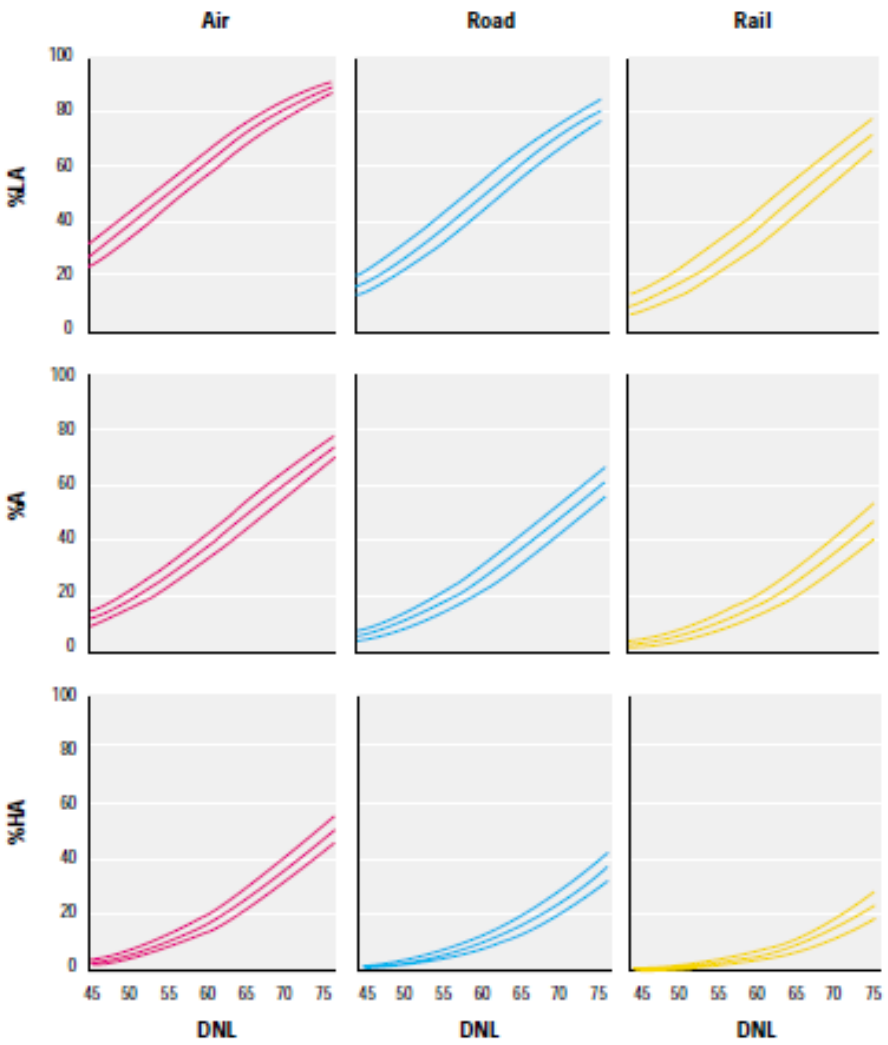
Miedama and Vos (1998) investigated noise annoyance from air, rail and road traffic by employing dataset on noise in affected areas in Europe. The research differentiates the annoyance level into highly annoyed (HA), annoyed (A), and little annoyed (LA) during the day and night time exposure (Ldn). Figure 3.1 indicates that with the same level of noise exposure, air traffic noise causes the highest percentage of highly annoyed (%HA) respondents followed by road traffic and rail traffic where the %HA starts at 45 dB(A).

Figure 3.1: Synthesised Percentage of Annoyance Curve (Highly Annoyed Response)



Source: Miedema and Vos (1998)

Figure 3.2: Synthesised Percentage of Annoyance Curve



Source: Miedema and Oudshoorn (2001)

Annoyance curves created by Miedema and Oudshoorn (2001) illustrate the level of annoyance from air, rail, and road traffic noise during both daytime and night-time exposure (DNL). Figure 3.2 shows different levels of percentage of annoyance (%LA, %A, and %HA). At 45 dB(A), approximately 30% of respondents report being a little annoyed and 10% as being annoyed by aircraft noise. Both Figures 3.1 and 3.2 not only provide information on annoyance level from aircraft noise but they also show that aircraft noise causes higher annoyance than road and rail noise at the same level of exposure. This implies that the aircraft noise is perceived as being more serious and more annoying than other modes of transport.

3.2.3 Human Health Impacts of Aircraft Noise

Hume and Watson (2003) categorised the effects of aviation noise to humans into annoyance, sleep disturbance and stress responses. Stress responses, in particular, can lead to physical and psychological health problems. Berry and Flindell (2009) examined health effects from transport noise and differentiated health effects into direct and indirect effects. Direct effects from high exposure to transportation noise include hearing loss, however Berry and Flindell (2009) concluded that hearing impairment from typical volumes of transportation noise is not significant.

Table 3.1: Sleep Effects from Aircraft Noise

Effects	**Results**	**Feedback and interactions**
Acute Response	Awakening	Acute annoyance
Total Night Effects	Reduction in sleep duration Sleep Loss Sleep Fragmentation	
Next Day Effects	Sleepiness Performance decrease	Perceived sleep disturbance Short term annoyance Tiredness & mood
Chronic Effects	Physical health effects Mental health effects	Perceived health effects Chronic annoyance Reduce quality of life

Adapted from: Porter, *et al*. (2000)

Indirect health effects from aircraft noise include mental health effects, cardiovascular and physiological effects, night-time effects, including sleep disturbance, and cognitive effects. Hume and Watson (2003) found that sleep disturbance is a major nuisance for neighbourhoods around airports. The research reports that the general aircraft noise threshold that cause people to wake up is 55-66 dB(A) which is comparable to the noise produced during normal conversations (Canadian Academy of Audiology, n.d.). Morell, *et al.,* (1997) describe sleeping problems associated with aircraft noise as delayed sleep, increased awakening from sleep, sleep loss, premature awakening and reduced sleep quality (see Table 3.1).

Stress responses to aircraft noise can lead to negative health impacts. Physical impacts include the release of stress hormones, cardiovascular stress leading to heart disease, and hearing loss. It is believed that long-term exposure to noise stress can lead to immuno-suppression, insulin resistance, osteoporosis and intestinal problems (Hume and Watson, 2003; Bugliarello *et al.*, 1975; Franssen *et al*, 2002). Initially, research by Hume and Watson (2003) and Morell *et al*. (1997) suggested that evidence of aviation noise-induced cardiovascular reactions was not strong and the mortality rate caused by aviation noise could not be established. More recently, Berry and Flindell (2009) conducted a review of studies conducted during the period of 2001-2008 and concluded that the evidence of cardiovascular reaction from road traffic noise had improved in comparison to the studies during the 1997-1999 period. Given the improved evidence, they concluded that there are sufficient data to establish the link between noise and cardiovascular reactions. Berry and Flindell (2009) also concluded that there are no evidence of cardiovascular effects where noise exposure is under 60 dB(A).

Apart from physical effects, aircraft noise is found to have impacts on mental health. A study of mental illness near London Heathrow airport by Herridge (1974) found that the number of patients suffering from mental health problems is higher in the areas near the airport. Nevertheless, the explicit causal effect of aircraft noise and psychological impact is hard to establish and Berglund *et al*. (1990) concluded that available evidence on aviation noise and mental illness is inconclusive. More recent work by Morell *et al*. (1997) and Franssen *et al.* (2007) indicate that aircraft noise creates mental illness. Further study by Stansfeld *et al.* (2009) concludes that the noise from aircraft and road traffic results in hyperactivity in children but it was not possible to establish a direct effect on other mental illnesses. Berry and Flindell (2009) report that the current level of evidence is insufficient to establish the causal-effect relationship between traffic noise and mental health but do note that noise could exacerbate existing mental health problems in individual cases.

Babisch (2006) discusses the noise exposure pathway that leads to health impacts from noise. Firstly, high noise exposure directly leads to hearing impairment whereas moderate noise exposure indirectly leads to disturbances in activities and cognitive and emotional responses which could be considered as annoyance. The effects from noise then lead to stress indicators which are physiological stress responses. These responses stimulate biological risk factors that eventually create cardiovascular conditions including hypertension, arteriosclerosis and ischemic heart disease.

Table 3.2: Summary of Evidences and Noise Dose-response Relationship

EFFECT	EVIDENCE	DOSE-RESPONSE
Annoyance	Sufficient	Yes
Mental Health	Insufficient	No
Cardiovascular	Sufficient (increased)	Yes
Sleep, awakening/self-reported sleep disturbance	Sufficient	Yes
Cognitive	Sufficient	Yes
Hearing	Sufficient	Yes

Source: Berry and Flindell (2009)

Table 3.2 summarises the impacts of noise dose-response relationship reviewed by Berry and Flindell (2009). It reports that there is sufficient evidence of responses except mental health for which the connection could not be established.

3.2.4 Other Impacts of Aircraft Noise

The first impact to be discussed is academic performance as a result of aircraft noise disturbance. Haines *et al*. (2002) studied the examination performance of year 6 students (approximate age of 11 years old) near Heathrow Airport and found that the scores were below the national average. Nevertheless, Berry and Flindell (2009) explains that cognitive impairment in term of study performance is related to aviation and transportation noise but to a lesser degree in comparison to other life events such as family bereavement.

Interesting, research has shown that it is not only humans who can be adversely affected by aircraft noise. Stokes *et al*. (1999) studied the noise disturbance from leisure aircraft activities in Hawaii and found that native wildlife were exposed to an extended period of aircraft noise intrusion. The research suggests that the geographical character of the natural environment (such as mountains and cliffs) could increase the acoustic intensity (and thus

disturbance) to the wildlife. Campo *et al*. (2005) examined the impact of music and transport noise on laying hens and found that simulated aircraft noise and other transport noises create stress and fear to the hens.

3.3 Local Emissions

Emissions from aircraft create two levels of effect. Firstly, emissions from aircraft landing and taking off and emissions from surface access trips and airport-related vehicles create local air pollution while aircraft emissions during the cruise have a global impact. This section begins by addressing local emissions and impacts on human health followed by an assessment of aviation's global environmental impact.

The US Federal Aviation Administration (FAA) (2005) states that the pollutants emitted from aircraft engines are similar to that of automobiles. These are SO_2 (Sulphur Dioxide), NO_X (Nitrogen Oxides), CO (Carbon Monoxide), VOC (Volatile Organic Compounds); unburnt hydrocarbons/soot (HC) and water vapour (H_2O). LTO emissions are considered as emissions from aircraft engines during taxi, take off, and landing to an altitude of 3000 feet (Hume and Watson, 2003; Kesgin, 2006). Hume and Watson (2003) suggest that $NO_{X,}$ CO and NMVOCs (non-methane volatile organic compounds, which include benzene, polyaromatic hydrocarbons and kerosene) are the pollution species of concern near airports. Kesgin (2006) suggests that approximately 25% of harmful emissions on a short haul flight are emitted during LTO cycle. The FAA (2005) estimates that on average aircraft emit approximately 30% of HC and CO during the LTO phase and 70% during the cruise phase while other pollutants are emitted in the proportion 10% during the LTO cycle and 90% during the cruise.

Airport-related road traffic and aircraft support equipment have been included in airport environmental impact studies such as research on monetising emissions at Lyon Airport by Perl *et al*. (1997). There are a number of emitted pollutants from these vehicles. Firstly, the concept of emissions and ambient pollution shall be introduced for clarification. The substances directly emitted from ground service vehicle engines are similar to aircraft emissions and include PM (particulate matter), SO_2 (Sulphur Dioxide), NO_X (Nitrogen Oxides), CO (Carbon Monoxide) and VOC (Volatile Organic Compounds) and unburned or partially combusted hydrocarbons. PM is the most damaging pollutant to human health as it consists of organic aerosols, sulphates, nitrates, and metals which can cause lung, liver, skin and respiratory cancers along with Leukaemia, neurobehavioral effects and cognitive impairment (McCubbin and Delucchi, 2003). PM is subdivided into two categories, $PM_{2.5}$

which is defined by the size of less than or equal to 2.5 µm and PM_{10} which has the size of less than or equal to 10 µm. When these substances are emitted they create ambient pollution which is caused by the emitted species dispersion and transformation (McCubbin and Delucchi, 2003). A list of the impact individual pollutants have on human health is detailed in Table 3.3.

Table 3.3: Health Impact of Local Emissions (Aircraft and Ground Service Vehicles)

Emissions Species	Ambient Pollution	Effects on Health
PM, SO_2, NO_X, VOC,	PM	▪ premature death ▪ chronic bronchitis ▪ respiratory and cardiovascular problems ▪ asthma attacks
VOC, NO_X	O_3 (Ozone)	▪ premature death ▪ respiratory problems ▪ asthma attacks
NO_X	NO_2	Minor respiratory problems (sore throat, excess phlegm, eye irritation)
CO	CO	Cardiovascular related disease
SO_2	SO_2	Minor respiratory problems (asthma, chest tightness)
VOC, PM	Toxins	▪ Cancer (polyaromatic hydrocarbons, dioxins/ furans) ▪ Lung cancer (arsenic, nickel, chromium, diesel particulates) ▪ Liver and skin cancer (arsenic) ▪ Leukaemia (benzene) ▪ Respiratory cancer (formaldehyde) ▪ Cognitive impairment (lead) ▪ Neurobehavioral effects (mercury)

Source: McCubbin and Delucchi (2003)

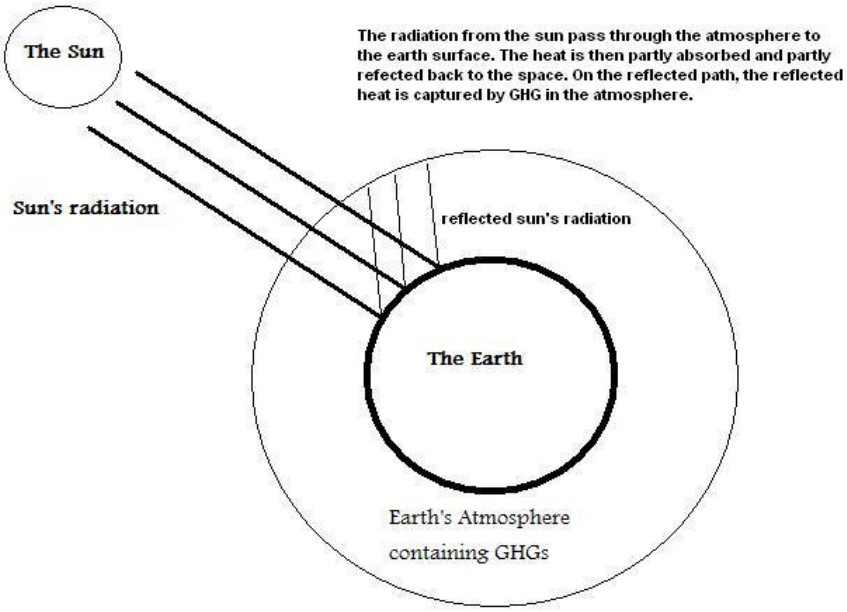
These emissions also create non-human impacts. PM is found to cause soiling of buildings and a reduction in visibility. SO_2 causes material damage by contributing to the formation of acid rain and harming crop yields. NO_X results in acidification and nitrogen deposition which

damages ecosystems, acts as an Ozone precursor and reduces visibility (Stanley and Watkiss, 2003). NO_X also creates a local air quality problem by contributing to surface-level Ozone which is found to have a negative effect on respiratory problems (Stedman and Kent, 2008). Finally, VOCs have the capacity to damage materials such as paints, polymers and rubber along with crops (Stanley and Watkiss, 2003).

3.4 Global Effects of Aircraft Emissions

Emissions from aircraft during the cruising phase have an impact on the climate. The Intergovernmental Panel on Climate Change (IPCC) published a comprehensive report on aviation's impact on global atmosphere which identified CO_2, O_3, CH_4 (methane), water vapour, condensation trails, cirrus clouds, and sulphate and aerosols as being of environmental concern (IPCC, 1999). The US FAA (2005) estimates that the composition of aircraft engine emissions during the cruise is 70% CO_2, almost 30% water vapour and less than 1% other pollutants.

Figure 3.3: Greenhouse Effect



Source: FAA (2005)

Before proceeding into greater detail, the concept of climate change and greenhouse gases will be introduced for a better understanding of aviation's impact on the atmosphere. Firstly, the greenhouse effect is a phenomenon in which when the sun's radiation reaches the earth

surface, it is partly absorbed and partly reflected back to the space. The reflected radiation is then captured by greenhouse gases (GHG) in the atmosphere. These make the Earth's temperature higher than it would be without GHGs (FAA, 2005). The process is depicted in Figure 3.3. Table 3.4 summarises the key pollutants and their impacts on the atmosphere.

Table 3.4: Aircraft Emissions and Atmospheric Effects

Emitted Pollutants	Atmospheric Effects
CO_2	Troposphere and Stratosphere ▪ Direct positive RF
H_2O	Troposphere ▪ direct positive RF ▪ Increase contrail formation, positive RF Stratosphere ▪ direct positive RF ▪ Increase polar stratospheric clouds → Ozone depletion→ enhanced UV-B ▪ Change ozone chemistry → Ozone depletion → enhanced UV-B
NO_X	Troposphere ▪ Ozone formation → positive RF + reduced UV-B Stratosphere ▪ Ozone below 18-20 km → reduced UV-B ▪ Ozone above 18-20 km → enhanced UV-B ▪ Enhanced polar stratospheric clouds formation → Ozone depletion → enhanced UV-B
SO_X and H_2SO_4 (Sulphuric Acid)	Troposphere ▪ Enhanced sulphate aerosol concentration ▪ Direct negative RF ▪ Contrail formation → positive RF ▪ Increased cirrus cloud cover → positive RF ▪ Change Ozone chemical composition Stratosphere ▪ Modifies Ozone chemical composition
Soot	Troposphere ▪ Direct positive RF ▪ Contrail formation → positive RF ▪ Increased cirrus cloud → positive RF ▪ Change Ozone chemical composition Stratosphere ▪ Modifies Ozone chemical composition

Source: IPCC (1999)

At this stage, it is important that the role of Ozone (O_3) and UV-B is explained. The US Environmental Protection Agency's Ozone depletion information (2008) explains that Ozone acts as a filter of UV-B (Ultra Violet radiation with a wavelength of 280-320 nanometres) from the sun. The depletion of tropospheric ozone allows more UV-B radiation to enter the earth's atmosphere causing skin cancer, skin-related disease, eye damage and immune suppression.

Condensation trails (or contrails), that are formed by the condensation of emitted water vapour, may seed cirrus cloud systems. Contrails have a role in positive RF (Radiative Forcing). IPCC (1999) defines radiative forcing as:

"The radiative forcing of the surface-troposphere system due to the perturbation in or the introduction of an agent (say, a change in greenhouse gas concentrations) is the change in net (down minus up) irradiance (solar plus long-wave; in Wm^{-2}) at the tropopause AFTER allowing for stratospheric temperatures to readjust to radiative equilibrium, but with surface and tropospheric temperatures and state held fixed at the unperturbed values"

In short, radiative forcing is referred to the change in lower atmospheric energy balance of the earth measured in Wm^{-2} whereby positive RF has a warming effect and negative RF has a cooling effect.

The IPCC report (1999) explains that the contrails are created by water vapour emitted from aircraft engines being exposed to cold air temperatures where it immediately condenses into small ice crystals that form contrails. Cirrus clouds have been reported to be related to persistent contrails and aircraft emissions. However, the phenomenon has yet to be adequately understood and further examination is required. A more recent study by Lee *et al*. (2009) suggests that a link between aircraft emissions and cirrus cloud formation has been established. However, results are varied as there are uncertainties surrounding the extent to which cirrus clouds absorb the reflected heat from surface (thereby capturing heat within the atmosphere) and the role of reflecting incoming radiation from the sun back out into space. To complicate matters further, the roles of sulphates and aerosols which are also by-products of fuel combustion have opposing effects. Sulphate has a negative RF while aerosols create a positive RF.

A recent study by Lee *et al*. (2009) of air transport's impacts on the atmosphere based upon earlier work by the IPCC (1999) used 2005 data and recorded the following results (see Table 3.5).

Table 3.5: Aviation RF

RF Type		RF value (Wm^{-2})	Level of Impact	Level of scientific Understanding
CO_2		0.0280	Global	High
NO_X	O_3 Production	0.0263	Continental to hemispheric	Medium-low
	Methane Reduction	-0.0125	Global	Medium-low
	Total CO_2	0.0138	Global	Medium-low
Water Vapour		0.0028	Hemispheric to global	Low
Sulphate Aerosol		-0.0048	Local to global	Low
Soot Aerosol		0.0034	Local to global	Low
Linear contrails		0.0118	Local to continental	Low
Cirrus Clouds		0.033	Local to Hemispheric	Low
Total (Exclude cirrus clouds)		**0.055**	**Global**	**Low**
Total (Include cirrus clouds)		**0.078**	**Global**	**Low**

Source: Lee *et al*. (2009)

Lee *et al*. (2009) estimate that the RF from aviation is 0.055 Wm^{-2} (Watts per square metre) and so aviation emissions have a warming effect. Aviation RF, based on 2005 data, represents approximately 3.5% of total human RF. However the level of scientific understanding of some RF types is low, particularly aircraft induced cirrus clouds. This makes it difficult to assess the exact impact. The IPCC report (1999) which employed 1992 data, estimated similar levels of aviation RF at 0.0478 Wm^{-2} (excluding cirrus clouds) or 3.5% of total human RF. Both studies produce forecasts for aviation RF until the year 2050. Lee, et al. (2009) predicts that RF from aviation will be between 0.146 and 0.194 Wm^{-2} in 2050 while the IPCC (1999) forecast a larger impact from 0.13 to 0.56 $Wm^{-2.}$ .The implication is that the scientists are still uncertain and the debate will continue. This lack of consensus may be hindering the effective calculation of changes in climate impacts.

3.5 Mitigation Measures

As environmental impacts from aircraft are commonly classified into local and global effects, this requires different measures to address each type of problem. This section discusses the available options ranging from regulatory to economic measures which cover both local (noise and local air pollution) and global impacts. The first part will examine policies for local impact by starting from noise regulation, noise emission charges and finishing at the measures for local pollutions from aircraft. The second part investigates global mitigation solutions and introduces the concept of emissions trading and the proposed inclusion of aviation into the European Union's Emissions Trading Scheme (EU-ETS).

3.5.1 Noise Mitigation Measures

As discussed earlier, aircraft noise is arguably the most noticeable impact of the aviation industry, particularly to those living near airports. Despite significant reductions in the noise footprint of individual aircraft over time, the growth in aviation activities necessitates a need for measures to control and reduce impact of aircraft noise. This section starts with the regulatory measures available to policy makers, which include noise limitation standards, noise budget, curfews, preferential runway use and/or runway alternation, environmentally beneficial air traffic management and ground turnaround procedures and land-use zoning and management. In the second part, economic measures to address aircraft noise levels are discussed.

a) Per-aircraft Noise Limit

This first measure allows regulators to introduce a ban on specific aircraft types based on their noise emissions. For example, a government may prohibit aircraft with high noise level from flying based on the ICAO Annex 16 Noise standard. The International Civil Aviation Organisation (ICAO) Annex 16 categorises noise level standards for aircraft into different chapters. ICAO Noise chapter 2 is applied for jet-powered aircraft designed before 1977, Chapter 3 is applied for aircraft designed after 1977 and the latest version which is Chapter 4 is applied for aircraft designed after 2006 (ICAO, 2004). Currently, the European Union bans all Chapter 2 and most Chapter 3 aircraft from operating within its airspace (CAA, 2007). The ICAO noise standard can also be used as the basis of an incentive-based policy which will be discussed in a later section.

b) Noise Quotas/Budgets

An alternative to per aircraft noise limits is the introduction of cumulative noise quotas which impose a limit for the total noise exposure at an airport. Girvin (2009) stated that these quotas can be set to a specific time such as day or night, or could be in a form of a restriction on number of movements which could mean restricting air traffic growth at the airport. Examples of airports that implement noise quotas include Copenhagen, Amsterdam Schiphol, Manchester, and Wellington (Boeing, 2010).

c) Noise Curfews

Airport curfews can be introduced to relieve aircraft noise problems during the night. A review of airport curfews by Girvin (2009) showed that a variety of practices were implemented by airport operators. The curfews could be imposed for a complete ban of air traffic at particular times, or only for specific aircraft categories. Curfew violations may result in mandatory fines to the operator whereas some airports such as St Petersburg, Florida and Providence, Rhode Island, impose a curfew on a voluntary basis. Toronto Pearson Airport in Canada allows airlines to obtain exception permits for regular operations during the curfew period. The curfew variations allow flexibility within the policy and enable a government or other regulatory agency to determine a curfew system that is suitable for a particular airport. Girvin (2009) suggests that airport curfew can create economic negativities; namely, revenue loss, consumer delays, and job losses. However, night time quota systems that allow night time operations with quieter aircraft can be a more acceptable solution that allows compromise between the community noise problem and airport utilisation.

d) Preferential Runway Designation and Noise Abatement Procedures

According to Boeing (2010), preferential runway designation and flight noise abatement procedures are the policy most commonly used by airport operators for purposes of noise abatement and mitigation. A total of 491 airports worldwide are reportedly using the runway preferential procedure (Boeing, 2010). Preferential runway designation, as the name suggests, is a practice whereby specific runways are designated for aircraft arrivals or departures (or both) during a particular time of day. Runway designation is used to minimise the noise impact by concentrating aircraft flight paths over areas that will cause the least community annoyance.

Noise abatement procedures are in-flight procedures or flight paths designated to reduce noise impact on the ground. There are a variety of procedures. At Zurich Kloten's Airport, for example, all departing flights have to fly a precise Standard Instrument Departure (SID)

route and are required to reduce thrust at 2,900 feet. Arriving aircraft must fly a Continuous Descent Approach (CDA) which involves inbound aircraft descending continuously with idle thrust (thereby reducing fuel consumption and noise) from a prescribed altitude until touchdown (Boeing, 2010). In other words, aircraft are given specific departure and arrival routes and procedures which are designed to minimise the noise problem to residential areas near the airport. Another example is the preferential runway and noise abatement procedures at Sydney's Kingsford Smith Airport which designates preferred runways and noise abatement procedures by concentrating air traffic in over-water areas thereby reducing the noise disturbance to nearby residents (Nero and Black, 2000).

The enforcement of noise abatement procedures is varied. They can be voluntary or compulsory. Airports may elect to fine airlines in case of procedural violation as a mechanism to encourage compliance. Girvin (2009) suggests that this policy is relatively cost-effective and simple in terms of implementation and monitoring. However, it is possible that procedures may result in an increase in fuel consumption should the designated procedure involves detour from the most direct flight trajectory.

e) Other Operational Restrictions

Apart from noise abatement procedures, which cover in-flight operations during the arrival and departure phases, operational restrictions on the ground can be imposed to reduce noise emissions. These procedures include restrictions on thrust-reverser deployments, the use of ground power units instead of the noisier auxiliary power units (Thomas, *et al*., 2003). Airports may choose to prohibit engine run-up tests and thrust-reverser deployment during a particular period of the day or on certain days of the week (often weekends). Designated engine run-up areas can also be constructed (Girvin, 2009).

f) Land-use Management

This is a different approach from the preceding measures as it seeks to lessen the noise problem by managing affected properties instead of aircraft. This includes the voluntary acquisition of properties, city planning, installing noise insulation, routine noise monitoring and establishing a dedicated airport environmental department to handle concerns raised by local residents (Airports of Thailand, 2010). Girvin (2009) argues that land-use management plays a role in improving relationship between affected populations but it doesn't address the real source of problem which is the noise itself. Thomas, *et al*. (2003) suggests that land-used management is not often being used in the most effective manner even if the authority or airport operator has a full control of the management as airport growth results in urban

development in the area which provide workforces and services to the airport. This problem is also occurring at Suvarnabhumi.

g) Noise Taxes and Charges

Noise-related problems from aviation can be addressed through economic measures in the form of noise taxes and charges, which are based on principle of 'let the polluter pay' for the damage they cause to the environment. Environmental taxes can be based on passengers, airlines or aircraft. Examples include a flat rate, fuel fax, and a per departure tax which could be used to address noise, local pollution and global effects from the aviation industry (Keen and Strand, 2007). However, differential noise charges based on the level of noise emissions are believed to be more effective incentive-based instrument (Carlsson, 1999)

In 2004, ICAO published guidelines for airport charging policies based on balanced approach to aircraft noise. The approach contains four key elements which are reduction of noise at source, land-use management and planning, noise abatement operational procedures and operating restrictions where operating restrictions are to be used as the last resort (ICAO, 2007). The noise charge guideline states that ICAO recognises the need to implement noise charges by Governments as a measure to recover the cost of aircraft-related noise mitigation works and recommends three main principles. Firstly, ICAO states that noise charges should only be applied at airports with a noise problem and the charging rates should not exceed the cost of the noise mitigation measures. Secondly, ICAO recommends that noise charges should be landing fee-associated in the form of surcharges or rebates and suggests that ICAO Annex 16 noise chapter level should be adopted as standard. Finally, it advises that surcharges should be uniform between users (i.e. no-discrimination) and should not be set at an excessive rate for the operators of certain aircraft.

Charging regimes vary across the world and there are differences in the charging rate classification and calculation methodologies. Some airports also differentiate the surcharge rate between night and day time. On the other hand, discounts on landing fee may be granted to airlines with quieter aircraft.

In the term of noise charge effects, Nero and Black (2000) examined the potential demand effect of Noise Levy Charges (NLC) system at Sydney's Kingsford Smith Airport and found that at a charge of £1.95 per passenger, passenger demand at the airport may be reduced by 36,000-249,300 and air traffic movement may be reduced by 322-2298 movements per annum. At a higher charge of £5.86, passenger demand is reduced by 108,460-748,000 passengers and air traffic movements by 969-6,896 annually. Furthermore, the study

concludes that, in the duopolistic aviation market (market with a few airlines competing), airlines have a tendency to pass on the cost to passengers as the demand for air transport is relatively inelastic. It also observed that, during the introduction of NLCs at Sydney airport, Australian airlines started to retire chapter 2 aircraft but it is more likely to be the case of the aircraft reaching the retirement age rather than incentives from noise charges (Nero and Black, 2000).

In the Netherlands, Morrell and Lu (2000) studied the social cost of aircraft noise through a hedonic pricing method and compared their results with aircraft noise surcharges at Amsterdam's Schiphol Airport. The damage cost from aircraft noise was estimated at £516.28 per flight whereas the average charge per flight was £130.35. The given explanation is that the charge revenue is used for sound insulation installation will not be able to fully compensate the local residents for the overall aircraft noise annoyance they experience.

Noise charges can influence airlines' decision on aircraft type utilisation, route network and flight frequencies according to Hsu and Lin (2005) who studied the case of Taipei's Chiang Kai Check Airport. Their conclusion is that when a hub airport imposes noise charges, airlines may respond by changing intermediate airports, changing to non-stop flights, switching to larger aircraft types and reducing flight frequencies. As a consequence, airports may suffer from declining profits. The study also found that a reduction in flight frequencies by utilising larger aircraft can actually increase noise levels.

3.5.2 Local Aircraft Emission Measures

Unlike aircraft noise which has a variety of options, measures for controlling local emissions from aircraft are relatively limited. Boeing (2010) reported that there are 20 airports worldwide that implement emission charges for arriving and departing flights. Such charges could be implemented by establishing different pollution categories (such as in Basel airport in Switzerland which has five charging levels). Other airports' charges are based on Nitrogen Oxides (NO_x) emissions such as Gatwick and Frankfurt which charge £4.52 and £2.49 per kg of NO_x respectively. APU usage restriction and engine emission certification can also help in reducing local emissions.

3.6 Global Effect Mitigation Measures

Addressing the global effects of the aviation industry could be achieved by setting regulations on emissions standards, operational procedures, emission charges and taxes, and emissions trading schemes. Ideally, the global impact of aviation should be addressed internationally. This will require collective action but the development process is slow and ICAO has so far failed to reach an agreement to formulate mitigation measures (van Essen, *et al*., 2005)

a) Emission standards and Operational Procedures

Van Essen, *et al*. (2005) suggest that the aircraft engine certification authority should set the emissions standards for engines and develop flight paths and alternative flight altitudes that prevent contrail formation. One barrier that policymakers need to overcome is the scientific understanding of the global impact of each pollutant in order to develop measures that cover all types of emissions from aircraft during the cruise phase.

b) Emission Taxes and Charges

Alamdari and Brewer (1994) arranged taxation options into three alternatives: per departure tax, fuel tax, and taxation on the emissions. Per departure tax is a flat-rate tax applied to passenger when buying a ticket such as the UK's Air Passenger Duty (APD) and Netherland's flight tax. Alamdari and Brewer (1994) state that flat rate per departure tax is a crude measure that doesn't provide an incentive for airlines to reduce emissions. It is, however, a taxation that arguably penalises passengers and suppresses demand.

Fuel tax, on the other hand, provides a direct incentive for airlines to reduce their fuel consumption (and thereby reducing aircraft emissions). Keen and Strand (2007) and Van Essen *et al*. (2005) both found that there is a legal obstacle (in the form of ICAO convention) which prevents the imposition on fuel tax for international flights. Consequently, fuel tax can only be implemented domestically. Van Essen *et al*. (2005) reported that in 2004, Japan charged £0.73, the Netherlands charged £0.58 and Australia charged £0.05 in jet fuel tax per US gallon. The study states that the introduction of fuel tax at a regional level may distort competition and lead to tankering in which airlines buy fuel for their aircraft in cheaper countries overseas.

c) Pollutant Emissions Charges

Another alternative is to charge for emissions from the aircraft. This practice is argued to be the most desirable among the three taxation options as the charge is directly imposed on the emission level which provides incentives to airlines to reduce emissions (Alamdari and

Brewer, 1994). Airlines' responses to emissions charges can be divided into short and long term. Carlsson (1999) examined the incentive-based policy for emissions charge in Sweden and concluded that, in the short run, airlines can respond by reducing flight frequency and by installing engine modifications. In the longer term, airlines can respond by acquiring new aircraft with lower emissions. Van Essen *et al*. (2005) suggest that, in the longer run, such charges could provide an incentive for airlines to retire inefficient aircraft earlier.

d) Emissions Trading Scheme for the Aviation Industry

The level of emissions from aviation can be controlled through an emissions trading (or cap and trade) scheme. Emissions trading is an environmental protection initiative whereby a limit of the permissible level of emissions is set (capped). Each company is allocated or sold a permit to emit up to a specified limit. Given that the total emissions level is capped, companies which seek to increase their emissions output must buy additional permits from companies with a surplus. By doing so, the firms that have reduced their emissions are financially rewarded by earning income from selling (trading) their surplus permits to companies which need to increase their emissions (UK Environment Agency, 2010)

In the context of the aviation industry, this market-based policy is a viable environmental mitigation measure that may help address the global impact of aviation. In doing so, a government (or other approved regulatory agency) sets a cap level for emissions (such as CO_2) for the aviation industry. Airlines are then allocated emissions permits which are then traded within the industry. An example for the application of emissions trading in to the aviation industry is the European Union Emissions Trading System (EU ETS)

e) EU-ETS

Currently, the EU-ETS is the largest emissions trading programme in the world and is also the first scheme that is being implemented internationally (Anger and Kohler, 2010). The scheme initially covered CO_2 emissions within the European Union member states from energy intensive industry. The EU-ETS was introduced on 1st January 2005 and it is now in its second phase (2008-2012). Anger and Kohler (2010) suggest that during the first phase, which can be regarded as a learning period, the EU-ETS did not create a sufficiently high carbon price due to the 'generous' allocation of carbon permits.

The inclusion of the aviation industry into the EU-ETS was proposed in 2006 and supposed to become effective in 2011. The details of the initial proposal were:

- All airlines within the EU and airlines from non EU states departing and arriving at EU airports were included.

- The total emissions cap was calculated based on annual emissions of CO_2 during 2004-2006 within EU member states with the aim of stabilising aviation carbon emissions at the 2005 level.
- The allocation method was based on the proportion of tonne-kilometres flown during one calendar year within 24 months before the trading period commencement (benchmark period or reference year).
- The same allocation methodology would be used for every member; permit allocation would partly be free and partly auctioned.
- An open trading system would be used in which airlines could buy allowances from other trading sectors but could not sell allowances to other sectors. Surplus allowances could only be sold within the aviation sector.
- New airlines will acquire an allowance through the market or through auctioning.

Further amendments were made in the European Commission directive 2008/101/EC which Anger and Kohler (2010) summarised as follows:

- From 2012, carbon allowance is to be capped at 97% based on 2004-2006 period and in 2013, it will be lowered further to 95%
- The first benchmarking period is 2010 and further benchmarking periods are based upon the emission level of the calendar year ending 24 months before the start of the next trading period.
- 5% of the emissions permits will be auctioned
- 3% of allowances will be reserved for new entrances and fast expanding carriers.

In 2012, the EU-ETS for aviation was implemented. A number of researchers have studied the potential effects of the scheme. Morrell (2007) studied the potential effects on airlines from three different emissions allocation methods that include grandfathering, auctioning, and benchmarking. The full service carrier British Airways, a low cost carrier easyJet, and charter carrier Thompsonfly were used as examples. With the assumed carbon trading cost of £25.16 per tonne, the study found that under the grandfathering method, full service airlines with slower growth rates were the least affected. On the contrary, low cost airlines which have a large growth rate would be worst-affected as more emission permits must be obtained in comparison to the larger but slower-growing carriers. Under the benchmarking method, charter airlines are expected to be credited with surplus emission permits as they operate with high efficiency aircraft and higher load factor. Low cost airlines still suffer most under this method, but only initially.

Table 3.6: Comparison of EU-ETS Cost and non-EU routes (£16.58/tonnes CO_2)

Origin	Stopover	Destination	Additional Cost/flight (£)	Additional Cost/Passenger(£)
New York	-	Dusseldorf	2,558.32	11.47
New York	Zurich	Dusseldorf	193.33	2.64
New York	Frankfurt	Dusseldorf	4,129,72	10.22
Singapore	-	Frankfurt	4,910.04	16.38
Singapore	Zurich	Frankfurt	119.77	1.23
Singapore	Istanbul	Frankfurt	497.34	3.89
Singapore	Dubai	Frankfurt	2,478.08	10.81
New York	-	Delhi	0.00	0.00
New York	Frankfurt	Delhi	9,834.37	22.20
New York	Zurich	Delhi	0.00	0.00
New York	Istanbul	Delhi	0.00	0.00

Source: Albers *et al*. (2009)

Albers *et al*. (2009) examined the potential of route-restructuring and the effect on non-EU member hubs near the EU such as Zurich and Istanbul in terms of additional cost and competitiveness. This raises the issue that airlines might introduce 'artificial stops' to reduce the cost. However, the study concludes that it would be unlikely since the practice will involve additional flight time and landing costs at these additional stops. Table 3.6 provides examples of the additional cost by comparing the routes that have a stop within and outside EU-ETS countries. For example, by flying from New York to Dusseldorf via Frankfurt (within EU-ETS coverage) it costs an additional £10.22 per passenger whereas it costs only £3.89 more per passenger if they choose to make a connection in Zurich (outside EU-ETS coverage). Another example is New York to Delhi. The EU-ETS will cost £9,834.37 to the airline by stopping in Frankfurt (within EU-ETS scheme) but zero cost if the airline chose to stop in Zurich or Istanbul which is not covered by the EU-ETS. The implication for intra-EU flights is that airlines have an incentive to arrange the flight using the most direct routing possible.

Boon, *et al*. (2007) studied the allocation method and possible scenarios of allowance cost passing to passengers. In all cases, airlines are highly likely to resort to industry measures to reduce their emissions level and lower the cost of purchasing additional emissions permits. Nonetheless, it is also likely that they will pass on the cost to passengers with the exception of repeated benchmarking allocation method. Similarly, demand effects are expected to be affected in line with ticket cost pass through.

Additionally Boon, *et al* (2007) projected different scenarios for 2020: one under the EU proposed allocation method and another under the 100% auctioning method. The forecast estimates that, by 2020, a carbon reduction of 3.5 and 10.2 million metric tonnes will be achieved when carbon is priced at £12.43 and £37.30 respectively using the EU's proposed allocation method. In the case of 100% allocation, carbon reduction is expected to be 6.4 and 17.7 million tonnes at the price of £12.43 and £37.30, respectively.

Anger and Kohler (2010) reviewed studies on EU-ETS and its potential impacts on the aviation industry. They conclude that full service airlines are unlikely to decrease seat capacity as a result of the EU-ETS as these operators predominately rely on hub and spoke traffic. LCCs may have an incentive to drop some of the less profitable routes as a result of the increased emissions cost. For the competitiveness between EU and non-EU airlines, it is suggested that there might be some effect and there is a possibility that non-EU airlines may use the most environmentally friendly aircraft on EU routes and allocate older aircraft to other routes. Scheelhaase and Grimme (2007) stated that the impact will be greater for low cost operators in the short term as the costs for low cost airlines are expected to increase by 3% in comparison to less than 1% increase on FSCs.

3.7 Conclusion

This chapter has examined the impact of aviation on the environment in the first part and the mitigation measures in latter part. The environmental impacts from aviation activities are divided into two level; local and global impacts. Aircraft noise and local emissions are the two main problems affecting residents living near the airport. Firstly, the noise problem causes annoyance, stress and disturbance which can lead to health problems. Secondly, local emissions, which come from aircraft taking off and landing (LTO emissions) and airport-related traffic, degrade local air quality. For the global emissions, it was found that aviation activities are responsible for 3.5% of all human radiative forcing. The review found the impact of noise on human health is generally reasonably well understood. Nonetheless, the level of impact of aviation on climate change remains inconclusive. The limitation on available data and full scientific understanding of certain emission species is a serious issue. This is bound to cause errors in quantifying the emission level and its effect on climate change. This, in turn, could open an opportunity for sceptics to attack any plans to introduce emission reduction measures.

The second part of this chapter identifies mitigation measures to address aviation-related externalities which include operational and economic measures covering both local and global emissions. Some of the operational measures are relatively inexpensive and easy to

implement while economic measures whether for local or global emissions can cause adverse impact on air passenger demand. The review shows that various airports and governments have different approaches to address the aviation impact particularly the economic measures, the EU-ETS is a good example of this. Although they are being imposed with good intent, it is likely to cause the controversy to airlines and passengers given the fact that some of the effects are not fully understood which could raise the problems of fairness and transparency.

The problems of quantifying aviation impact and finding a fair and effective mitigation measures open a gap for this study to address the issue from a different angle approaching the aviation impact problem from the public perceptions through monetary valuation. In doing so, it has an advantage in removing the problems of measuring the actual emissions which is complicated given the lack of reliable data in Thailand (see next chapter) and the complete scientific understanding. It could also improve the fairness and transparency of the economic measures given that this study investigates monetary valuation from the perceptions of those who are affected (residents) and those who cause the problems (passengers). The measures reviewed in this chapter are imposed by the airport operators and governments which approach the problem from scientific point of view. Also, the full effect may be unknown but the evidence is clear on effects of these emissions.

4. AVIATION ENVIRONMENTAL IMPACTS AT SUVARNABHUMI AIRPORT

4.1 Introduction

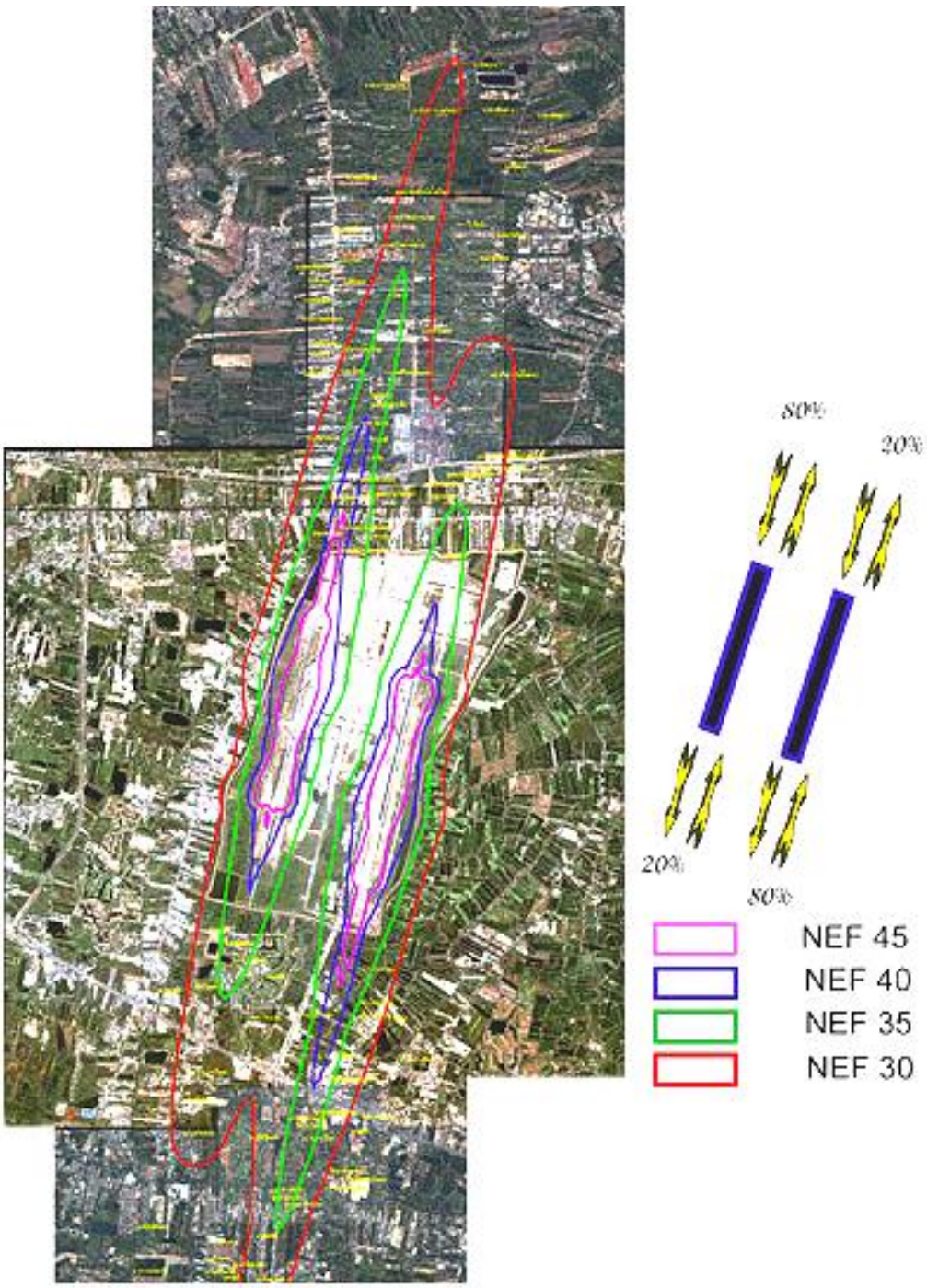
As the main airport serving the capital covering 69% of flight movements in Thailand and 51 million passengers in 2013 (DCA, 2014), Suvarnabhumi Airport is the airport with highest environmental impact in the country. The airport's operator, Airports of Thailand (AOT), published an environmental assessment report in 2002 which forecast the future environmental impacts at Suvarnabhumi. Subsequently, in 2005, the AOT published a revised forecast as passenger numbers were anticipated to increase to 45 million annually by 2010. This is much higher than the original forecast in the 2002 report of 30 million passengers per annum (Team Consulting Engineering and Management, 2002, 2005). This section discusses the environmental impacts of Suvarnabhumi Airport and the measures that are being taken to address them.

4.2 Aircraft Noise Pollution at Suvarnabhumi Airport

The official noise contour map at Suvarnabhumi Airport is a version made in 2007 by the Pollution Control Department (PCD). The PCD set up 20 noise monitoring stations around the airport. As part of the environmental impact monitoring programme, the AOT should update the noise contour map every two years (Team Consulting Engineering and Management, 2002).

There are issues with the noise emissions data at Suvarnabhumi Airport. Firstly, both versions of the Environmental Impact Assessment report employed a data set from the period before the airport opened. Secondly, the official noise contour map released by the AOT was supposed to be published bi-annually. As of August 2013, there has been no updated version to replace the one published in 2007 (see Figure 4.1, produced using the calculations of Noise Exposure Forecast (NEF) method developed by the Federal Aviation Administration (PCD, n.d.). This raises two issues. Firstly the forecasts could be incorrect if they were based on the incorrect assumptions on number and types of aircraft movements. Secondly, the development of housing projects within the contours may lead to an underestimation of the numbers of people affected.

Figure 4.1 Suvarnabhumi Airport Noise Contour Map



Source: AOT (2007).

N.B. NEF 45 = Leq 75 dB(A); NEF 40 = Leq 70 dB(A); NEF 36 = Leq 65 dB(A); NEF 30 = 60 dB(A)

Table 4.1: Forecast of Buildings Affected by Aircraft Noise at Suvarnabhumi Airport (2003)

Building Types	Leq 60-65 dB(A)	Leq 65-70 dB(A)	Leq 70-75 dB(A)	Leq> 75 dB(A)	Total Buildings
Governmental	5	2	5	-	**12**
Academic	35	11	-	-	**46**
Religious Sites	77	-	-	-	**77**
Factories	131	70	7	-	**208**
Residential	2,198	833	170	-	**3,398**
Commercial	85	20	2	-	**107**
Hospitals	5	-	-	-	**5**
Others	13	30	4	-	**47**

Source: Team Consulting Engineering and Management (2005).

By utilising satellite images from 2003, the environmental impact assessment report (2005) predicted the number of buildings affected by noise (Table 4.1). Buildings in the residential category are the most affected in terms of number at 3,398 households in total, 170 of which are in the noisiest Leq 70-75 dB(A) area. A total of five hospital buildings are also located under the noise contour area. Actual noise from aircraft activities at Suvarnabhumi Airport has been monitored by the PCD which reported that noise levels at the monitoring posts increased by 3-13.3 dB(A) in 2006 (PCD, 2006). Airports of Thailand reported that, in 2009, there were 8,966 household under the Leq 65-70 dB(A) whereas the 2005 report predicted that only 822 households would be affected. This suggests a gross underestimation of noise impacts at the airport. One reason is that proximity to the airport attracted property developers into the area and residential as well as commercial properties have been built (The Nation, 2005). As a result, the forecast does not reflect the real property growth in the area.

4.3 Air Quality at Suvarnabhumi Airport

Table 4.2 Pre-opening Air Quality at Suvarnabhumi Airport Monitoring Station (2001)

	Concentration (mg/m^3)		
	PM_{10}	SO_2	NO_2
Average Value	0.05	0.29	0.23
Legal Limit	0.12	0.30	0.32

Source: Team Consulting Engineering and Management (2005)

Table 4.2 shows the results of air quality monitoring that was conducted between 27 February and 8 March 2001 before the airport opened. Three pollutants were measured during the process and all were below legal limit. However, the level of SO_2 (Sulphur Dioxide) was approaching the legal limit at 0.296 mg/m^3 out of 0.3 mg/m^3 allowed under Thai law. Given the age of the data, there should be follow on measurements of air pollution at the airport to quantify the current level of air pollution. Also, the opening of the airport will bring the pollution to a higher level which suggests that some limits will be exceeded.

4.4 Mitigation Measures

The AOT (2009) has implemented land use management and noise abatement procedures to lessen the noise impact of aircraft at Suvarnabhumi. Land use management planning is based on the noise contours. Each area has been managed as follows:

1) Areas within Noise Exposure Forecast (NEF) > 45 (Leq 75 dB(A)) are declared as being the most severely affected areas. AOT has acquired all properties within the area.
2) Areas with NEF>40 (Leq 70 dB(A)) are declared unsuitable for residential purposes. AOT offers to buy properties on a voluntary basis or install noise insulation. There are 498 households in this category.
3) Areas with NEF 35-40 (Leq 65-70 dB(A)) are declared as moderately affected. AOT provides sound insulation to these properties where the noise level exceeds the legal limit. There are 8,966 households in this category.
4) Areas with NEF 30-35 (Leq 60-65 dB(A)) are declared as being minimally affected. AOT will provide sound insulation to these properties in case of noise level exceeding legal limit.

Overall, 70 properties were purchased. 739 and 15 public buildings were insulated at a cost of 983 million baht. Noise Abatement Procedures have also been introduced at Suvarnabhumi Airport to reduce the impact from aircraft noise. The procedures are as follow

1) Take-off: Departing flights are required to follow Standard Instrument Departure routes with thrust reduction between 1,500-3,000 feet above ground level. Acceleration is permitted only above 3,000 feet.
2) Landing: Minimum flap setting (as per certified by the aircraft manufacturer) must be used.

3) Thrust Reverser: No thrust reverser deployment between 0200-0600hrs unless it affects aircraft safety.
4) Engine Run-up Restrictions: engine run-ups are only allowed to occur between 0700-2200hrs in two designated areas.
5) Auxiliary Power Unit (APU) Operations: The airport provides a fixed ground power supply and mobile ground power units (in case the fixed supply is inoperative). Airlines are allowed to use APUs for no longer than 5 minutes.
6) Installation of Noise Monitoring Stations: the data will be reviewed on a bi-annual basis for possible changes to noise mitigation measures.

There are also other measures implemented which are a ban on Chapter 2 aircraft and the creation of an environmental department to handle environmental and airport area residents' concerns. Additionally, the pollution control department at the airport has installed air pollution monitoring posts. The Environmental Impact Assessment for Suvarnabhumi (2005) stated that noise charges or landing fees could be used to fund environmental improvement projects. It also suggested that noise and air quality should be assessed twice a year. However, none of these strategies have been pursued.

4.5 Conclusion

This chapter has outlined the available evidence on environmental impacts at Suvarnabhumi airport. However, the information available is limited and out of date. It appears that the impacts especially the aircraft noise were underestimated in the original EIA which is still being used as a reference by AOT. This study, by examining the value placed on such impacts by those affected will contribute to our understanding of environmental impacts at Suvarnabhumi airport and whether the mitigation measures in place are adequate.

5. REVIEW OF ENVIRONMENTAL VALUATION METHODS APPLIED TO AIRCRAFT NOISE AND CARBON OFFSETTING

5.1 Introduction

The process of ascribing a monetary value to an environmental impact is different from other goods as environmental impacts are not market goods. As a result, there is no market value for environmental damage as there is with other traded goods in a market. However, a number of methods to assign value to non-market impacts have been proposed. This chapter of the thesis introduces the methods of Hedonic Pricing (HP) and Stated Preference (SP) and examines the benefits and limitations associated with each method. In the case of SP method, both the Contingent Valuation Method (CVM) and Stated Choice Methods are evaluated.

5.2 Hedonic Pricing Method

Hedonic Pricing (HP) is often used to study the value of environmental characteristics that affect the price of market goods (Espey and Lopez, 2000). The application of HP in the context of examining aviation-related environmental impacts can be found in the area of hedonic pricing of property values near airports. Here, the Noise Depreciation Index (NDI) (the percentage change in property prices per unit increase in noise) is commonly employed (Navrud, 2002; Dekkers and van der Straaten, 2009).

The application of HP in property markets enables an environmental value to be elicited, as housing price is partly influenced by environmental characteristics including local air (and, in certain contexts, water) quality, noise level, scenery, availability of public facilities and transport access. In other words, HP uses property prices as a proxy to assess the characteristic value (such as noise and air pollution) of an area.

The main advantage of the HP method is that the data is gathered from actual market behaviour which is based on actual cost and benefits thereby allowing more accurate estimations of willingness to pay (Whitehead, *et al.*, 2008). However, there are a number of disadvantages associated with HP method. Whitehead *et al*. (2008) argue that the HP method is based on historical data which means that it is not possible to gauge the effect of new policy or products on the market. It is also difficult to analyse the economic benefits of a policy using Revealed Preference (RP) data. Secondly, HP requires accurate model specification as the decision making process in the property market is dictated by many factors, including (but not limited to) aircraft noise (Navrud, 2002; Nelson, 2004). Finally,

gathering HP data is a costly and complex exercise given that the housing characteristics, along with transaction price data, are difficult to obtain (Hensher and Louviere, 1983).

5.2.1 HP Studies Overview

The HP method has been widely employed to investigate the effect of aircraft noise on property values near airports. Table 5.1 details existing HP studies of aircraft noise on property values around airports. Most of these studies focus on cities in North America.

Noise Depreciation Index (NDI) values in Table 5.1 below range from 0% to 2.3%. On average, the NDI values are generally in the range of 0.5-0.8%. Interestingly, larger airports with more aircraft movements do not necessarily have a higher NDI value. For example, Winnipeg in Canada has an NDI of 1.30% whereas the larger and busier airport in Vancouver has an NDI of 0.65%. Also, NDIs for the same airport could be different, possibly due to differences in time period, sampling strategy and the estimation methods that are used. Sydney's NDI ranged from a high of 1.10% to statistically insignificant. The NDI value for the new Bangkok airport is relatively high at 2.12%. Only London Gatwick and Dallas have higher NDIs (of 2.3%).

Wadud (2010) conducted a meta-analysis of 65 HP studies that explored the effect of aircraft noise on property price and compared the results with previous studies by Schipper *et al.* (1998) and Nelson (2004). The NDI values ranged from statistically insignificant to 2.3% where the average NDI value is 0.5. The study concludes that research using linear specification in HP models normally report higher NDI values (19% higher) in comparison to semi-log models. Furthermore, the study found that higher relative property prices or higher income levels result in higher NDIs. The implication is that more affluent households are more sensitive to aircraft noise compared to those with lower incomes. Schipper *et al.* (1998) meta-analysis of 30 NDI values from airports in North America and Europe reported that NDI values vary significantly. The mean NDI value in this study was 0.83%. The research aligned NDIs of the original studies together with the relative mean value of properties. A more recent meta-analysis by Nelson (2004) used similar NDI studies to Schipper *et al.* (1998) but incorporated newer studies to give a total of 33 NDIs. The research concluded that the NDIs are generally in the range of 0.50-0.60% per dB. It also reported that differences in NDI values may be caused both by differences in the socio-economic conditions of each country and by individual model specifications.

Table 5.1: HP Studies on Aircraft Noise and Properties

Author	Location	NDI Estimate (%)
Emerson (1969)a	Minneapolis	0.58
Dygert (1973)a	San Francisco	0.50
Dygert (1973)a	San Jose	0.70
Price (1974)a	Boston	0.83
De Vany (1976)a	Dallas	0.80
Blaylock (1977)a	Dallas	0.79
Maser et al. (1977)a	Rochester	0.55
Paik-Nelson (1978)a	New York	1.90
Paik-Nelson (1978)a	Los Angeles	1.80
Paik-Nelson (1978)a	Dallas	2.30
Roskill Commission (1970)c	London Heathrow	0.71
Roskill Commission (1970)c	London Gatwick	1.58
Nelson (1978)a	Washington	1.06
Mieskopwski & Saper (1978)a	Toronto	0.52
Abelson (1979)a	Sydney, Marrickville	0.40
Mark (1980)a	St. Louis	0.56
McMillan et al. (1980)a	Edmonton	0.51
Nelson (1981)a	San Francisco	0.58
Nelson (1981)a	St. Louis	0.51
Nelson (1981)a	Cleveland	0.29
Nelson (1981)a	New Orleans	0.40
Nelson (1981)a	San Diego	0.75
Nelson (1981)a	Buffalo	0.52
Mason (1971)c	Sydney	0.00
Coleman (1972)c	Eaglewood, USA	1.58
Gautrin (1975)c	London Heathrow	0.62
Fromme (1978)c	Washington Reagan	1.49
O'Byrne et al. (1985)a	Atlanta	0.67
Hoffman (1984)c	Bodo, Norway	1.00
Levesque (1994)a	Winnipeg	1.30
Opschoor (1986)c	Amsterdam	0.85
Morey (1990)a	Coolidge	0.10
Uyeno et al. (1993)a	Vancouver (houses)	0.65
Uyeno et al. (1993)a	Vancouver (condos)	0.90
Pommerehne (1988)c	Basel	0.50
Burns et al. (1989)c	Adelaide	0.78
Pennington et al. (1990)a	Manchester	0.34
Gillen & Levesque (1990)c	Toronto	1.34
BIS Sharpnel (1990)c	Sydney	1.10
BAH-FAA (1994)b	Baltimore	1.07
BAH-FAA (1994)b	Los Angeles	1.26
BAH-FAA (1994)b	New York JFK	1.20
BAH-FAA (1994)b	New York La Guardia	0.67
Tarassoff (1993)b	Montreal	1.07
Kaufman (1996)a	Reno	0.34
Collins & Evans (1994)c	Manchester	0.47
Mitchell & McCotter (1994)c	Sydney	0.67
Yamaguchi (1996)c	London Heathrow	1.51
Yamaguchi (1996)c	London Gatwick	2.30
Myles (1997)b	Reno	0.37
Tomkins et al (1998)c	Manchester	0.63
Espey & Lopez (2000)b	Reno	0.28
Burns et al. (2001)c	Adelaide	0.94
Rossini et al. (2002)c	Adelaide	1.34
Salvi (2003)c	Zurich	0.75
Lipscomb (2003)c	Atlanta	0.08
McMillen (2004)c	Chicago	0.88
Baranzini & Ramirez (2005)c	Geneva	1.17
Cohen & Coughlin (2008)c	Chicago	0.69
Pope (2007)c	Raleigh	0.36
Dekker and van de Straaten (2010)	Amsterdam	0.77
Chalermpong (2010)	Bangkok Suvarnabhumi	2.12

Adapted from: Schipper *et al*. (1998)[a], Nelson (2004)[b], Wadud (2010)[c], with additional material.

5.2.2 Recent HP Studies

An example of a recent HP study in Europe is reported by Dekker and van de Straaten (2010). They investigated the impact of transportation noise near Amsterdam Airport (which included aircraft, rail and road traffic noise) using transactions from 1999 to 2003 and house characteristics in the regression. A log-linear model was used to analyse 66,000 transactions. This found that NDI for aircraft noise is 0.77 and this has the largest impact on property values among the three modes of transport. Railway and road transport NDIs were 0.67 and 0.16 respectively. The report notes that a reduction of 1dB equates to €1,459 EUR per house or a total of €575 million for all areas impacted by aircraft noise around the airport.

HP applications can also be found in the rental market. Boes and Nuesch (2011) employed a repeat rent model and used time series rental rates for the same properties to assess the impact of aircraft noise on rents around Zurich Airport. They suggest that this approach eradicates bias that arises from unobserved apartment and neighbourhood attributes that remain the same over time. Following the change in Zurich airport's runway utilisation, some areas have been subjected to increased noise. The study used 37,539 transactions between 2002 and 2008 to observe the change in runway utilisation implemented in March 2003. Only apartments with noise changes of more than 3dB were analysed and the study found that the NDI on rental rate as a result of the change was a decline of 0.54%.

Conversely, however, although aircraft noise can have a negative impact on property values, studies by McMillen (2004), Cohen and Coughlin (2008) and Tomkins *et al*. (1998) found that proximity to an airport can also have a positive effect on prices as a result of improved access to transportation and employment opportunities. Such findings align with those of Polasub (2010) at the old Bangkok Airport. McMillen (2004) examined 1997 property values around Chicago O'Hare Airport and found them to be 9% lower under the 65dB noise contour than to other areas in Chicago. The aim was to predict the effect of expanding O'Hare airport on aggregated property values. The study analysed 110,243 properties within two miles of the 1997 65dB noise contour. The proposed runway reconfiguration was found to reduce the noise impact on properties to the south and northwest of the airport whereas the properties to the east of airport would be exposed to increased noise. The result suggests that the proposed expansion may result in an increase of aggregated property values of $284.6 million. The explanation for the increase is that runway reconfiguration enables the runways to be used more efficiently and the retirement of older and noisier aircraft, along with the reduction of night flights, makes the area within the 65dB noise contour shrink by one-third.

Cohen and Coughlin (2008) used a spatial HP method (which also considers distance to the airport) to investigate the impact of aircraft noise in Atlanta, Georgia in 2003. Properties within the Ldn (Day-night average sound level) 70-75 dB(A) were found to have 20.8% less value than those in Ldn 65 dB(A) areas. The study assessed the price elasticity against airport proximity and reported an elasticity value of -0.15 (a 1% increase in distance makes the price fall by 0.15%) which close proximity to the airport has a positive effect when the noise variable is controlled.

Tomkins *et al*. (1998) also found that proximity to an airport elevates property prices near the airport. The semi-log HP equation observed 568 properties near Manchester Airport (UK) during 1992-1993 when expansion plans for a second terminal, an additional runway and an estimated 20,000-30,000 more jobs were proposed. The results suggest that it may be possible that improvements in access and employment prospects may outweigh the noise impact. For example, the properties under the Leq 60dB noise contour 2.5km from the airport had a predicted price of £70,795 whereas those situated 9km away from the airport had a predicted price of £59,387. The Leq 63dB noise contour reported a predicted price of £68,870 for properties 2.6km from the airport and £60,125 for those situated 7km away.

5.2.3 HP Studies in Bangkok

There have been two HP studies of Bangkok's airports. Firstly, Polasub (2010) employed the HP method to assess the impact of the old Donmuang Airport when it was in full operation (using 108 transactions from 2005) on house prices using the Spatial Autoregressive Model. A dummy variable was assigned to houses under the NEF 30 noise contour. Variables influencing the price were the size of the house, the size of the land plot, availability of a communal swimming pool, parks, distance from main roads and the distance from the airport. It was found that distance from the airport had a positive relationship with house prices whereas aircraft noise had no influence on the price. A 1% increase in distance from the airport saw the house price decrease by 0.23%. The implications could be that the level of aircraft noise is considered acceptable by residents around the airport or that the residents are aware of the noise pollution created by aircraft but they are willing to live in the area for better access to local amenities and transportation. In addition, 69% of respondents stated that they suffered 'medium' or 'low' level of aircraft noise disturbance and approximately one-third responded that aircraft noise had minimal or no effect on their decision to buy a house. Furthermore, 90% of homeowners did not take any actions to reduce noise from aircraft such as installing double glazing or other forms of noise insulation.

Secondly, Chalermpong (2010) employed the HP method to examine transactions between 2002 and 2008 to assess the aircraft noise impact at Bangkok Suvarnabhumi Airport. This airport began operating in 2006 and the transaction period of 2002-2008 was used to explore the anticipatory and actual effects of air traffic noise on local property prices. The data consisted of house size, structural characteristics of the property (such as the number of bedrooms), location variables (transport access, distance to the airport, distance to nearest expressway entrance and distance to transit station) and property prices in an area of 70 km^2 within the NEF 30 aircraft noise contour and above around the new airport. The study used 37,591 transactions of newly built houses from 2002 to 2008. However, most of these houses were built by large property developers and had similar characteristics and price therefore the final unique observation size was 384. The results showed no anticipatory effects to property values before airport opened in 2006. After the airport opened, property prices fell by 19.5% in the worst affected areas and by 8.55% in the moderately affected neighbourhood and the NDI value was reportedly 2.12%, which is comparatively high when compared with previous studies. Furthermore, the results showed that every 1km closer to a transit station increases property values by 1.8% and 0.97% for 1 km closer to the airport. The problems with these two studies in Bangkok is that they both used a crude noise measurement of NEF 30 noise contour owing to the lack of noise data making it less robust than it could have been. Also, the sample size is extremely small making it much less robust that it could have been. This opens an opportunity for this study to apply SC method to study valuation case of Bangkok.

5.2.4 Conclusion for HP Studies

HP has been well established as a method to assess aircraft environmental impact though an assessment of property prices in areas around airports. It has been extensively applied in North America and Europe but not much elsewhere. The HP shows that aircraft noise generally has a negative impact on property prices but it also suggests that proximity to an airport can also be beneficial as a result of increased employment opportunities and better transportation access. In the case of Bangkok, despite the problem with crude noise measurement and small sample, research suggests that airport noise has a significant impact on property values but it also confers some benefits at the same time. This gives the opportunity for this research to investigate in more detail how, why and to what extent different attributes of the airport environment affect the quality of life of local airport residents.

5.3 Stated Preference (SP)

The SP approach enables the valuation of non-market goods based on a hypothetical setting where respondents are given hypothetical questions and scenarios to elicit a value of their Willingness-to-Pay (WTP) or Willingness-to-Accept (WTA). Within the SP approach, researchers may either employ Contingent Valuation Method (CVM) or Stated Choice (SC) to elicit individual values. The main difference between the SP and HP approach is that while SP is based on a hypothetical market, HP method (HP) is based on actual market observation. The advantages of SP over HP are summarised by Wardman and Bristow (2004) as follows:

- Correlations between variables can be avoided during the survey design.
- Variation of data can be obtained sufficiently through the control of attribute levels.
- SP can offer better trade-off options than the real world.
- SP can be used to analyse a product that doesn't exist in the real world or attribute a level that does not currently exist.
- More accuracy in estimation as more data is collected.
- SP can be designed to reduce the key influence on secondary variables.
- There is no measurement error in the independent variables.

5.3.1 Contingent Valuation Method (CVM)

The CVM approach directly obtains environmental valuation in hypothetical markets through the elicitation of an individual's willingness-to-pay (WTP) or willingness-to-accept (WTA; Bjonstad and Kahn, 1996). For example, respondents are asked how much they are willing to pay for improvements to their environment. Alternatively, respondents are asked how much compensation they are willing to accept to endure a sub-optimal environmental condition or a future deterioration to that condition. The components in a CVM questionnaire should include the payment vehicle (such as a tax or offsetting fee), details of the socio-economic background of the respondents and the question of WTP/WTA itself. CVM surveys can be either open-ended or closed-ended. For open-ended CVM, respondents are asked to specify the maximum willingness to pay to improve a specific environmental condition where the WTP/WTA functions can be written as (after Mitchell and Carson, 1989):

$$WTP = f(S_j; \Delta Q) \quad (5.1)$$

$$WTA = f(S_j; \Delta Q) \quad (5.2)$$

In this case, S_j is the sampled respondents' variables of j characteristics such as income, age, gender and environmental behaviour and ΔQ is the change in environmental quality. Close-ended CVM is the method in which respondents are given a specified value of WTP or WTA. For example, respondents may be asked if they are willing to pay a tax of £20/month to improve local air quality. Close-ended CVM could be either 'single bid' which asks respondents whether they are willing to pay or accept that specified amount. Alternatively, double bounded close-ended CVM can be used. The respondents are first given a single price. If the respondent accepts it, they will be given another price which doubles the original price to see if they accept it. On the other hand, if the respondent rejects the given price, he/she will be given another price which is a half of the original value to see if he/she accepts it.

The application of CVM can be found in traffic-related studies of environmental impact that includes impacts from railway, road, and aircraft noise. Navrud (2002) and Brons *et al.* (2003) reviewed CVM studies of transportation improvement impact in Europe. Most of the studies elicited the WTP value by using noise annoyance reduction scenarios. The applications of CVM to aircraft noise have mainly been conducted in Europe and are summarised in Table 5.2.

Table 5.2 CVM Studies of Aircraft Noise

Scenario	Study	Data Period	Location	WTP (Historical exchange rated adjusted for inflation)
50 % noise reduction/household/year	Pommerehne (1988)	1988	Basel, Switzerland	£32.73
	Thune-Larsen (1995)	1994	Oslo, Norway	£112.14-556.96
	Faburel & Luchini (2000)	1998	Paris Orly Airport, France	£51.13
WTP to buy a new property in the areas with less aircraft noise	Feitelson *et al.* (1996)		Israel	£108,000 (no noise), £70,200 (severe noise)
Stop flights increase per month	Caplen (2000)	1998	Southampton	£3.35(day)-£9.11(night)

Adapted from: Navrud (2002), Brons *et al.* (2003)

Caplen (2000) employed CVM to study aircraft noise effects on residents near Southampton Airport in 1998. Some respondents were given a questionnaire to elicit WTP and the remaining respondents were contacted to arrange a verbal interview. The question asked for WTP to stop or WTA to allow a 'noticeable' difference in aircraft movements (a 10% increase). In the model estimation, two dummies were assigned, one for the membership of residents associations who voiced the concerns of the local population for noise coming from the airport. The second dummy was for double glazing. The mean income is £12,000 per annum. A total of 116 questionnaires were completed with the mean age of respondents being 59 years old. 87% lived in property with double glazing. The results found that mean WTP to stop a flight increase was £3.35 per month and £9.11 for night time (2300-0600hrs) increase. WTA to allow flight increase was £8.13 during day time and £23.30 during the night time. Respondents wished to extend the night-time period although there are disagreements in terms of the period that should be designated as 'night time' as older and younger respondents had different preferences.

Feitelson *et al*. (1996) employed CVM to assess WTP and argued that WTP is more similar to purchasing decisions in a household than WTA as, in reality, people generally spend money to improve their living conditions. The study used telephone surveys in the areas that would be affected by airport expansion. The property owners were asked for WTP for a 4-bedroom property in the area without aircraft noise and then asked for WTP for the same home but located within the area with different aircraft noise exposure and flight frequencies. The renters were similarly asked about a 3-bedroom property and monthly rental rate are used instead. Respondents were given 10 noise scenarios in the property and asked to elicit their WTP ranging from no noise at all to severe noise. 10.8% were not willing to pay at all whereas 31.4% were not willing to pay for property with occasional severe noise and 45.1% were not willing to pay for properties with frequent severe aircraft noise. For rented properties, 4.4% were not willing to rent a property with any level of noise and 42% were not willing to pay for a property with severe frequent aircraft noise. In terms of property values, homeowners were willing to pay for a property with no noise for £108,000 and tenants were willing to pay a monthly lease of £391.67. On the other hand, property with severe noise level had a mean WTP of £70,200 for property price and £285.34 monthly rent.

Pommerehne (1988) used HP and CV methods to assess traffic noise impacts (including aircraft) in the Swiss city of Basle using 1988 data from 223 properties. The HP study reported that an increase in one unit of NNI (Noise-and-Number-Index) resulted in property price increases of 0.22% In the CV exercise, respondents were given a hypothetical situation of moving to a nearby street with 50% less aircraft noise and the WTP to halve the aircraft noise was approximately45 CHF per household per year.

Faburel and Luchini (2000) employed CVM to study the WTP for aircraft noise reduction in six districts surrounding Paris Orly Airport. The survey was conducted during 1998-1999 and invloved 607 respondents. More than 50% of the respondents stated that they were annoyed by aircraft noise, 98 respondents stated that they were 'very bothered' by aircraft noise, 40 of whom were living within the extreme noise area (Lmax > 80dBA). During the CVM exercise, the respondents were given 2 successive offers (referendum with double interval) to elicit their willingness to pay. The study had the problem with the results with the full sample so it had to exclude the respondents who had zero WTP valuation from the analysis thereby making a final sample size of 510. Results showed that the mean WTP was 45.87 Francs per household per month with an aggregated value of 12 million francs per year. In terms of differences in aircraft noise, the areas with Lmax >80 dB(A) has a WTP of 547 francs/person/year, Lmax 75-80 dB(A) had a WTP of 203 francs and 70 francs for the areas with Lmax 70-75 dB(A). These studies show that CVM allows overall noise problems from the aircraft to be valued but they did not address different attributes created by noise problem. This can be achieved using SC method as described in the next section.

5.3.2 Stated Choice

The theoretical background of the SC method is based on choice theory and the principle of utility maximisation (Ben-Akiva and Lerman, 1985). That is to say when people are faced with choice they choose an option that maximises their utility by evaluating the attributes of available alternatives.

There are a number of theories and assumptions involved to facilitate the choice behaviour analysis. Firstly, the choice theory which Ben-Akiva and Lerman (1985) provides a framework of choice theory as '*an outcome of a sequential decision-making process*' which is divided into a five-step process:

1. Definition of choice problem
2. Generation of alternatives
3. Evaluation of attributes of the alternatives
4. Choice
5. Implementation

Secondly, an assumption of rational behaviour which assumes that an individual's decision given the same circumstance and same attribute will be consistent is used (Meyerhoff and

Liebe, 2009). This is then applied to the economic consumer theory which suggests that individuals choose a bundle of goods based on utility within budgetary constrain.

However the economic consumer theory was extended into discrete choice theory because it does not include assumption on the characteristics of the alternatives (Ben-Akiva and Lerman, 1985). As a result, Lancaster's consumer theory was introduced which considers an alternative as a collection of attributes not just as a bundle whereby consumers' utilities are derived from attribute (Lancaster, 1966) which is the concept that the SC method is based upon.

In practice, respondents participating in SC studies are given a set of SC choice cards (see Figure 5.1 for an example of a choice card). Each option comes with different attributes to choose from and asks the individual to evaluate trade-offs between different attributes and choose the option that maximises his/her utility. Louviere *et al*. (2004) stated that the framework for SC experiment is based on the consumer decision process. In this context, the consumer must firstly be aware of the problem(s) that need to be solved. Consumers then study the products or choices available and form perceptions of each choice. Consumers then compare the value and trade off attributes of each choice. These are then used to develop a preference order of the available choices. Finally, they will make a decision about whether or not to purchase and which option to purchase based on their preference order and other constraints

Figure 5.1 Example of SC Choice Card

	Alternative 1	*Alternative 2*	*Alternative 3*
Early morning 7 am – 9 am	16 per hour	12 per hour	3 per hour
Morning 9 am – 12 noon	10 per hour	10 per hour	5 per hour
Afternoon 12 noon – 5 pm	11 per hour	11 per hour	5 per hour
Evening 5 pm – 10 pm	12 per hour	6 per hour	0 per hour
Your payment per month for a reduction in noise (per year)	0 SEK (0 SEK)	50 SEK (600 SEK)	75 SEK (900 SEK)
Your choice			

Source: Carlsson *et al*. (2004)

The SC method shares similarities with CVM because both ask respondents to elicit a value of non-market goods based on hypothetical scenarios. Each option comes with different attributes to choose from and requires the individual to evaluate trade-offs between different attributes and choose the option that maximises his/her utility. Louviere, *et al*. (2004) stated that the framework for a SC experiment is based on the consumer decision process. The consumer must firstly be aware of the problems that need to be solved. Then consumers

learn more about the products or choices available to them and form perceptions of each choice. Consumers would then form a utility function by comparing value and trade off attributes of each choice which are then used to develop preference order for available choices. Finally, they will make a decision on whether or not to purchase (and, if so, which option to purchase) based on preference order and other constraints. For the design of SC experiments, Carlsson and Martinsson (2008) identified three key steps. The first involves determining which attributes should be included. The next is to decide the level of attributes and the number of options. The final stage involves determining which attribute levels are to be included in which option set. The differences between SC and CVM have been described as follows:

- SC method is more flexible than CVM as SC allows several attributes to be valued simultaneously whereby respondents are asked in a manner that is similar to actual purchasing decisions (i.e. choosing between different products with different trade-offs) and the method is applicable to the Lancaster's consumer theory (Lusk and Schroeder 2004; Wardman and Bristow, 2004).
- SC asks for order of preference whereas CVM asks for strength of preference (Wardman and Bristow, 2004).
- SC is a behavioural model of implied values. On the other hand, the CVM is a direct valuation method (Wardman and Bristow, 2004).
- The SC has the ability to accurately to control choices and attributes to respondents allowing variables' correlation (that is typical of RP exercises) to be avoided (Hensher and Louviere, 1983; MacKerron, *et al.*, 2009).

5.3.3 Issues with Stated Choice Method

a) Problems with WTP and WTA

Zhai and Suzuki (2008) state that WTP can be used to obtain a monetary value of the public to improve a condition such as WTP for reductions in noise impacts from aircraft and associated environmental damage. WTA elicits the valuation by asking how much the respondents are willing to accept compensation for negative changes in personal circumstances. Horowitz and McConnell (2002) and Zhai and Suzuki (2008) both suggest that WTA valuations are normally higher than the values gained from the WTP method. Horowitz and McConnell (2002) reviewed studies of WTP and WTA to see the factors that

influence differences in WTP and WTA elicitation. They found that if one non-market good shares a closer characteristic with the real market than another non-market good the valuation differences between WTP and WTA will be smaller than the one that has less similarity to the real market good. According to Mitchell and Carson (1989), problems with WTA could arise as some respondents may state that their WTA is infinite in value or overstate the value. Whereas problems with WTP may arise as respondents might have difficulties in eliciting a maximum WTP value (particularly in a hypothetical condition).

b) Bias Issues

Lu (2007) categorises bias in SC method into two groups: design bias and response bias. The types of design bias are summarised in Table 5.3.

Table 5.3: SC Design Bias

Type of Bias	Description
Framing Effect Bias	Respondents respond to the same problem differently if given a different description of the problem.
Packaging Effect	Respondents elicit the value of the bundled choice less than the sum of the value of each part of the choice.
Unfamiliarity	Respondents with less experience or understanding of the attributes value the attribute/choice set differently from respondents with experience and understanding of them.
Unrealistic Value	When the value given in the hypothetical setting doesn't reflect the reality, respondents may misinterpret the choice set or attributes.

Adapted from: Lu (2007); Meyerhoff and Liebe (2009)

Response bias which is caused by the response of respondents is presented in Table 5.4 below.

Table 5.4: SC Response Bias

Type of Bias	Description
Status Quo Bias	Respondents have a tendency to choose the current state of being rather than choosing other options (i.e. they choose the 'as now' or current situation).
Simplifying Bias	When respondents are given complex alternatives and attributes they may change their decision strategy to simplify the choosing.
Social Norm Bias	Respondents state their preferences based on an anticipation of what other might say or a social norm rather than stating the true value.
Strategic Bias	When SC is used to assess new policy, respondents may state a preference using a strategy to obtain a favourable outcome rather than stating their true preference.
Protest Bias	Respondents may have a protest attitude towards the issue and therefore may have a tendency to focus on the attributes that are close to their protest attitude rather than their true preference.

Adapted from: Adamowicz *et al*. (1998); Lu (2007); Boxall *et al*. (2009

The biases mentioned above will be addressed in the presentation design for this research using the information and discussions derived from the experimental focus groups. During these focus groups, choice cards were tested. The findings from these focus groups informed the final design by taking account of any biases that may arise from respondents.

c) Attribute Level Presentation

Given the flexibility of a hypothetical scenario presentation in SC method, different approaches have been used to present attribute levels to respondents to elicit their WTP. Firstly, Thanos *et al* (2011) state that the use of categorical scales (for example noisy, very noisy or moderate pollution, low pollution) is problematic when attempting to relate individual's stated scale to the actual exposure and also the change from one level to another. For percentage changes as a medium of presentation, Thanos *et al* (2011) suggest that percentage change is a common presentation method but there is difficulty in terms of respondents' understanding when relating to an actual situation. In context of aviation, aircraft movement changes have often been used as a proxy for aircraft noise (Wardman and Bristow, 2008; MVA Consultancy, 2004; Carlsson *et al*, 2004). Respondents have to consider changes in the number of aircraft movements and interpret it into actual exposure. This process may lead to misinterpretation of the reality and over or under estimation of a

WTP value. Another method is to present respondents with different locations of property with different exposure levels. However, property characteristics must be the same and respondents need to be familiar with the presented areas (Thanos *et al.* 2011).

Table 5.5 Stated Choice Studies of Airport Noise

Study	Data Period	Location	Scenario	WTP/WTA (adjusted inflation and historical exchange rate)
Carlsson et al (2004)	2003	Stockholm Bromma	Changes in aircraft movements in different periods of day per month	£0.50-£2.35
MVA Consultancy (2004)	2005	United Kingdom	WTP for reduction of one aircraft per period per month	£1-£5 (turboprop) £2-£10 (Jumbo)
Wardman & Bristow (2008)	2002	Manchester	WTP for reduction of a flight in different time periods	£0.005-£0.061
Wardman & Bristow (2008)	2002	Lyon	WTP for reduction of a flight different time periods	£0.017-£0.136
Wardman & Bristow (2008)	2002	Bucharest	WTP for reduction of a flight in different time periods	£0.002-£0.05
Thanos et al (2011)	2005	Athens	WTP for zero aircraft noise per household per month	£7.73 for old airport £10.64for new airport
Chalermpong & Klakleung (2012)	2011	Bangkok	WTA for an increase of a flight per month	£0.39-1.41

Table 5.5 details SC studies of aircraft noise impact and WTP. In the aviation context, Carlsson *et al.* (2004) used SC method to assess the WTP for aircraft movement changes (which is interpreted as noise changes) in different time periods at Stockholm's Bromma Airport. Respondents were given the hypothetical situation of increasing (with compensation payment) or decreasing (with additional payment) numbers of aircraft movements and asked to state their preferred option. The SC question card was designed using a D-optimal design procedure consisting of 15 choice sets for increase and decrease in movements for both weekends and weekdays. Each respondent was given 5 to 15 choice sets of different times of the day for both weekdays and weekends. 46% of 1558 questionnaires were completed and used in the analysis. Mixed logit model was used for the estimation. The results showed that the marginal WTP (the WTP for a decrease or increase in one flight) was 10 SEK per month for weekday early mornings and 20 SEK per month for weekend mornings. It also reports that a significant number of respondents preferred the current level of traffic (45% for the increase and 75% for the decrease situation version) particularly among the respondents who regularly use Bromma Airport. There was an issue with this study as the some of the coefficients signs for aircraft frequency were positive and this was unexpected and illogical.

Also, it was mentioned that in fact the aircraft noise problem at the airport only caused small annoyance to residents.

Wardman and Bristow (2008) employed two SC formats to see if a transparent design yielded different (i.e. higher) value than a non-transparent design due to response bias for aircraft noise at Manchester, Lyon and Bucharest airports. The first was a standard SC with pairwise comparisons of two alternatives consisting of local tax and aircraft movement. The second, a newly developed Priority Ranking approach used to assess the effect of aircraft noise within a quality of life context. The standard SC is based on binary choice format of a few attributes which considered trade-offs between local tax and flight frequencies. Air traffic was grouped into jumbo jet, twin-engined jet, and turboprop categories for respondents to consider air traffic for each aircraft type in different time periods. The fractional factorial design was used for the scenario design and produced 16 choice sets. Each respondent was subsequently given 8 choice sets to obtain a valuation. In the Quality of Life experiment, aircraft noise was assessed along with 9 other quality of life indicators with local taxes. Respondents were asked about aircraft annoyance either by movements or through a description of the noise (such as extremely noisy). Respondents to choose the most preferred improvement and then disregard the selected option (by assuming that option was not available) and chose the next preferred option. The process was repeated until all choices are exhausted to obtain a ranking of preference. After the improvement ranking is completed, the respondents were asked to evaluate the deterioration by stating the worst scenario in the same manner with the improvement evaluation but starting from the worst scenario to the least bad.

The standard SC experiment reports the WTP for one aircraft movement was 0.75, 5.42, and 36 eurocents at Manchester, Lyon and Bucharest, respectively during weekdays 9am-6pm and 6.94, 2.94, 1.31 eurocents during Sunday. Priority ranking improvement results suggested that time of the day has an effect on the WTP and Lyon has a high sensitivity to cost. The day-time and evening improvement value is 1.48 and 1.89 cents per flight in Manchester and 1.26 and 5.68 cents in Lyon. For Priority Ranking deterioration, the study found that the value is not statistically significant for evening movements at Manchester and Bucharest. Lyon evening movements were valued at 4.75 cents per flight. An attempt to remove illogical responses (such as choosing invalid orders and mis-trading) was made to find a better fit for the model but it was still unable to make it statistically significant in the first SC. The study states that strategic bias may have an influence on respondents and results given the difference in values obtained.

In the UK, the MVA consultancy (2004) investigated aircraft noise at the 20 largest airports in England using CVM and SC. Council tax was used as payment vehicle. In the CVM study, the respondents were asked whether to remove all aircraft noise but pay up £500 a year or maintain the same level of noise and retain £500. Those who were willing to pay £500 were then asked the maximum amount that they were willing to pay to remove the noise. Those who were not willing to give up £500 were given show cards from £450 to £0 a year with a reduction of £50 for each step.

In the SC experiment, the time period was separated in to six periods of four hours each. Respondents were given three periods with four question sets for each period. There were three options for each set. The respondents were asked to state the most and least preferred option (ranking). To familiarise the respondent, samples of recorded aircraft noise were played along with a presentation of current level of aircraft activities. The SC result gave a comparatively high WTP per month (for example the reduction of one aircraft during 1100-1500 in the LAeq>60 dB is £5-£9 per “Jumbo” and £2-£6 per “Under-wing” aircraft). The study stated that it could not explain the cause of the high SC value but suggests that it may be the result of SC design problem, problems in relating time period and aircraft activities, along with problems in data capture and analysis. Additionally, package effect and bias issues may contribute to the high value.

The CVM study reported that 57% of respondents were not willing to pay to eradicate the aircraft noise. Of those, 32% were not annoyed by aircraft noise, 14% chose not to pay on principle and 3% couldn’t afford to pay. By taking noise exposure levels into consideration, it was reported the average WTP value of £0.27 per week or £14 per household annually to reduce one dB of aircraft noise.

The SC method was to investigate the aircraft noise changes within the context of airport relocation in Athens by Thanos *et al*. (2011). The study stated that airport relocation allows SC method to assess the ‘actual inter-temporal noise change’ whereas SC studies are normally based on a hypothetical setting. The SC exercises were divided into three groups; new airport, old airport and old airport with land use. The latter exercise was included to assess how the residents would like the old airport land be used. Municipal tax was used as the payment vehicle and five levels (of €10, €20, €35, €50 and €60 per month) were offered. The attributes included public transport travel time to the city centre during the peak period, availability of tram stops within walking distance and aircraft noise at home (no aircraft noise/ with aircraft noise). An orthogonal fractional design was employed to produce 25 choice set for each SC exercise and each individual was presented with eight randomly selected choice cards. The survey was conducted in 2005 via face-to-face interview with 700 respondents.

The findings report that WTP to remove all aircraft noise at the new airport was €13.12 per household per month and €9.53 to avoid aircraft noise at the old airport. For the WTA, residents near the new airport have a WTA of €81.77 per household per month and €59.43 for the old airport. Additionally, WTP per dB reduction in aircraft noise was reportedly €1.11 and €1.14 per dB at the new and old airport, respectively.

In Suvarnabhumi's case, Chalermpong and Klaiklung (2012) studied the WTA of rent reduction of 189 students living near the airport for a proportional increase in flight movements. It was found that the WTA is 18.87 to 62.86 baht per month. The problem with this study is that it chose students as respondents which is not a true representation of residents in the area and could be the reason for high WTA values as respondents were mostly students with little or no income and so it was likely that they were much more sensitive to reduction in rental cost with is the payment vehicle than the aircraft noise issue.

5.3.4 Comparisons between CVM and SC studies

The CVM studies into airport noise reviewed in this chapter are mostly based on the double-bound bidding format and the popular choice of hypothetical scenario is 50% reduction in aircraft noise. Comparing results between different studies is difficult due to differences in the scenarios presented to the respondent. For example, the WTP to reduce aircraft noise by 50% at Paris Orly is £74.04 per year (Faburel and Luchini, 2000) while the corresponding figure was £32.30 at Basel Airport (Pommerehne, 1988). This may be explained as Basel Airport has fewer aircraft movements. Feitelson *et al*. (1996) used a different hypothetical approach by asking respondents for WTP to buy or rent property in a different area of varying aircraft noise exposures and ask for their overall willingness to pay for a house, not for additional payment as favoured by other studies.

Four SC studies of noise around airport have been reviewed. Aircraft movement in different periods of the day is the most frequently used scenario. This has the benefit of differentiating how people value aircraft noise at different time periods. The values per aircraft movement differed significantly from £0.002 per flight to £0.06 owing to the aircraft size (which is used as a proxy to represent aircraft noise) and time of day (Wardman and Bristow, 2008). As with the CVM studies, comparison between different studies are difficult as the scenarios offered are different. However, MVA Consultancy (2004) appears to report a very high WTP value for a single aircraft reduction from £1 to £10 per month.

There have been studies that use both SC and CVM but those are also difficult to compare. MVA Consultancy (2004) used different scenarios for each method, namely aircraft movement changes for SC which report WTP of £1-£5 for a reduction of one turboprop aircraft per month and £2-£10 for 'Jumbo' aircraft whereas in CVM it asked for a total removal of aircraft noise which yielded an average WTP of £1.08 per month to reduce 1dB of aircraft noise (adjusted for different noise exposure area). Wardman and Bristow (2008) also employed CVM to compare with SC method. The CVM question asked for a scenario of reducing noise by half and it reported a daytime WTP of €1.96, €8.92 and €0.05 for Manchester, Lyon and Bucharest, respectively. The CVM WTPs reflect the result of SC in which Lyon has the highest valuation and Bucharest has the lowest (5.45 and 0.36 eurocent, respectively for one aircraft reduction during weekday mornings).

Although it is difficult to compare results owing to the difference in the scenarios presented, it shows the flexibility of the SP method that allow researcher to frame the question and scenario that are suitably adapted to the different sites and cases especially in terms of attribute categories and levels. The majority of CVM studies use noise reduction as a basis for the scenarios whereas the SC studies seem to favour using flight frequency to represent aircraft noise. Nevertheless, when identifying the value per flight, the WTP to reduce aircraft noise for one flight may be unrealistically high in some cases.

5.3.4 Stated Preference Studies on Carbon Offsetting

Table 5.6: Aviation Carbon Offsetting Studies

Study	Location	Route	WTP
Brouwer *et al*. (2008)	Amsterdam		£22.68
Mackerron *et al.* (2009)	United Kingdom	New York-London	£26.49 (CV) £26.81 (SC)
Lu and Shon (2012)	Taipei, Taiwan	China Far East Asia Southeast Asia Western	£3.30 £5.81 £7.13 £18.88

The CVM application has also been used to elicit WTP for carbon offsetting of air passengers (see Table 5.6). Brouwer *et al.* (2008) conducted a study in 2006 at Amsterdam Airport using face-to-face interviews asking respondents for their WTP to offset carbon

emission from air travel along with air travellers' awareness of environmental impact created by flying. Over 400 respondents were asked if they were aware of the Kyoto Protocol as a proxy of their environmental awareness and concern. Secondly, respondents were asked if they were willing to pay a carbon tax 'on principle' (14% of respondents refused to pay as they mostly argued that the tax is unlikely to solve the problem). Those who rejected the given price were then given a lower price. Lastly, respondents were given an open-ended question on the maximum price. The result found that the open-ended value is much higher than the double-bound value. It found that air travellers from the EU had the highest WTP of £23.65 per flight followed by North American passengers at £17.96 per flight and Asian travellers at £14.31 per flight. Overall, it was found that the WTP for offsetting carbon emissions is £20.54 per flight.

Mackerron *et al*. (2009) employed both CVM and SC methods to examine WTP for aviation carbon offsetting among young adults in the UK. An online survey was used as it was suggested that online surveys reduce interviewer bias and allow respondents to proceed at their own pace. In CVM, the respondents were given a situation of travelling from New York to London and asked if they were willing to pay the randomly offered price with double-bound bidding. Half of the respondents were given question cards which state the certification by the UK government for the scheme and the rest make no mention of the certification. In the SC experiment, respondents were given an explanation of the certification programme and associated co-benefits (conservation, biodiversity, human development and low carbon technology). Each respondent was given 6 choice cards. Each card consisted of three options (two offsetting options and one no offset) with three attributes (co-benefit, certification and price). An orthogonal design was used to produce 24 scenarios from the maximum 40 possible scenarios (4 co-benefits x 2 certifications x 5 prices). For the analysis, the CVM data was analysed using logistic regression and the SC data was assessed by mixed logit model. A total of 321 young adults with high-education were sampled. The WTP value from CVM was £26.49 per flight, the SC valuation was £12.47 per person per flight and the implicit value for certification was £11.14 The explanation for the high value of certification was that when respondents are aware of a certified programme they become more doubtful about the uncertified one. For the co-benefit valuation, biodiversity was the highest at £14.98. In comparison with Brouwer *et al*. (2008), this study has much lower value (£12.47 against Brouwer's £20.54 per flight). Nonetheless, the values are similar to Brouwer *et al*. (2008) if the carbon offset programme is certified by the government (£23.61 per passenger per flight against £20.54) as respondents believe that it gives the offsetting programme more credibility.

In Asia, Lu and Shon (2012) employed CVM for a study of WTP for carbon offsetting of Taiwanese air passengers in different flight lengths. WTP values range from £3.30 for flights to China to £18.88 to western destinations.

5.4 Conclusion and implications for this study

This chapter has reviewed the methods that can be used for environmental impact valuation in both revealed preference and stated preference methods. Stated Choice will be employed in this study for the following reasons. Firstly, the stated choice method data is more practical and cost effective to obtain as the data can be derived from questionnaire and interviews whereas the HPM requires the compilation of property prices and the process could be more complicated and time consuming and the availability of data is limited. The SC method also allows this study to assess how respondents value the environmental impacts of aviation through various attributes. Additionally, as this study proposes to examine the aviation environmental problems from the views of both the polluter and the affected parties, using HPM will not reveal the value of noise abatement of air transport users.

There are issues that need to be addressed in the area of survey design for stated choice method which may cause biased responses. The studies reviewed in this chapter reveal a number of important issues. Firstly, the NDI index shows varying degrees of difference, from no effect up to 2.3% and an average NDI of 0.5% (in which Bangkok Suvarnabhumi NDI show a relatively high NDI of 2.12% and the study itself is of questionable robustness). Taking the work of McMillen (2004), Cohen and Coughlin (2008), and Tomkins *et al*. (1998) into consideration, there is the opportunity to explore the benefits from improved access and employment opportunities at the new Bangkok Airport through stated choice. Reviews of CVM and SC methods reveal different hypothetical settings used by various studies which are primarily based on 50% aircraft noise reduction, noise relocation and changes in aircraft movement changes. The implication is that there are various ways to ask the respondents to obtain the valuation and each scenario yield different values. It is therefore important to ensure that the hypothetical settings are realistic and easy for the respondents to understand. It was therefore necessary to conduct a number of focus groups to ensure the choice and presentation of attributes was appropriate for the intended respondents.

6. FOCUS GROUP DESIGN AND IMPLEMENTATION

6.1 Overall Approach

This experimental study has two key stages beginning with the qualitative study which has two aims. The first of these two aims is to explore the opinions of local residents and air passengers about the advantages and disadvantages of aviation activities. Residential areas around Bangkok airport are expanding rapidly due to growing employment opportunities and improvements in transportation access. The second aim is to report on the pilot of the Stated Choice (SC) experiment using different presentations and attributes to elicit both residents' and air passengers' willingness to pay to reduce aviation's environmental impact. This process will identify problems associated with the SC card presentation and reveal any difficulties respondents experience with the presentation of different proxies for aircraft noise attributes, price range, payment vehicles and any other issues. This feedback will directly inform the final SC study in the second stage. The results are reported in Chapter 7.

The second stage of this study is a combination of social survey and SC exercises. The aim is to obtain residents' and passengers' attitudes and awareness of aircraft impacts and obtain valuation of aviation externalities. The social survey results on attitudes and awareness will be used to analyse the respondent's characteristics and their impacts on valuation and attitudes towards aviation externalities.

6.2 Qualitative Method

Focus groups were used as the survey method in this qualitative study. While direct interviews are an appropriate tool when a researcher wants to test theory, gather opinion or obtain narratives (Flick, 2006), this method was not selected because one-to-one interviews are time consuming and this study required a relatively large number of participants to gather general perceptions and attitudes about aviation externalities from two target groups. Interviews also risk isolating individual interviewees. This scenario may restrict daily life interaction elements when discussing perceptions and attitudes of the participant (Flick, 2006; Babour and Kitzinger, 2000). The advantages of focus groups are that they create a dynamic group discussion and provide checks and balances to extreme views (Flick, 2006). The dynamic nature of focus group interactions encourage participants to share their perceptions and engage in self disclosure to the group (Krueger and Casey, 2000; Barbour and Kitzinger, 1999).

Focus groups were chosen for this phase of the research because of the following properties. Firstly, focus groups are a tool to explore views, wishes and concerns on certain topics and try to understand differences among a group of participants (Krueger and Casey, 2000; Babour and Kitzinger, 1999). Thus focus groups may be used to explore perceptions of airport residents and air passengers of aviation externalities and identify similarities and differences among participants. Secondly, Krueger and Casey (2000) stated that they can be used to identify factors that influence decision making and behaviour. The economic implications of living near an airport to understand peoples' reasons for moving to the airport or decision not to move away from the airport. Lastly, focus groups can be used to test-run design or ideas which could then be used to define further research (Krueger and Casey, 2000; Babour and Kitzinger, 1999). This ability allows the testing of different SC presentations to assess the practicalities and cognitive burden and obtain feedback from a group of participants.

6.3 Focus Group Design

Two groups of participants were used in this study in line with the aim of the research to assess the attitude and perceptions of environmental problems created by aircraft from the perspective of the polluter and the polluted. The first group was the residents around the airport. This group was chosen to represent those who are most likely to be affected by aviation externalities. The reason is that they are living near the airport and may be subject to direct air and noise emissions from it. They are also the people who may enjoy economic benefit from being in close proximity to the airport. The second group comprise air passengers. They were included to represent the views and environmental awareness of the polluting party.

6.3.1 Airport Resident Groups

The focus group sessions were designed to obtain information on how people react to aircraft activities and identify the differences between those who have lived in the area before the airport opened and those who moved in later for potential direct and indirect employment. It addresses the priority or trade-off decisions of residents between economic benefits and negative environmental impacts from the airport (pollution, traffic congestion, safety and potential health problems). Furthermore, it is used to identify different problems or severity of noise in different areas around the airport to examine if the perceived annoyance corresponded with the actual level of recorded noise.

Four focus groups with eight participants in each group from areas both to the south (Bangna) and the north (Ladkrabang) of the airport were undertaken. A total of 1 hour and 30 minutes was allotted for each session (thirty minutes for each topic and another thirty minutes for SC card testing). Details of the participants and recruitment strategy for these focus groups are provided in Appendix A. Section 6.4 describes the general characteristics and background of the areas around the airport to provide a better understanding of the situation.

The pilot study recruited those who are between 21-60 years old which is the age group that has economic power (in the labour market) and make decisions in Thai households. Only those who lived within the noise contour of NEF 30 or over were recruited. Each focus group included at least one participant from the following categories: participants who moved into the area after the airport opened, people who live and work in the area, members of low and medium income households and participants from both genders. Low income groups are defined as those earning less than 15,000 baht a month, medium income groups are those earning between 15,000 and 60,000 baht/month and the high income group are those earning more than 60,000 baht a month.

6.3.2 Air Passenger Groups

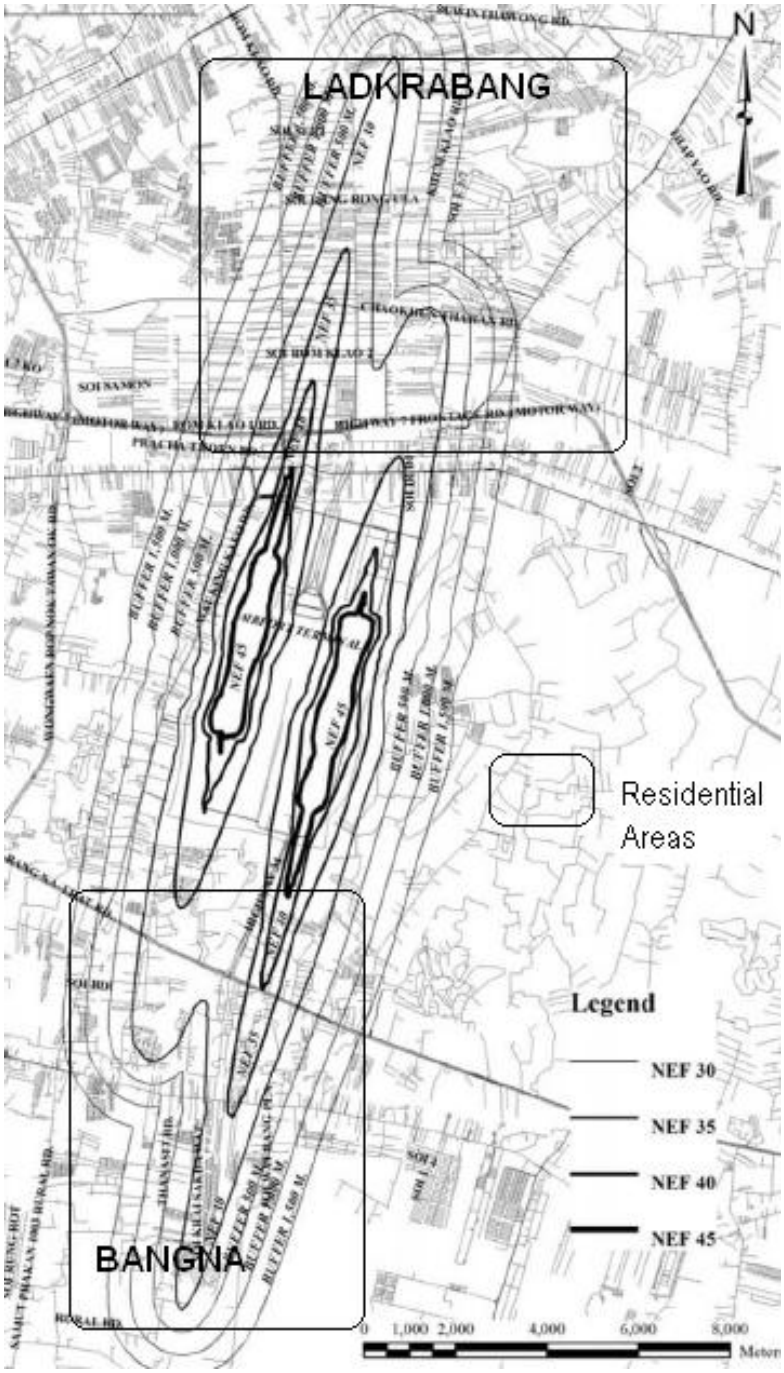
In each focus group there was at least one person who has flown in the past 12 months in the following categories; passenger on an international flight, domestic, economy class, business class, low cost airlines and passenger who fly for business purposes. This enabled the assessment of the differences and similarities of attitudes and perceptions toward environmental problems of those who fly on different types of flights and on different purposes. The income category was defined in the same manner as the airport residents. Passenger group 3 specifically consisted of relatively young group of participants to see if the attitudes of the younger generation of Thai air travellers are different from those of older groups as environmental problems have been emphasised through education and exposure through modern lifestyles which often cite environmental issues.

6.4 Overview of areas surrounding Suvarnabhumi Airport

Suvarnabhumi airport lies 30km east of Bangkok city centre. Table 6.1 provides information on the local area, including transportation options to Bangkok centre and the average wage in Thailand. The areas around the airport chosen in this study are categorised into two groups which are Ladkrabang (to the northern end of the airport) and Bangna (to the south of the airport). See Figure 6.1 for a location map. Both are residential areas which are expanding in conjunction with the growing businesses around the airport. These businesses are mostly warehouses which store exported and imported goods as the area is close to both the seaport and the airport. There are also industrial estates as the Government's city planning department allocated the area for manufacturing. The area was popular for cargo warehouses and manufacturing before the airport opened but it has grown very quickly since the airport became operational. As a result, there are people moving into the area for jobs both at the airport and in its related businesses.

Traditionally, the areas to the north and southwest of Bangkok city centre were popular choices for urban expansion and housing development as the city has grown (current population is approximately 10 million). Property development firms are now switching their focus to the areas around the airport (REIC, 2011) owing to easy access to transport networks (expressways and express trains which were built to serve the airport and surrounding area have both shortened the commuting time to city centre considerably).

Figure 6.1: Residential Areas Chosen for This Study



Source: Airports of Thailand

Given the highly congested nature of Bangkok road traffic, property developers along with house buyers value shorter commuting times to their work places (REIC, 2011). The area south of the airport (Bangna) mainly comprises older communities with detached houses built long before the airport opened in 2006. There are also a number of recently built

apartments as a growing number of factories have been built in the area. Residents in Bangna are mostly villagers who have been living in the area for several generations but a growing number of new residents now work in the factories. The area north of the airport (Ladkrabang) has one large university, a town centre, and residential areas. Those living in Ladkrabang benefit from the express train link to Bangkok city centre. The residents consist of those who have lived there before the airport opened and those who moved in more recently due to employment opportunities relating to the airport operation (direct and indirect) and those who reside in the area due to the property development to take advantage of the relatively low property prices and improved access to Bangkok city centre. According to Chalermpong (2010) there have been a number of protests by residents at the airport about aircraft noise and on-going disputes concerning compensation. The protests imply that the airport residents are suffering from aircraft noise nuisance and that existing compensation and mitigation measures may be inadequate.

Table 6.1 Spatial and Social Information about Suvarnabhumi Airport

Distance to City Centre	30 km (19 miles) east of Bangkok
Transportation to City Centre	Express Train 30 Minutes, 30 baht fare Two Express Ways: 40 minutes-1 hour (65 baht fee) Normal Road: 1-1.5 hours Bus 1.5-2 hours (£0.14 for normal bus, £0.48 for air-conditioned bus)
Airport Operating Hours	24 hours
Bangkok Income level	As reported by Adecco Thailand Salary Report (2010): Minimum wage: 6,000 baht/month University Graduate: 8,000-15,000 baht/month Office workers with 10 years' experience: 15,000-30,000 baht.

6.5 Preliminary Stated Choice Question Design

The second aim of this qualitative study phase was to assess SC card presentations and attributes by asking the focus group participants to complete the SC cards and gather feedback. This section explains the design process of the experimental SC cards used in the focus group study. It begins by explaining the resident card design followed by the air passenger card design.

6.5.1 Airport Residents' SC Design

Three designs were developed for the experiment to test different means of presentation and performance with ease of understanding and use.

Version A: Experience of Noise at Different Times

This first version asked respondents to compare different experiences of departure patterns during low and peak periods and provide a valuation. This incorporated transport access as an attribute. The noise experience attribute levels were based on aircraft movements during different periods of the day. There are two low traffic periods (which assumed as quieter) of 0300-0600hrs local time with 1 departure per hour and 2000-2300hrs with 12 departures per hour. The high time is 0700-1100hrs with around 23 departures per hour and 1800-2000hrs with around 20 departures an hour. The question card could be differentiated into day-time and night-time to provide valuation of different time of day. Results from the noise discussions from the focus group ultimately helped to define the period based on residents' actual experiences of noise. The attribute of commuting time on public transport to the workplace was used to represent the potential benefits of moving to the airport by having better access to transportation and employment opportunities in the area near the airport. The time period for assessment of noise experience to elicit willingness-to-pay will be differentiated into 4 periods of weekends and weekdays. See Table 6.2.

For the payment vehicle which is a method of payment/receiving compensation, this study initially planned to use household tax. However, while this tax exists, it is not collected in practice and even if it is collected, it is very low (approximately 5 baht per *rai,* which is a local unit equal to 1600 sq.m., or approximately 10 pence per year). This left two options: a monthly income tax or a hypothetical monthly noise reduction tax. This study used a noise reduction fee as the payment vehicle. Income tax has an advantage of being a real tax payable to the government and for the case of increased flights and noise, the option of tax refund can be used as attribute. The noise reduction fee has an advantage of applicability to everyone, there are cases of people working in the 'informal sector' which do not pay income tax and to whom the attribute of income tax is irrelevant. The downside is that the hypothetical tax may not be accepted by the respondents. The appropriateness of the payment vehicle was discussed during the focus groups.

Figure 6.2 shows the SC card for version A. It must be noted that, in practice, any combination of attribute levels can be put in to the choice card. As a result, one option can be receiving money and another could be paying money. The combinations are generated

through experimental design software (see section 8.3 for more details). However, the 'paying' option always contains improvements in the environmental condition and the 'receiving' option always contains the deteriorating environmental condition. The respondent's task is to choose the option presented in the card that is the best for their interests.

Table 6.2: Version A Attribute Levels

Attributes	**Levels**
Noise like	Decreasing scenarios: Early morning 0300-0600 hrs (1 flight/hour)/Early night 2000-2300 hrs (12 flights/hour) Increasing scenarios: Late morning 0700-1100 hrs (23 flights/hour)/ Early evening1800-2000 hrs (20 flights/hour)
Commuting time to work place on public transport	30 minutes/ 45 minutes/ 1 hour/ 1.5 hours/ 2 hours
Monthly Tax (Baht)	Tax increase: 250, 500, 750, 1000 Tax refund: 250, 500, 750, 1000

Figure 6.2: Question Card Version A Sample

Noise like	Early Morning (3-6am with 1 departure per hour)	Late Morning (7-11am with 23 departures per hour)
Commuting time to work place on public transport*	30 minutes	1 hour
Monthly tax or tax refund (Baht)	You would pay 750 baht	You would receive 1000 baht
I would choose.....	A	B

*Those who drive or walk to their workplace will be given card with 'Commuting time to your workplace' question instead of 'commuting time to work place on public transport'.

Version B: Comparison of noise before the airport opened

The second version of the SC card asked residents to elicit the WTP to pay for the noise experience by comparing the current level and the level before the airport opened. This version is similar to version A except for the first attribute (see Table 6.3). In this version, the first attribute used the pre-opening period as a proxy to obtain a value of complete removal of aircraft noise whereas Version A used a different time period to obtain valuation of quieter times. During the experiment, the respondents who have lived in the area before the airport

opened were asked if they remember how it was like (noise-wise) during the time. Commuting time is used to represent potential employment opportunities in the area and accessibility. Those who moved into the area after the airport opened were asked to compare the noise level of their old residence before moving into the area. Figure 6.3 shows the SC card.

Table 6.3: Version B SC Attribute Level

Attributes	**Levels**
Noise like	Before airport opened (For those who have lived in the area before airport opened) Your former residence (For those who moved in after the airport opened)
Commuting time to work place	30 minutes/ 45 minutes/ 1 hour/ 1.5 hours/ 2 hours
Monthly Tax (Baht)	Tax increase: 250, 500, 750, 1000 Tax refund: 250, 500, 750, 1000

Figure 6.3: Question Card Version B Sample

Noise Like	Before airport opened	As now
Commuting time to work place	30 minutes	2 hour
Monthly tax or tax refund (Baht)	You would pay 1000 baht	You would receive 1000 baht
I would choose.....	A	B

*Those who drive or walk to their workplace will be given card with 'Commuting time to your workplace' question instead of 'commuting time to work place on public transport'

Version C: Flight Movements

The third version used aircraft movements to represent aircraft noise. The aim of this version was to examine if residents have problems with overall noise or with the frequency of specific noise incidents (i.e. the number of take offs and landings) and to see which one caused the most annoyance. This version is based on SC cards used in previous studies on aircraft noise valuation (Wardman & Bristow, 2008; Carlsson *et al*., 2004).

The attributes consisted of changes in the number of large and small jet aircraft movements (to differentiate between the different levels of noise annoyance they create). The change is for both increasing and decreasing number of flights. In doing so, it could simultaneously assess how people would react if they were presented with a case of increasing flight

activities in which they are offered monetary incentives. A proposal to ban night flights (as a way of eliminating the noise problem during the night) and a monthly fee used as the payment vehicle were also included (see Table 6.4). Each respondent was given 4 question cards to obtain a valuation. The hypothetical time period in this study was noon to 6pm on weekends as it is the time period that residents likely to be at home and thus experience the most aircraft noise. A question card is shown in Figure 6.4.

Table 6.4: Version C: SC Attribute Level

Attributes	**Levels**
Large Jets	Decreasing scenarios: 8, 6, 4 flights/hour Increasing scenarios: 10, 12, 14 flights/hour
Small Jets	Decreasing scenarios: 8, 6, 4 flights/hour Increasing scenarios: 10, 12, 14 flights/hour
Night flight ban (midnight-6am)	Yes, No
Monthly Tax(Baht)	Tax 250, 500, 750, 1000 Tax refund: 250, 500, 750, 1000

Figure 6.4: Question Card Version C Example

Large Jets 	6 flights/hour (around every 10 minutes)	12flights/hour (around every 6 minutes)	As now
Small Jets 	6 flights/hour (around every 10 minutes)	12 flights/hour (around every 5 minutes)	As now
Ban on night flights (2300-0600hrs)	Yes	No night flight ban	No night flight ban
Monthly fee	You would pay 500 baht	You would receive 750 baht	No payment
I would choose.....	A	B	C

6.5.2 Air Passengers SC Design

The passenger experimental design consists of four attributes which are aircraft noise, air pollution emissions, carbon offsetting and airport departure tax (which is used as a payment vehicle). The four attributes assess impacts at both local (noise, local air pollution) and global levels (carbon emissions). See Table 6.5.

Aircraft noise was selected as the first attribute as it is the most prominent local environmental problem created by aircraft. The second attribute is local air pollution which also represents a local problem. These attributes were presented in terms of percentage change. The third attribute is carbon offsetting which asked respondents if they are willing to offset their carbon emissions or not (Yes/No). The yes option also indicated how the money could be spent. This format of carbon offsetting and co-benefit attributes is based on Mackerron, *et al.* (2009). The focus group will be able to inform the effectiveness and understanding of the co-benefit attributes.

The first three attributes allow the study to see how respondents prioritise the importance or severity of the three kinds of environmental impact through their trade-offs between the given attributes. An airport departure tax was used as payment vehicle. Other forms of payment vehicle were considered, including ticket price and value-added tax. The airport departure tax increased from 500 baht per flight in 2006 when the new airport opened to 700 baht today and has not changed since. Generally, passengers are aware that they have to pay an airport departure tax but they may not know how much the tax is since it is included in the fuel surcharge and insurance when they buy a ticket. Therefore it is important that passengers must be made aware of the current level of 700 baht. Before 2006, the airport departure fee was collected separately before a passenger went through passport control. An airport departure fee is a preferred payment vehicle for this study as the airport operator is the one who manages the environment impacts of the airport and, in theory, could use the fund to relieve or offset environmental problems. By using air ticket fare, passengers may not understand how an airline (which is the one that collect the money) will solve the problem around airport neighbourhoods.

Respondents were presented with 4 question cards to choose from. Each one included 2 options and a no offsetting alternative (as now). Figure 6.6 shows the question card for air passengers.

Table 6.5: Passenger SC Attribute Levels

Attributes	Levels
Aircraft Noise	10%, 25%, 50% less noise 10%, 25%, 50% more noise
Air Pollutions	10%, 25%, 50% less emissions 10%, 25%, 50% more emissions
Carbon Offsetting	Yes/No Environmental Preservation Projects Poverty Eradication Projects Sustainable Energy Development
Airport Departure Tax (Baht)	700, 800, 900,1000, 1200, 1500 650, 600, 550, 500, 450, 350

Figure 6.5: Question Card Example for Air Passengers

Offsetting Option	Option A	Option B	Option C
Aircraft Noise	25% quieter (a quarter less noise)	50% less noise (halves noise)	As now
Local Air Pollutions	10% less emissions (one-tenth lower emissions)	25% less emissions (a quarter less emissions)	As now
Carbon Offsetting	Yes, and revenues to be spent on Environmental Preservation Projects	Yes, and revenue to be spent on Sustainable Energy Development	No
Airport Departure Tax	100 baht more	200 baht more	As now (700 baht)
I would choose...	A	B	C

6.6 Conclusion

This chapter reports the design of the qualitative study using focus groups which is aimed to identify awareness and perception towards aviation externalities among residents and air passengers. It also used to test the stated choice presentations to identify potential problems and address them before the final SC experiment. Focus groups were selected as this study needs qualitative data in to inform the actual SC experiment. These groups enable this study to test three SC presentation styles for residents and one design for passenger. Two of the residents designs (Version A and B) are based on the comparison of noisy and quiet period

and the comparison between the current level of noise. The third version (Version C) was based on the existing studies which used aircraft movement as a proxy to noise. The passenger version is also a new design by incorporating local impact elements (noise, local pollution) into the valuation. Focus group findings will be used to inform the final designs for the actual SC experiment later in this study.

7. FOCUS GROUP FINDINGS

7.1 Introduction

This chapter reports the results from the focus group sessions. The results are presented by theme of the discussions as they emerged from the focus group. This starts with the resident groups which involved the discussions on problems and benefits of Suvarnabhumi airport then an experiment on three SC card designs. Passenger group discussions followed the same structure as the resident groups. The results from this chapter are used to inform the SC card design in the final SC experiment.

7.2 Airport Residents

7.2.1 Disadvantages of Living near the Airport

The following themes emerged from the discussions. The problems identified by all groups are discussed first and then the problems that are unique to one group are identified.

Aircraft Noise

Noise was the first problem identified by the residents in all the groups and they indicated that aircraft noise is the most serious impact of all, *"I think the aircraft noise is louder than a thunder noise"* (Bangna 1). The effects of aircraft noise are more prominent during the night. The effects of night noise were mostly described in terms of sleep disturbance and abrupt awakening, *There have been several occasions that I was awaked abruptly because of aircraft noise"* (Ladkrabang 1). THAI Airways is perceived as the noisiest operator given the fact that they are the largest operators at the airport and operate wide-bodied aircraft whereas Thai Air Asia and Bangkok Airways are perceived as less noisy operators (Thai Air Asia operates Airbus A320s, Bangkok Airways operates Airbus A319/320s and ATR-72 Turboprops). Residents in Ladkrabang 2 also suggested that aircraft noise during the night is noisier and more annoying as background noises from other sources such as road traffic is reduced.

Health Problems Associated with Aircraft Noise

When asked about the health effects of aircraft noise, every focus group indicated that stress from aircraft noise is the most serious health problem among residents. The stress is particularly high during the night when residents are abruptly awakened by sudden aircraft noise. *"During sleeping time, aircraft noise cause stress from abrupt awakening"*

(Ladkrabang 2). One participant stated that he suffered from mood swings due to stress. Bangna 2 and Ladkrabang 1 groups reported that some of them are suffering from high blood pressure from stress caused by low flying noisy aircraft. Hearing issues were also raised. For example, Ladkrabang 1 group suggested that *"Some of us have hearing impairments, especially the elderly. We have to raise our voice to communicate".*

Activity Disruption

When an aircraft flies overhead it causes disruption in three ways. Firstly, disruption to normal activities, residents in all groups indicated that they lose concentration. One participant from Ladkrabang 2 said that he works as a carpenter and there are some instances when he loses concentration during because of the noise of low-flying aircraft and he then has to spend time correcting his errors. Respondents with children report that their children were affected by aircraft noise during their study, *"My children can't concentrate on their homework, especially during exams"* (Ladkrabang 1). Also, residents have to raise their voice or stop conversations when an aircraft flies overhead. During one of the focus group meetings, the aircraft noise was very loud and it sometimes became disruptive. Participants also complained of more specific problems when aircraft pass overhead.

Television and radio reception disruption was identified as being the second most severe and annoying problem as most residents use an aerial or satellite dish for television reception. All groups reported that reception is interrupted when aircraft fly over and also they can't hear the television or radio. For example a Bangna 1 participant reported a *"Fuzzy signal when there is an aircraft passing by".* Aircraft noise also affects the ability to hear the television or radio, *"Can't hear the TV or radio show"* (Bangna 2). The last problem is mobile telephone reception. It was indicated that mobile phone reception could be interrupted, *"Mobile reception is sometimes jammed*" (Ladkrabang 1) but there is no problem with landlines. All groups reported that it iss impossible to converse on the phone due to intense noise from the aircraft, "*I have to use a higher voice pitch when [on the] telephone*" (Bangna 1), "*Sometimes the noise is too loud and can't hear anything on the phone*" (Ladkrabang 2).

Vibration

Aircraft movements were also reported to cause vibration to buildings and furniture. Residents complained that aircraft vibrate windows, window frames and roof tiling. Glasses, dishes and furnishing accessories are also affected, *"When aircraft fly over, the windows and dishes vibrate and sometimes they vibrate quite violently"* (Bangna 1), *"Furniture and kitchenware rattle during take offs"* (Ladkrabang 2). There were worries that prolonged vibration will eventually cause windows and roof tiling to break down causing rain to leak into

the house. Respondents expressed concern about the long-term damage to house structure and those in Bangna 1, 2 and Ladkrabang 1 reported that their roof tiles have been damaged. Bangna 1 group reported that vibration is the second most severe problem after noise.

Air Pollution

Residents mentioned air pollution as one of the main environmental problems at Suvarnabhumi Airport. Nonetheless, all of them agreed that they do not actually know the real extent of the severity of air pollution in their neighbourhood but all perceive that air pollution is a problem, *"I know that there must be something released from the aircraft engine but I don't really know what are they and what are the effect"* (Ladkrabang 2), *"There's pollution for sure, but I can't really see"* (Bangna 1). Soot and traces of oil were reported by all groups except Ladkrabang 4. The problems relating to soot were reported; *"It contaminated the water, I once experimented by putting water in a large bowl and I can see soot in the bowl"* (Bangna 2), *Rain water cannot be consumed immediately anymore, I have to keep it for at least 2 years until I can consume it"* (Bangna 2), *"You can see soot or traces of smoke on leaves and on clothes that have been air-dried"* (Ladkrabang 1). One resident from Ladkrabang 2 said that he can smell aircraft fumes whenever he visit food shops close to the airport perimeter for a meal. Other concerns resulted from increases in road traffic brought about by the airport's proximity to their homes.

Road Traffic

Residents stated that local road traffic has become much more congested since the airport opened, *"Before airport opened, the traffic was only the problem during rush hours but the traffic is also very congested during the non-rush hours"* (Ladkrabang 2), *It takes me 40 minutes to drive to work if I leave before 7am, if I leave after that, it will take 2 hours"* (Ladkrabang 1). This has been caused by increasing activities at the airport for both passengers and cargo transport along with development in the surrounding areas which have seen an increase in the number of residents and businesses, *"There are more roads built during the airport development but it couldn't cope with the traffic"* (Bangna 1) Residents in Ladkrabang 1 and 2 stated that congested traffic is the second worst problem caused by the airport whereas all groups reported that heavy lorries are serious problems because these vehicles carry heavy load which damage the road surface and are sometimes driven dangerously. Furthermore, pollution from road traffic is also identified as a problem caused by the airport.

Fear of Aircraft Accidents

It was suggested that they sometimes experience a fear of aircraft accidents. For example, *"Sometimes I'm afraid that aircraft parts such as engine or wheels might come off and land on my house"* (Bangna 2), *"The plane may crash land in front of the garden if things go wrong"* (Bangna 1), *"I'm alarmed when I hear the strange noise made by airplanes"* (Bangna 2). The fear is sometimes dictates by weather condition, "*It's quite scary during stormy weather as it seems to me that the planes are flying very low" (*Bangna 1). Nonetheless, they agreed that the fear was not persistent and was not a serious problem.

Property Prices

Some residents stated that they wanted to move out of the area but it is impossible to sell their house as no one wants to buy the property. They reported that there are many properties are on sale in the areas under noise contour but they are not selling, *"Those who can afford to move have already left and just abandoned their houses, but we have no alternatives"* (Ladkrabang 1), *"Many houses are on sale but they are not selling"* (Bangna 1). Some properties were reported to be sold at a much reduced price.

Issues unique to each group

In addition to the general issues discussed above that were common to all focus groups, the discussions also revealed issues unique to particular groups.

Bangna 2: *Agricultural Effects*

Residents in Bangna 2 were mostly living in the area long before the airport opened and some of them make their living in the agricultural sector activities such as fish-farming and plantations. This had an adverse impact to their living, *"Many of us used to have large rice farm but the airport bought it off from us because of the noise. We now don't have income from growing rice anymore"*. The remaining land is used for fish farming and growing fruit plants such as mangoes. They reported that the fish behave strangely such as flipping over when an aircraft passes overhead. They also observed premature death of their fish, *"Fish are alarmed when they hear noise and aircraft casts shadows on the water surface, and I believe that this affects my yield"* They expressed concern about the effect of aircraft noise on mangoes and other plant yields as they find soot on mango trees' leaves. Finally, respondents also expressed fear about detrimental effect of airport operations and flights on water and soil quality.

Turbulence from Aircraft

Bangna 2 residents also suggested that the high trees such as coconut could be seen swirling on the top because of the wake turbulence from aircraft. One respondent stated that the tin roof of her house was blown off once by the turbulence caused by passing aircraft. She made a claim to the airport operator but she was refused compensation as she could not produce a photo of the roof before it had been damaged.

Aircraft Lights

A resident in Bangna 1 group mentioned that during the night time aircraft lights sometimes penetrate the bedroom.

Flooding

Ladkrabang 1 residents suffered from flooding in their neighbourhood since the airport opened. They suggested that the building development in the area, especially the warehouses, have blocked the natural waterways and have caused floods.

However, in addition to identifying environmental problems caused by the airport, some focus group members also reported benefits from living near the airport.

7.2.2 Advantages of Living near the Airport

Improved Access to Air Transport

The first thing that residents in all groups suggested was that it is easier for them to go to the airport when they need to catch a flight *"It's close to the airport, easy for catching a plane"* (Ladkrabang 2). However, it must be noted that not many participants have ever travelled by air as air travel is expensive. *"I suppose it's easier to use airport for some, but I can't afford to fly myself"* (Bangna 2). In particular, none of the participants in Bangna 2 have flown before, and they also stated that they are unlikely to do so due to ticket price.

Improvement in Transportation Infrastructure

Every group said that they have seen an improvement in transportation infrastructure such as better roads and public transport *"Better public transport such as more buses"* – (Ladkrabang 2). Road improvements include the construction of new roads and the enlargement and re-pavement of existing roads. However, they believed that the road expansion is not sufficient to cope with increased demand associated with airport activities

and the traffic has worsened significantly. Ladkrabang 1 group is the only group that is benefits from the new 'Airport Link' commuter trains to Bangkok city centre which shorten their travel time to work but it was considered as too far for other areas. *"Airport Link only benefits those living in Ladkrabang. We in the south can't use it because it's too far"* (Bangna 1).

All groups, except Bangna 1, stated that their communities have generally improved with new property developments, better local facilities, *"Town expansion is fast, it used to be nothing at all around here, just paddy fields"* (Ladkrabang 1). Ladkrabang 2 residents stated that they have greatly benefited from the town enlargement because it has created more trading opportunities. Two respondents who work in the construction industry said that their sales have increased significantly. Also the same group stated that they now have a better drainage system in the road, which has helped to prevent flooding. Conversely, Ladkrabang 1 residents stated that the flooding events have been more frequent since the opening of the airport due to the construction of new properties that have blocked the natural floodway. This was also caused by the flood prevention system at Suvarnabhumi Airport which has diverted water away from the airport to nearby areas. The Ladkrabang 2 group was particularly happy with the development of their areas in various aspects. For example, *"There's larger market and it's better for shopping", "The area is beautiful because the town authority planted more trees"* and *"Improvement in safety, there are more police in the area".*

Employment Opportunities

Residents in Bangna 2 and Ladkrabang 2 groups indicated that the airport provides direct and indirect jobs. The direct jobs are mainly low-skill labour such as janitorial posts. ,*"I know a few people in my area that work at the airport but it's a low skilled job"* (Bangna 2), *"A few get office jobs, but it's very hard to get this kind of job"* (Bangna 2). Indirect employment includes work in logistic firms, construction and security services. One participant in Ladkrabang 2 said *"I was sent here by my boss to do carpentry because the area is growing fast".* As stated earlier, the respondents in the construction business have seen their income increase during both the construction of the airport and following the further development of the urban area, *"I have been selling concrete here before the airport opened and the business has been very good"* (Ladkrabang 2). Ladkrabang 2 participants all agreed that benefits from employments and business outweigh the adverse impacts of the airport.

Plane-spotting

Residents stated that sometimes it's a good distraction to see the aircraft flying overhead. One participant from Ladkrabang 2 said that she sometimes enjoys watching the planes while cooking her dinner.

7.2.3 Noise Level and Time Periods

Noisiest Times

The opinions on what are the noisiest times varied among the residents. Generally, they indicated that between midnight to 3am is the noisiest period. It was indicated that during the night there is less background noise such as road traffic thereby making the aircraft noise much more prominent in comparison to the day time. Participants stated that at around 2-3 am while there may be far fewer flights than during the day time the quieter background noise makes the sudden noise from flying aircraft cause them to awake abruptly. Also, these periods are normally used by wider-bodied freighter aircraft which are generally noisier than other passenger planes. The variation in perceived noisy periods is also dependent on the different times that each participant is at home. Participants are more annoyed by aircraft noise when they are at home and even more during their rest or sleeping times such as late afternoons, weekends, and during the night. For example, a respondent suggested that it is noisy during her cooking times and another one suggested that it is noisy when he is jogging around his neighbourhood in the late afternoon. All groups reported that take off noise is much worse than noise on landing. There is also seasonal variation in noise level as the airport switches the direction of take-offs and approaches due to wind direction changes mostly during November, December and January. Those living in Bangna indicated that these three months are the quietest time for them as landing aircraft makes less noise, *"Winter is a relief as planes are landing in this direction"* (Bangna 1) The Ladkrabang group, also indicated that it is noisier when they are exposed to taking off noise, *"Take offs are noisier, also winter time [because of the aircraft taking off]"* (Ladkrabang 1).

Quieter Times

Residents all stated that there isn't any particular time that is described as quiet but preferred to consider it as 'moderate noise' periods. As reported earlier, Bangna groups consider winter to be quieter as it is used for approaches. Participants mostly suggest that morning and during the day are quieter than during the night, *"During the day time is better*

than the night" (Ladkrabang 1), *"5am till noon is quieter"* (Bangna 2).This may be due to the fact that many of them are at their workplaces. Some suggested that because it's the period that they go out of home to work they don't notice the noise. Those in the Bangna area stated that winter is quiet for them and bring much relief due to aircraft switching direction, *"November, December and January are quiet"* (Bangna 1). Also, they preferred the night time to be quiet such as 10pm-7am which is when the majority of them wish to be asleep.

7.2.4 Stated Choice Experiment

Each participant was given question cards to elicit their willingness-to-pay for a reduction in the environmental impact consisting of 3 versions with 3 cards in each version. Version A asked respondents to choose the level of noise of different times of day during a given period. Version B asked them to choose between the current noise level and the noise level that was experienced before airport period. Version C used aircraft movements as a proxy for aircraft noise.

Presentation Issues

Version A

Figure 7.1: Version A Card Example

Noise like	Early Morning (3-6am with 1 departure per hour)	Late Morning (7-11am with 23 departures per hour)
Commuting time to work place on public transport	30 minutes	1 hour
Monthly tax (Baht)	You would pay 750 baht	You would receive 1000 baht
I would choose.....	A	B

Version A was found to be most problematic to understand by every group owing to the time period concept, *"I don't understand the time period scenario"* (Bangna 2), *"These look quite the same to me, the time period given"* (Bangna 1). They were told to think of the current noise level during weekend afternoons (which is the busier period for the airport and most of the participants are at home getting the full noise exposure) and asked if they wished to change the noise level to be like the one experienced at quieter times of day. Respondents reported that they found it hard to understand and imagine the situation of noise changes.

The explanation could be that each individual has different perceptions of the quiet and noisy times of days explained in earlier in the noisy period section (section 7.1.2). The lack of agreement about which time is the quietest makes the choices appear unrealistic. For example, some may think that weekend afternoons are already quiet and the choice offered to them is being perceived as noisier or no different than the time period given in the options and they have to pay for that. The second problem is that since respondents stated that there are no time periods that are noticeably quieter or there is not much different in terms of noise throughout the days, they cannot differentiate whether or not they will be better or worse off by choosing the given options. Since there are no agreed quieter time periods, it may make this presentation style impractical. Nonetheless, using landing noise or seasonal variations may be a practical alternative as participants agreed that landing aircraft are quieter than those taking off.

Version B

Figure 7.2: Version B Card Example

Noise like	Before airport opened	As now
Commuting time to work place on public transport	30 minutes	2 hour
Monthly tax (Baht)	You would pay 1000 baht	You would receive 1000 baht
I would choose.....	A	B

For Version B, which asked for choice of noise level before the airport opened and current level, many respondents stated that they still remember the time before the airport was opened, *"I still remember when it was quiet, with no aircraft noise at all"* (Ladkrabang 1), and they suggest that it was easier to understand than Version A. They mentioned that it may have problems with realism of the hypothetical situation as the airport has already been in operation which is the main disadvantage of this version, *"This is quite unrealistic as the airport will not go away"* (Bangna 2). It is true that the hypothetical situation is ideal (i.e. no aircraft noise at all) but the lack of realism of the possibility of the airport being close down and undermine the credibility of the SC card and WTP elicitation. Nonetheless, there is an alternative to the airport closing down which is to offer a case of aircraft rerouting away from their house. Therefore they could be asked they if the aircraft noise is to be removed by rerouting the flight path elsewhere. The Ladkrabang 1 suggested that the rerouting attribute is more practical and they wish that it could be implemented.

This version also incorporated commuting time as an attribute. Residents stated that it could take 1.5-2 hours for commuting time on public transport but those who do not work had problems understanding this so they were asked to imagine a shopping trip or a trip to contact government agencies.

Version C

Figure 7.3: Version C Card Example

Large Jets 	6 flights/hour (around one every 10 minutes)	12 flights/hour (around one every 6 minutes)	As now
Small Jets 	6 flights/hour (around one every 10 minutes)	12 flights/hour (around one every 5 minutes)	As now
Ban on night flights (2300-0600hrs)	Yes	No night flight ban	No night flight ban
Monthly fee	You would pay 500 baht	You would receive 750 baht	No payment
I would choose.....	A	B	C

All groups reported that Version C, which used changes in flight frequencies as a proxy for aircraft noise, was the easiest to understand, *"I think aircraft movements reflect the reality"* (Ladkrabang 2). Most of the respondents stated that it was less confusing, *"Less confusing than the first version because I don't understand the noise like concept"* (Bangna 2), as they normally have problems only when the aircraft fly over (such as disturbance to TV and mobile telephone reception and the number of noise incidents). The implication is that they value the number of noise incidents more than the overall noise footprint. This may be due to the fact that everyone is disrupted by aircraft noise incidents. Disruptions make it easier for respondents to relate the number of flights to problems caused by aircraft noise. *Frequency is the source of nuisance, not overall noise level, it's per flight noise emission that cause annoyance"* (Ladkrabang 2).

When asked what they thought the level of noise will be if the flight frequencies were to be reduced by half, some suggested that the noise footprint per aircraft will be the same. Others believed that they expected the overall noise level to reduce by half. Also, it was stated that

the frequency of noise incident is the source of annoyance, *"Less frequency, less noisy"* (Ladkrabang 1). The residents also indicated that smaller aircraft are much less noisy. A proposed night flight ban was included in the experimental cards as an attribute. Residents supported the idea as they believe that it will give them a quieter sleeping time, *"A ban during sleeping time will be a relief"* (Bangna 1), *"I don't mind the noise during the day as long as I have a quiet night sleep"* (Bangna 2). A number of residents inquired whether it is used at any airports around the world and they were told about examples. One resident in Ladkrabang 2 suggested that he was willing to forego a night flight ban if it will have adverse effect to the economy. It appears from the feedback that this is the most preferred attribute given the different opinions about quiet and noisy times of day. Sleeping time, particularly from midnight to 3 am, is the only period that respondents in all groups agreed was the noisiest. A noise level reduction during sleeping time through a night ban would thus give them a noticeable improvement in the noise situation.

Monthly Fee

In general, most residents agreed that the price range was acceptable. They indicated that anything more than 1000 baht (£20) was too much for them to pay. Six respondents from all groups only chose the option with compensation no matter how worse the situation became. They suggested that it is likely that the situation will worsen in any case therefore it is better for them in reality to accept the compensation rather than paying to avoid it. Three people suggested that the airport already has the financial means and it is not right for them to be asked to pay. Most of the residents agreed that paying 250, 300, 400 baht a month to reduce the noise is affordable, *"Considering the health implication, 300 baht a month to reduce noise is an acceptable deal"* (Ladkrabang 1).

Other Issues Arising from the Discussion

Bangna 1 group is concerned about the airport expansion plan which proposes to double capacity and they believe that the noise level will double. They indicated that Donmuang Airport (the old airport) should remain open to relieve air traffic from Suvarnabhumi. Bangna 2 and Ladkrabang 1 groups stated that they have to live with the airport since the airport is already there and there is no other realistic way to improve the noise situation. For this reason they have started to get used to the noise and they understand that the airport is good for the community even if the noise is far too bad. They suggested that most houses were built without anticipating that the airport will be open as the airport had been planned 50 years ago and many administrative delays made them think that the airport wasn't going to be built, therefore they didn't built the house that incorporate noise insulation features. Additionally, the Ladkrabang 1 group called for the government to set up a special

administrative zone for areas around the airport to enhance the development of the area for economic benefit. Ladkrabang 1 and 2 suggested that they wish that the aircraft would change their landing path to reduce noise problem. One resident suggested that the WTP or WTA for environmental problem price should be based on health insurance rates that reflect the adverse impact on their health.

7.3 Air Passenger Focus Groups

7.3.1 Environmental Problems in Daily Life

Most participants from all passenger groups suggested that climate change is the most severe environmental problem as this causes natural disasters including storms, flooding, earthquakes, landslides, *"I think weather pattern change is very severe"* (Group 1), *"Change in nature's balance is affecting the weather and everything which leads to natural disasters and many other problems"* (Group 1). They acknowledged that these are partly human made such as from deforestation and pollution emissions. Flooding is the main concern as Thailand has a large agricultural sector and flooding has an adverse impact on crop yields.

The second most severe environmental problem is identified as air pollution, *"Pollution released from factories"* – (Group 1), *"Road traffic emits pollution, especially the congested traffic"* (Group 2). They consider air pollution to be the forms of smoke, exhaust odour, soot, particles and dust. Others problems mentioned by the participants included waste water from factories, general waste, stray animals, noise pollution from traffic and natural resource exploitation.

Mitigation Measures

Respondents were also asked about whether they were aware of environmental mitigation measures. Some suggest that they are and already try and behave in an environmentally responsible way; *"I bring my own shopping bags"* (Group 2). Some try to save on energy and water consumption. One participant in Group 3 stated *"My mum joined the Red Cross and they teach us how to make organic dish washing liquid. We use it at our home"*. Also, some respondents have participated in tree planting initiatives.

Secondly, they suggested measures that they believed should be implemented to improve the environment. All groups suggested that education and perception are important to make people aware of problems and how to solve them "*Children must learn to preserve the environment and the importance of environment"* (Group 2), *"Change values and perception*

toward personal car usage, some thinks that cars are status symbol" (Group 2) . Public and children alike should be informed about the ways to reduce the environmental impact of their daily activities. The participants also suggest that the change in traffic management system and improvement in public transport could reduce energy consumption and air pollution. Finally, Passenger 2 group indicated that corruption reduction is important as they alleged that corrupt officials have been involved in deforestation problems.

7.3.2 Aviation-related Problems

Every group suggested that aircraft noise is the most serious problem. Four participants in the Passenger 1 group indicated that they can hear aircraft noise at their homes and are sometimes annoyed by it.

Emissions from aircraft and from traffic to and from the airport are considered to be the second most serious environmental problem. Most of the participants believe that emissions from aircraft are serious but they also stated that they do not know how harmful they are as they cannot directly see the effect. When asked about the local and global emissions of air pollutions, five respondents in Passenger Group 2 believed that local emissions are more serious as the residents are affected directly, *"I think ground level emissions are more serious because the aircraft must use full power for take-off.* Three believed that atmospheric emissions are more important as aircraft spend most of the time in the air. Passenger 3 group all stated that they believed that atmospheric impact is more serious and it is likely that the emissions from the ground level would rise up to the atmosphere eventually, *"Global impact is bad, and it has a long term effect. Nonetheless, it's hard to quantify the effect", "Planes spend most of the time in the air, the emissions at a global level must be worse than at the local level".*

The third theme that emerged from discussion was waste from aircraft and airport. Airport waste includes waste water and general waste. Respondents commented that *"There's a lot of leftover food from aircraft, there should be measures to deal with this"* (Group 2), and there is also *"waste from cabin service items"* (Group 2).

Air Passenger 3 group (the under 30 year olds) identified several other problems including land subsidence, flooding, animals losing their habitats, deforestation to clear the way for the airport, jet fuel odour, land eviction causing residents to lost their homes and work, aircraft accidents, and increasing carbon emissions.

7.3.3 Carbon Offsetting

Air passengers were also asked if they had heard of Carbon Offsetting and if anyone had paid for it.

A total of seven participants were aware of Carbon Offsetting as a measure to mitigate environmental problems, *"I've heard of the concept in the other industries, but not in an airline business"* (Group 2). None of the participants in group 1 had heard of the term, whereas two people in the second group and five people in the third group had heard of it. Two participants stated that they have seen it on the internet when they reserved a ticket, *"I have seen carbon offsetting offered when I booked an easyJet flight"* (Group 3). Furthermore, two people in both the second and third groups indicated that they were aware of the carbon trading and understand how it works. Other participants needed to be told about what carbon offsetting involves. Once the participants understood the concept they were asked for their opinion.

Most of the participants expressed concerns that carbon offsetting may not be very effective. Many also had questions about the transparency of the system (this will be discussed in the next section). One participant suggested that it may actually encourage people to emit carbon irresponsibly if they know that they can offset it. It was also considered as a marketing tool: *"Many companies do carbon offsetting just for the advertisement of their firms"* (Group 2). Nonetheless, all agreed that environmental problems and climate change are serious issues and they must be dealt with.

7.3.4 Stated Choice Experiment

Participants in the air passengers focus groups were all given five SC cards to elicit their willingness to pay (see figure 7.4 for an example of SC card). Once completed, they were asked for their feedback on it.

Figure 7.4: Passenger Card Example

Offsetting Option	Option A	Option B	Option C
Aircraft Noise	25% quieter (a quarter less noise)	50% less noise (halves noise)	As now
Local Air Pollutions	10% less emissions (one-tenth lower emissions)	25% less emissions (a quarter less emissions)	As now
Carbon Offsetting	Yes, and revenues to be spent on Environmental Preservation Projects	Yes, and revenue to be spent on Sustainable Energy Development	No
Airport Departure Tax	100 baht more	200 baht more	As now (700 baht)
I would choose...	A	B	C

Presentation Issues

Before completing the SC exercises, participants were given an explanation of how to complete the SC card. They were told to consider attributes given (Noise, Pollution, Offsetting and Departure Tax) in each option and asked to choose the option that they preferred. Some participants asked whether they could choose each attribute individually to suit their preference, *"Do I have to choose the whole column? Can't I just choose each attribute that I preferred?"* (Group 1). There have been suggestions by the participants that the presentation of each option must be clearly separated. For example, respondents may be given options presented as bubble forms, clearly separated from each other instead of table. Also, it was suggested that the attributes should be presented horizontally, *"I think most Thai readers would prefer that each attribute is presented horizontally, it's the way we tend to read"* (Group 3). Another problem is that some air passengers did not understand the revenue usage option and they needed more explanation. Some respondents also expressed surprise and annoyance that they may be asked to pay more.

Protest Response (Group 2)

Passenger group 2 expressed a strong opinion against the carbon offsetting scheme for air passengers to the point that they refused to pay anything at all. They exhibited a strong mistrust of the airlines and the airport operator and believe that both may try to take advantage of the carbon offset revenue *"Airlines increase their ticket price all the times, they make a lot of profits, why should I pay more?", "Even if we pay for it, the airlines will take credit that they are environmentally friendly but the passengers who are the one who pay".* Airlines should be responsible and it is likely that if airlines are forced to pay for carbon

offsetting, passengers will have to pay through a price increase anyway. They cited a case of fuel surcharge in which they believe that passengers are being exploited by the practice, and an addition of carbon offset will worsen the situation. They indicated that airlines and airport operators should share responsibility for environmental damages cause by their businesses, *"Airlines and airport operators should take half of the responsibility for the aviation externalities and passengers shouldn't be exploited", "Airlines should reduce their profit margins and use that money for the environment themselves"* However, they were asked a hypothetical question if they have option to buy a car, would they be willing to pay around 50,000 baht (£1,000) more for a car with less emission? Interestingly, they responded that they are willing to pay in that case because it is their responsibility to the environment.

Payment Vehicle

In the SC card, airport departure tax was used as a payment vehicle. Respondents were asked if they thought that was appropriate. Every group asked who will be responsible for handling the money and called for transparency in the process, *"By giving money to the airport operator, they may use it as a bonuses for the executives"* (Group 1) They wanted a strict set of regulations about how the revenue could be spent as they suggested they do not trust those who deal with the carbon offset fee (especially if there is any government authority, including the airport operator). Others preferred an international organisation, *"There should be a central organisation, maybe an international one to manage this fee. It can help reduce the problem globally"* (Group 1). The majority of passengers wanted the carbon offset fee to be included in the airport departure tax instead of a stand-alone fee. They said that an additional fee will make ticket buying more complicated. Other comments include, *"I don't think I will be willing to pay as a separate environmental fee, better to be included in the airport fee"* (Group 3), *"Separate fee make me feel like I'm having to pay more"* – Group 3 In terms of price range given in the exercise, most respondents stated that a range of a few hundred baht increase is acceptable and it is worth to pay within that price range to protect their health and well-being. Most suggested that a price range of 200-500 baht increase is acceptable provided that the fee can really reduce the impact.

Service Cuts for Carbon Offsetting

During the first group discussion, a participant suggested that he is willing to give up some of the services for the environment, *"Thai Airways tickets are already expensive. They can cut down some services and use the money for the environment"*. The rest of the group agreed and suggested that they are happy to do so especially during short flights, *"Sometimes airlines offer too much food on a short flight, I am happy if they cut it down a bit and used the*

money saved for carbon offsets" Participants from the second and third groups were asked if they were willing to give up some in-flight services so that the saved cost could be used to spend on carbon offsetting. The second group rejected it as they thought adding a fee was the airline's attempt to transfer the responsibility to customers whereas the third group stated that they were happy to have their level of inflight service reduced in exchange for a better environment on short flights. However, participants suggested that airlines may want to maintain their in-flight service and reputation which may make it unrealistic.

Hypothetical Situation Changes

The SC cards used percentage changes to elicit the WTP and respondents were asked if they could visualise the change and whether they had any suggestions to make it more realistic. There were two main opinions on the use of percentage change. Most believed that percentage change is the standard practice, *"I'm quite used to percentage change, I encounter the percentage concepts in everyday life"* (Group 2), *"Percentage is an international standard"* (Group 1). Also, they suggested that they were familiar with the percentage change in daily life and they could imagine roughly the magnitude of the changes. But they agreed that each individual perception of change is not the same, *"Each person has different value per percentage"* (Group 1), *"I think I understand, although not everyone may have the same idea"* (Group 3). It was suggested that fuel consumption may be used as a proxy or attribute to represent engine efficiency and real-life noise should be used as a proxy to noise change; for example, comparing with gunshot noise which may give the respondent a better idea of change.

7.4 Conclusions

7.4.1. Residents

The resident focus groups have confirmed that they perceived negative environmental externality effects from aviation activities at Suvarnabhumi Airport. Noise is of prime concern to local residents along with air pollution and vibration. Other problems include effects on agricultural yields and traffic congestion. Some consider environmental problems to be the priority whereas others value the economic benefits of the airport more than the impact. It also found that the perception of noise level during different times of the day differed between individuals. This can be partly attributed to the fact that each individual is at home at different times of the day. Residents tend to report that they are most annoyed during the period that they are at home and asleep and particularly at night time from midnight to 3am.

Contextual differences between groups were identified in two areas. Firstly, noise. Given that every participant unanimously agreed that take off noise is much worse than landing noise, it can be concluded that residents in Ladkrabang groups (which are primarily exposed to noise from landing aircraft) are less affected than residents in Bangna groups which were exposed to noise from taking off aircraft. The change in noise level is noticeable by every group when the airport switches its take-off and landing path during winter season.

The second aspect is livelihood. Ladkrabang groups were found to have benefited from the airport development more given that they have access to direct commuting rail to downtown Bangkok and the urbanisation in the area leading to business and job opportunities. However, Bangna resident's livelihoods were adversely affected as they were mostly living in the area before the airport opened and engaged in agricultural activities. They have not benefited from urbanisation as in Ladkrabang area, and the aviation activities have a detrimental effect to their agricultural produce and their way of life. This problem, while was not anticipated in this study, is similar to Heaver (2003) report at Bucharest's Otopeni airport which also found that pollution from aircraft has detrimental impact on residents' agriculture such as black soot on tomato crops. Apart from agricultural impact, Otopeni study is also found to have similar problem with this study in terms of aircraft interference with television and telephone reception.

The findings from aircraft noise-related impacts in residents are mostly in line with literature. In terms of aircraft noise, annoyance is the main concern which is the same as stated by Hume and Watson (2003). Furthermore, the problems of sleep disturbance, cognitive problems along with hearing were also found which are in line with Berry and Findell (2009) which showed dose-response relationship between noise exposure and these problems.

7.4.2 Air Passengers

Air passengers revealed that they are aware of broader environmental problems and also the environmental problems created by their air travel behaviours. None of them have offset their carbon when buying air ticket and the majority of respondents had never heard some of the carbon offset concept. However, most of them have been practising environmentally friendly behaviours. They acknowledge that climate change is a serious problem and they have been affected by it. In terms of WTP acceptability, second group adopted a strong opinion of refusing to pay. The rest agreed in principle that they are willing to offset provided that the offset scheme is realistic and transparent. Group 3 which consisted of younger

participants under 30 years old were found to have similar attitudes toward aviation externalities and general environmental problems in Thailand in comparison with other groups. This group exhibited a greater awareness of aviation externalities and carbon offsetting than other groups. This is attributed to the change in educational system in Thailand to focus more on environmental concerns.

7.4.3 Implications for SC Designs

a) Residents

For airport residents, the SC experiment found that there was confusion and problems with the presentation format particularly with the need to stress that respondents have to choose the whole option rather than each attribute individually. The noise like concept (Version A) is problematic for residents to understand as each person has a different opinion about the noisy and quiet times. While it was promising in the design stage, it didn't work in this study because each individual had a different perception of the noise level at different times of the day. Version B, which asked for the WTP to completely remove aircraft noise was identified as unrealistic since closure of the airport is highly unlikely. They expect that the situation will worsen in the future. An alternative suggested and worth pursing is flight path re-routing. This implies a removal of aircraft noise but not reduction in flights which would have an economic impact on the country and the area. In reality, re-routing would mean aircraft noise will be emitted elsewhere and there will still be impact to the environment but it can be used as a proxy for aircraft noise.

Seasonality and take off patterns could also be considered as an attribute instead of the flight frequency. It has been found that landing aircraft are less noisy than take off and seasonal changes to landing and take-off patterns cause a noticeable difference in aircraft noise level (particularly for those living in Bangna who report that landing periods in Winter are less noisy).

Version C was the easiest to understand. It works because residents are more concerned about the number of noise incidents which disturb their activities than an overall noise level. It was agreed that larger aircraft are far noisier than the smaller ones. This design has been used in previous SC studies but it may cause confusion in terms of how a change in one movement causes the noise level to change. Another option is a night flight ban. It was found that this is exactly what the residents want as they desire a quiet night sleep. It has the advantage of being realistic and it is implemented at various airports around the world.

As for the payment method, it was found that it was acceptable to have a range of 200-400 baht a month which is similar to value of WTP to offset carbon per flight. This amount is similar to monthly fees for other things that they buy in real life (such as internet and water bills) and the amount is not too high to impact their economic well-being.

In conclusion, a night flight ban and flight rerouting were recommended by residents and will be in the final SC design along with the payment level used in this experiment with an adjustment to question card design that clearly separates the individual options to reduce confusion.

b) Passengers

The SC experiment showed that some passengers are willing to pay to reduce the problem but there are areas to be addressed. Firstly, the percentage change was used in the design where they agreed that each one has different perceptions toward the percentage change although they believe that it's a standard way of asking. The problem that is unsolved is the presentation of noise and pollution change levels. Even though respondents suggested that they are familiar with the percentage change concept, the interpretation differed between individuals. One suggestion that emerged from the discussion is to use real life noise to compare the reduction of noise such. However, this still does not solve the pollution attributes level. It may be possible to explain the respondents of the current effects of pollutions and tell them of how the effect can be reduced at a given reduction rate. Furthermore, the presentation of options in separate bubbles and in the horizontal order to fit Thai reading patterns should be considered. The payment vehicle of airport departure fee raises some controversies such as the accusation of a possible mismanagement of any offset fee. The concern is understandable as there have been various corruption allegations involving the airport. However, it is found that using a departure fee is better than a standalone offset fee.

To conclude, it is recommended that noise and air pollution are used in the final stage design as attributes along with carbon offset options. It will need to decide what should attribute be used to represent changes in aircraft noise and air pollution level. The payment vehicle used in this experiment is suitable along with the payment rate. Furthermore, there is a need to design a card that clearly separates the options to reduce confusion in choosing the preferred scenario.

8. STATED CHOICE QUESTIONNAIRE EXPERIMENTAL DESIGN AND PILOT STUDY

8.1 Introduction

This chapter discusses the experimental design and pilot study of the SC experiment. The results from the focus group study (Chapter 7) are used to aid in the choice of attributes for the SC experiment. This chapter first discusses the attributes and level selections and subsequently the three SC designs that used in the actual survey. The latter part of the chapter is dedicated to the implementation plan for the survey and the pilot study results to identify and resolve any problems with the designs before the actual survey, which is discussed in Chapter 9.

8.2 SC Design

8.2.1 Attribute Selection

Potential attributes for use in the SC experiment have been discussed in chapters 6 and 7. The next step is to select the attributes that are appropriate to this study. There are two main issues regarding attribute selection to be addressed. Firstly, the attributes must be relevant and meaningful to the respondents. Secondly, the attributes must conform to the objective of this study, that is to say they must provide a comparable value of aviation externalities from both the perspective of airport residents and Thai air passengers.

Taking the two issues into consideration, it is clear that two designs are needed. The first one is a design aimed at residents, and contains suitable attributes and presentations that are relevance to residents. The second design is aimed at passengers and contains attributes and presentations that are relevant to passengers while, at the same time, being suitable for comparison with airport residents. The next section discusses individual attributes, their relevance to each group of respondents and how to present each attribute appropriately.

Aircraft Noise Attribute

Aircraft noise is chosen as an attribute to represent the environmental impact aspect of the valuation. In the case of Suvarnabhumi airport, aircraft noise is the most severe and noticeable problem experienced by residents and it is the cause of other problems including vibration, activity and conversation disruptions, health concerns and interference with television and mobile phone signals.

Two presentation styles were chosen for the residents and passengers surveys. These are noise proxy for residents and proportionate change for passengers. By using a proxy for noise, it is believed that residents can easily relate their preference based on the presented proxy, although it acknowledges the limitation is that the changes in proxy level may not accurately reflect the actual level of noise changes. Percentage or proportional changes will also be used to present level changes. These level change presentations have a disadvantage as respondents may not have the same idea about a given percentage or proportional change, particularly in terms of how aircraft noise and emission change (for example, an increase by a quarter may not be perceived equally or accurately by residents). However, the focus group found that while respondents agreed that they may have discrepancy in interpretation of changes from one individual to another, they are used to the percentage presentation in everyday life and suggested that they have an understanding of the percentage change concept and provides comparable data for residents and passengers.

Aircraft noise presented to residents in the form of flight path rerouting. Aircraft rerouting attribute can also be a proxy for other problems including aircraft engine emissions and air accident risk as re-routing means that the aircraft air flying elsewhere which imply that noise, engine pollutions and accident risks are moved elsewhere. It must be noted that the re-routing attribute may cover most of the negative aspects of aircraft operations at Suvarnabhumi as a whole, but it does not provide a valuation of an individual local problem. Half of the residents will have re-routing presentation and the other will have percentage change design.

Local Air Pollution Attribute

According to the focus groups with residents and passengers, local air pollution is the second most important issue associated with aircraft operations. One problem with this attribute is that residents are not able to quantify the volume of aircraft-related pollutants. They are also uncertain about the exact implications of aircraft engine pollution on their health and well-being. This makes the presentation of the attribute problematic.

The design of the SC resident card addresses local air pollution by using flight-path re-routing scenarios, but there is still a need to establish value of local air pollution. This is addressed in the passenger design as an attribute. There have been no previous studies on air passengers' valuation of local air pollutions before. One possible attribute is the number of flight or aircraft movements which, as discussed before, has long been used in resident WTP to present as aircraft noise proxy in airport resident valuation of aircraft noise. Although it could be used as a proxy to noise and air pollution (less flights, less pollution emitted), it

could be perceived as causing negative impact to passengers as less aircraft movements may be interpreted by air passengers as less convenient and it is therefore unsuitable as an attribute.

In passenger design, local emissions are presented using percentage change which is the same method used in noise attributes. Given that participants in both passenger and resident groups suggested that they are familiar with percentage change in many circumstances in their life, it is adopted for the passenger card presentation. Also, it is relevant to both groups since residents can choose how much more or less pollution in their area and passengers can choose how much more or less emissions are created by aircraft engines.

Global Level Pollution Attribute

Carbon emissions from aircraft are of worldwide concern and are the focus of passenger valuation. Global level pollution is therefore selected as an attribute for the passenger card. The problem with this attribute is that residents may not perceive it to have a direct impact on their life and wellbeing even though it has a macro impact on the world as a whole. Thus it was ultimately decided not to include this attribute in the re-routing card.

As for the passenger card presentation, previous studies on passengers' WTP to reduce aviation impacts used carbon offsetting as an attribute (Lu and Shon, 2012; Mackerron *et al*., 2009; Brouwer *et al*., 2008). Mackerron *et al*. (2009) additionally explored how passengers wanted the offset revenue to be used and examined whether the offsetting programme was certified by the government. The design used in this study follows previous studies by using carbon emission offsetting option for global emissions attribute and in practice passengers are offered the chance to offset their carbon emissions on some flights. As for the comparison issue with residents, they will also be given a chance to elicit valuation in the resident's percentage change card even if they are not directly affected, but it can be justified since global emissions which causes climate change also has an indirect impact on residents such as flooding and a hotter climate in Thailand.

Travel Time Attribute

This attribute is used to present the economic benefits of Suvarnabhumi Airport in the form of travel time reduction to workplace or shops. It was selected because it is considered as an attribute that is applicable to everyone and a good representation of the benefits brought about by the airport opening.

The focus groups report three main benefits of Suvarnabhumi Airport namely; improved business and employment opportunities, enhanced transport infrastructure, and the development of the neighbourhood. Wardman and Bristow (2008) incorporated quality of life into an SP study which offered various attributes such as local crime rate and school examination result into the valuation. However, in the case of Suvarnabhumi Airport, there is no information available on those quality of life indicators making the utilisation of such attributes problematic.

Since it was suggested that proximity to Suvarnabhumi Airport improves employment and earning prospects, this study considered incorporating those variables within an attribute. It could be presented as the rate of unemployment or proportionate change in income. The problem was that there is no published rate of unemployment or available jobs to make comparison, and changes in income would not be relevant to the unemployed respondents.

With respect to transport improvements around airports, Thanos *et al*. (2011) used distance to a tram stop as an attribute. In Bangkok's case, the government built an airport express railway which benefits residents from Ladkrabang by offering a rail link to Bangkok city centre that reduced commuting time from the area to 30 minutes from 1-2 hours. However the focus group discussion revealed that, while important, commuting time was not relevant to unemployed respondents and to those travelling to work on private transport. This study uses therefore travelling time to workplace/the shops as an attribute to represent the benefit of Suvarnabhumi Airport. This attribute covered many economic benefits of the airport. Firstly, it represented the development of transport infrastructure for both public and private transport (bus network and rail link development for public transport users and the building of new roads and motorway for private car users). Secondly, it represented new business and employment opportunities as a result of the airport presence, since shorter travel times could also be interpreted as living closer to the workplace or businesses. Thirdly, for those who are not employed, respondents in this group are asked for travel time to do shopping. It represents the development in the area; for example, new shopping malls, new markets as a result of the expansion and urbanisation of the areas around the airport. This also represents the improvement of transportation infrastructure and public transport in the area.

Since this attribute only represents benefits to the residents, it is presented only in the resident cards and is not included in the passenger design.

8.2.2 Payment Vehicle

For the resident group, various forms of local tax have been used in previous studies as payment vehicle for aircraft noise valuation (Carlsson *et al*., 2004; MVA Consultancy, 2004; Wardman and Bristow, 2008). In Thailand, there is a household tax (*Pasee Rong Reuan*). Nevertheless, the rate is extremely low (approximately 10 pence per *rai* per year, one *rai* is 1,600 sq.m.) and as it is rarely collected in practice it represents an impractical payment vehicle for the purposes of this study. In the Chalermpong (2012) study of Bangkok, compensation in a form of a percentage reduction in monthly rental price was used as a payment vehicle. However, this payment vehicle only covers rented property and it is not applicable for the owner-occupied properties that were included in this study.

Instead, an 'Airport Impact Relief Scheme' was used as a payment vehicle in the resident SC card. This can be used for both payments to reduce the impact from aircraft and as a form of compensation offered to affected residents. Thai nationals are familiar with the word 'scheme' as the government often uses the word for public projects. For example, the universal 30-baht health care scheme where patients pay 30 baht for all medical care. Another example is the flood relief scheme which offers flooded residents and farmers compensation when floodwater is directed into their area to protect the city centre.

For the air passenger payment vehicle, Mackerron *et al* (2009) used a carbon offsetting price as a payment vehicle in a SC study on air passengers. This approach is similar to the one adopted by Lu and Shon (2012) and Brouwer *et al* (2008) as these studies both asked for the willingness to pay to offset the carbon emissions their flight creates. In this study, three alternative payment vehicles were considered: air fare, a stand-alone offsetting fee and an airport departure tax. The participants in the focus groups suggested that an airport departure tax is the preferred payment vehicle. Changes to air fares were perceived to be a revenue generator for airlines whereas stand-alone offsetting fees were considered to be too complicated. Consequently, an airport departure tax was considered as payment vehicle. It has problems with deteriorating scenario price range as currently the airport charges 700 baht per passenger per flight and the price range for both payment and compensation is from 300 to 1,500 baht making it problematic since it cannot provide a reduction of more than 700 baht. Therefore, air ticket price is used instead. An air fare increase or reduction eliminates the problems of the limited price range of airport departure tax. It is also more appropriate than a standalone offsetting fee as there is no suitable compensation method for the worsening scenario.

8.2.3 Resident Card Levels and Options

a) Levels

The re-routing attribute contains five levels based on proportional level changes (see Table 8.1) which are: all flights rerouted elsewhere, half of flights are rerouted, as now, airport expanded for 50% more flights and airport expanded for doubling of flights. Airport expansion was chosen as a worsening scenario as the AOT currently has a plan to expand the airport to double the capacity. Initially, the design only considered two extreme forms of change; complete removal of aircraft noise (all flights rerouted) and airport expansion doubling current flight movements.

Table 8.1 Resident Card Attributes and Levels

Attributes	Levels
Aircraft flight path	All flight rerouted elsewhere (no aircraft noise) Half of the flights are rerouted (100 flights/day) As now (200 flights/day) Same flight path with airport expanded for a half as many flights (300 flights/day) Same flight path with airport expanded for doubling flights (400 flights/day)
Travel time to work place/ the shops	Travel time reduced by half Travel time reduced by a quarter As now Travel time increase by half Travel time is doubled
Airport Impact Relief Scheme (Baht)	Monthly Fee: 300, 700,1100,1500 Monthly Compensation: 300, 700, 1100,1500

The travel time attribute also used proportional level changes and consisted of five levels (two improvement, one as now, and two deteriorating levels). The proportional level change was used because it is flexible and applicable to everyone. During the focus group, the commuting time was presented in x minutes shorter or longer. This is not applicable to everyone since each individual has different times to commute and in some cases the offered level is irrelevant to them. Therefore proportional change will be used in this study. Given that respondents have different travelling patterns, the questionnaire included question on the duration of travel time, and the frequency of travel, to set up the status quo level for respondents.

Lastly, the payment attribute consists of nine levels (four level for noise reduction fee, one as now, and four levels for worsening attribute). The price level starts from 300 baht/month and ends at 1,500 baht/month. Chalermpong and Klaikleung (2012) used percentage change in rental fee (10%, 20% and 30%) with the mean monthly rental of 3,508 baht which reflects the similar rate of this study.

The focus group suggested that residents may be willing to pay between 200 to 700 baht per month to reduce aircraft noise but are unlikely to pay anything more than 1,000 baht. Nonetheless the design included 1,500 baht level to assess people with high incomes.

This is the first design which uses flight rerouting to obtain a valuation of the overall aircraft noise problem at Suvarnabhumi Airport. An example of the card is shown in Figure 8.1. Each rerouting card contains three options; an improving, a worsening, and an 'as now' option.

b) Option

In each card, respondents were given three options. Two SC options and an 'as now' option (see Figure 8.1). The inclusion of an 'as now' or 'opt-out' option has a number of advantages. Firstly, the 'as now' option improves the realism of choice situation and avoids forcing respondent into making a choice that does not truly reflect their preference and it is therefore consistent with economic choice theory (Adamowicz and Boxall, 2001; Carson *et al.,* 1994). Kontoleon and Yabe (2003) suggest that normative theories of rational choice consider the 'not to choose' option as being a choice when the level of the options did not reach the threshold level of utility for the respondents to choose between the given options (i.e. if the levels in the options offered is not 'satisfactory' enough, the respondent will not choose any of them).

Figure 8.1: Resident Card Example

Attribute	**OPTION A**	**OPTION B**	**OPTION C**
Aircraft flying over your residence	**All aircraft rerouted elsewhere** (you will not hear aircraft noise)	**Half of the flights re-routed elsewhere** (you will not hear rerouted aircraft noise)	As now (200 flight/day)
Travel time to work/ the shops	Travel time **reduced** by half	Travel time **doubled**	As now
Airport Impact Relief Scheme	You would **pay** 1,500 baht/month	You would **receive** 1,100 baht/month compensation	No payment/ compensation
I would choose	**A**	**B**	**C**

Nonetheless, including the as now option as an opt-out alternative introduces problems into the SC experiment. Firstly, the ‘as now’ option may be regarded as an ‘easy’ option for respondents when they have to choose from the complex set of choices, thus causing bias (Carson *et al.,* 1994). Furthermore, status quo bias may occur as respondents may prefer ‘inaction’ in which they do not have to bear the consequences and choose the status quo (Kontoleon and Yabe, 2003). There are also problems in analysing the results since as now option does not allow the study to assess the information on relative preferences of each attributes. Also it does not provide information of what attribute levels made the respondent to choose the opt-out option (Kontoleon & Yabe, 2003).

With respect to previous studies and the inclusion of an ‘as now’, the studies by Wardman and Bristow, (2008) & MVA Consultancy (2004) did not include an as now option for the aircraft movement change valuation whereas Carlsson *et al*. (2004) and Chalermpong & Klaiklueng (2012) allowed the respondent to choose the current situation option. This design incorporates an as now option in the choice cards for realism and avoiding forcing respondents into choosing an unwanted option. There is a potential status quo bias but the focus groups did not show such tendency from either the residents or the passenger groups. The potential for bias will be assessed again during the pilot study.

8.2.4 Passenger Card Levels and Options

An example of the passenger card is displayed in Figure 8.2. The first two attributes have similar levels and presentation (see Table 8.2). Each attribute has two improvement levels, an as now option and two deteriorating levels presented in the form of percentage change.

Carbon offsetting attribute has two options which are yes (to offset) or no (for no offsetting). Carbon offset revenue usage was included in the focus group study by adopting the similar offsetting attributes and level as Mackerron *et al*. (2009). In the focus group, however, it was found that passengers are willing to pay to offset their carbon but experience difficulties in choosing how the offset fees should be spent and they suggest that this may be too complex and they also have to consider other attributes on noise and local pollution which may cause cognitive problem. Therefore, only a yes or no option is offered.

The air ticket price range has nine levels. Starting from 300 baht a flight, the rate increases at intervals of 400 baht up to 1,500 baht which is the same range offered to the resident card for comparison. The air ticket price reduction range is also the same to provide a comparison.

It was found during the focus group discussions that passengers are generally willing to pay to offset their environmental impact at a level of around 100-300 baht. The appropriateness of these levels will be tested during the pilot study.

Table 8.2: Air Passengers Attributes and Levels

Attributes	Levels
Aircraft Noise	25%, 50% less noise
	As now
	25%, 50% more noise
Aircraft Engine Emissions	25%, 50% less air pollution
	As now
	25%, 50% more air pollution
Carbon Offsetting	Yes/No
Air Fare	Increased by 300, 700, 1100, 1500
	As now
	Reduced by 300, 700, 1100, 1500

Figure 8.2: Passenger Card Example

Attribute	**OPTION A**	**OPTION B**	**OPTION C**
Aircraft are	25% louder	50% quieter	As now
Aircraft engines produce	25% less air pollution	25% more air pollution	As now
Carbon offsetting	Yes	Yes	No
Air fare	**increased by** 1,500 baht/flight	**increased by** 1,100 baht/flight	No change
I would choose	**A**	**B**	**C**

Comparison with Resident Group

As previously mentioned, the passenger design will be used to compare the valuation from both passengers and residents. Airport residents will also be given this design, called 'Resident Percentage Change' for valuation alongside the re-routing card to enable the objective of obtaining valuation of the same problem at Suvarnabhumi from the users' and affected parties' perspective. The only difference from the passenger card is the payment vehicle, which is changed from air fare to airport impact relief scheme and the rate given will be per month instead of per flight. Everything else remains the same to preserve consistency and eventual comparability of the results.

In terms of value comparison, it is expected that valuation from the resident's card will be higher than the value from comparison cards as the attributes offered in resident card are directly related to the benefits and costs of Suvarnabhumi airport whereas attributes in the passenger card used for comparison with residents contain only the environmental aspects of the problem.

8.3 Experimental Design

Choice cards were constructed in accordance with the D-efficiency principle (Rose et al., 2008) using the Ngene software with the help of Dr Alberto Zanni. Each respondent was given eight SC cards to complete in the questionnaire.

There were 32 SC cards for each SC exercise. These 32 cards were divided in to four blocks of eight cards. Each block of design is then given to 50 resident respondents and 100 passenger respondents. The full design is available in Appendix F

8.4 Questionnaire Design

This section discusses the design of the survey questionnaire. Firstly, it describes the nature of the information that is required for the analysis and explains the rationale for the questions that are included in the survey. The final versions of questionnaires are available in Appendices B, C and D.

8.4.1 Resident Questionnaire

Each questionnaire is divided into four sections (see appendices B and C). The first section contains questions about residential characteristics in terms of address, type of residence, duration of residency and financial situation. This information aims to compare different types of properties and the valuation of residents. This is followed by questions to assess the attitude and awareness of the environmental condition problems in Thailand which are also asked in the passenger questionnaire. There is a need to establish the benefits and problems of living near the airport and these questions are based on questionnaire format of Bristow, *et al.* (2003). The question wording takes into account recommendations by Fields, *et al*. (2001) on standardised wording for noise annoyance questionnaire surveys. There is also a question to assess the benefit of the airport by giving a list of potential benefits of

living near the airport. This asks respondents to rate how they benefit from different socio-economic improvement brought about by the airport. The types of benefits are taken from the focus group study results about the positive impacts of Suvarnabhumi Airport. There is a need to identify the different sources of annoyance in terms of noise for comparison with the aircraft noise level. Hence, there is a question to identify different sources of noise annoyance near their residence along with the level of annoyance of each source. Furthermore, the study needs to gather information on different types of impact caused by aircraft activities with an emphasis on aircraft noise and the perceived severity of the problem. This is addressed by a question which asks respondent to identify aircraft noise-related problems.

Section 2 of the study is the SC exercise and contains written instructions and an example of how to complete the SC exercise. In this section, there are questions relating to 'travel time'. Since each individual has different travel behaviours the study must establish the travel time and frequency of travel of the respondent. They are asked to provide information on where are they travelling to, frequency of travel and means of transport to provide information for the analysis of travel time attribute.

Section 3 is designated as a debriefing section immediately after respondents complete the SC exercise. Firstly, the study uses aircraft re-routing and percent changes in flight frequencies as a proxy for aircraft noise. It needs to understand how respondents interpret and relate a given flight number increase to the actual noise level. As a result, respondents were asked how they think the overall noise level will alter if the number of flights is doubled. Respondents are asked if there were any attributes that they ignore or emphasise which could provide insights into the results of this study. Additionally, the study wants to know information about compensation and how the compensation money would be used. Therefore in the last part of section 3, the questions ask about whether they have made noise complaints to the airport authority, whether they have received any compensation and, if so, how any money they received was spent.

Section 4 asks demographic information about the respondents to provide an insight into the extent to which different demographic backgrounds lead to different valuations being made.

8.4.2 Air Passenger Questionnaire

The passenger questionnaire contains 22 questions that are designed to be delivered by an interviewer. This is to facilitate faster completion as departing passengers have limited time

in the departure area before boarding their flights. The questionnaire is divided into five sections. Section 1 (questions 1-8) contains questions about the flight the respondent is taking including their destination, airline, class of travel, ticket price and purpose of travel. This data will help identify any differences in valuation between different types of passenger. Questions 7 and 8 ask about the availability of carbon offsetting for their flights. It was found during the focus group study that most of the passengers did not know about carbon offsetting or how it works. If the respondent does not know about carbon offsetting, the interviewer will briefly explain the concept to the respondent. There is also a brief explanation on what is carbon offsetting and how does it work in the questionnaire.

Section 2 has three questions which are essential to gauging the awareness and attitudes towards general and aviation-specific environmental problems in Thailand. These are also asked in the resident survey for the same purpose. The first question in this section asks respondents about their perception of the severity of each environmental problem in Thailand. This is to assess the general perception of air travellers towards the current environmental situation in Thailand. The list of problems is compiled from problems identified by the focus group. Question 9 is used to examine the 'environmentally-friendly' behaviour of the respondents. The aim of this question is to see if passengers care about the environment and try to do anything to reduce the effect in everyday life therefore question. Lastly, there is a need to examine air passengers' perception toward each type of aviation-related environmental problem.

This is asked in question 11 by asking respondents to rate the severity of aircraft-related environmental problem in Thailand. The list of problems is based on the finding from the passenger focus group. Questions 9-11 are also asked in the residents' questionnaire.

Section 3 comprises the SC exercise. Passengers will be given verbal and written instructions about how to complete the exercise. Section 4 contains debriefing questions (questions 12-14). Questions 13 and 14 are used to analyse the results by asking if there are any attributes that the respondent ignored or focused on. Section 5 (questions 15-22) contains the socio-economic background information to assess different demographic and economic background effects on valuation and attitudes.

8.5 Pilot Survey

In order to verify the practicalities of the three SC design and identify any problems associated with them, a pilot study was conducted prior to the actual experiment. The pilot had the following aims;

- To test the questionnaire wording and format.
- To test the SC presentations in terms of attributes and levels.
- To identify potential cognitive burden, fatigue and bias.
- To obtain preliminary WTP values and co-efficient of attributes to inform the efficient experimental design.

8.5.1 Sample Size and Sampling Method

The pilot test involved 60 respondents, 40 were residents and 20 were passengers. Since there were two versions of the resident SC design, the SC respondents were divided into two groups of 20. The first group was given the rerouting version. The second group was given comparison card. Five passengers and five residents also participated in the earlier focus groups. They were included to see how their discussions from focus group were developed in to the SC exercise.

Respondents' recruitment in this pilot was the same as the method used for the focus group recruitment. Residents were directly recruited through random house-to-house canvass from residential areas under NEF30 noise contour or over. 20 participants were recruited from each side of the airport using this method (Ladkrabang and Bangna). Ten on each side were given rerouting card and the other ten were given with percentage change cards. Passenger respondents were recruited using a snowball technique using acquaintances from various socio-economic backgrounds who were each asked to recruit 4 participants who had flown within the last two months.

8.5.2 Experimental Design and Analysis

An Orthogonal design was used for the SC cards in the pilot test. Each design was divided into four blocks of eight cards with illogical choices removed and SC cards were paired by shifted method in which the choice cards were paired by using the subsequent card in the same block; for example, card number one is paired with card two, card two is paired with card three (and so on).

Two assistants were responsible for conducting the pilot test in Thailand. Both were involved in organising the focus groups and had a good understanding of the survey and the scope of the research. They were briefed about the objectives of the pilot test, what questions to ask (see details in pilot test question section), and pilot test procedures.

To test the planned experimental procedure, a mock survey procedure was used. At the beginning, it was explained that this was a pilot test with the aim of verifying the wording, presentation, and attributes and level. Residents were given a questionnaire to complete on their own whereas passengers were interviewed. The survey sessions were timed, respondents were asked to circle any wording that they did not understand or ask the assistants who took a note on the problematic wording or presentation and add any other comments that they may have.

When complete, respondents were debriefed using the following questions;

1. What do you think about the attributes and levels offered in the cards? Do you understand what they are?

2. What do you think about the price range and payment vehicle?

3. What is the highest amount are you willing to pay to eliminate the aircraft-related environmental problems?

4. Did you have any difficulties completing the choice cards; for example, understanding, unfamiliarity, tiredness, or boredom?

5. Are there any attributes do you wish to add or have remove from the cards?

6. Any further comments?

Finally, the completed questionnaires were scanned and sent to Loughborough for data coding.

8.6 Pilot Results

8.6.1 Questionnaire Wording and Format

None of the participants reported problems in understanding questions or the instructions to complete the questionnaire. There were complaints about the length of questionnaire as participants felt that it was quite long, but when asked if they suffered from fatigue or

boredom they responded that it was not a problem but they wished it was shorter. The average completion time for resident was 25-30 minutes and 15-20 minutes for air passengers.

In terms of questionnaire completion procedure, respondents confirmed that they preferred to be given a questionnaire to complete in their own time along with verbal instruction on how to complete the SC card. Air passengers agreed that questionnaire-based interview were the best option as it is quicker and easy to understand.

8.6.2 SC Card

The pilot survey found no problems with participants in terms of how to complete the SC cards. For the number of cards, respondents found that eight was an acceptable number. Only one resident respondent did not finish and completed only six cards saying that it was too confusing for her. The rest reported that they had no problem completing all eight cards and reported no fatigue or confusion with the presentation of the SC cards.

In terms of attribute presentation, participants reported that they had no problems in understanding the attributes with the exception of carbon offsetting as most of the participants never heard of it before. However, there was an explanation available in the questionnaire and it was found that they understood the concept after reading the explanation.

The debriefing question on attributes found that in the resident comparison card there is a similar numbers of resident participants who ignored each attribute as shown in Table 8.3. For air passengers, it shows that aircraft noise attribute is the most ignored attribute (12 respondents) whereas carbon offsetting was the least ignored attribute.

Table 8.3: Ignored Attributes on Passengers and Resident Comparison Cards

Attributes	Residents	Passengers
Aircraft noise	12	6
Air pollutants from aircraft engines	12	2
Carbon offsetting	14	1
Aviation Impact relief scheme fee/ air fare	14	5
None	0	9

In terms of focused attributes, Table 8.4 shows that 28 residents paid special attention to the aircraft noise attribute followed by air pollutants (18 respondents), carbon offsetting (14 respondents) and the impact relief fee (12 respondents). Passengers were more concerned about air pollutants with 11 of them indicating that they had focused on this attribute and five reported that they had focused on the air fare. An equal proportion of passengers (20%) focused on aircraft noise and carbon offset attributes while 2 passengers did not focus on any particular attribute. The implications from these two tables are that passengers and residents see different priorities in the aviation externalities. That is to say, passengers are more concerned about air pollution and residents are more concerned more about aircraft noise. The differences between the two groups are anticipated to cause different valuation results in the SC experiment in which air passengers are likely to elicit higher valuation for air pollution than noise and residents are likely to value noise more than air pollution.

Table 8.4: Focused Attributes on Passengers and Resident Comparison Cards

Attributes	Residents	Passengers
Aircraft noise	28	4
Air pollutants from aircraft engines	18	11
Carbon offsetting	14	4
Aviation Impact relief scheme fee/ air fare	12	5
None	0	2

In the rerouting card attribute (Table 8.5), half of the respondents indicated that they focused on rerouting and relief scheme fee and a quarter of them focused on travel time. Two respondents did not focus on any particular attribute. On the other hand, nine ignored travel time while five and three respondents ignored relief scheme fee and aircraft route attribute respectively.

Table 8.5: Attribute on Rerouting Card

Attributes	Focused	Ignored
Aircraft Route	10	3
Travel Time	5	9
Aviation Impact relief scheme fee	10	5
None	2	6

8.6.3 Attribute Levels and Payment Vehicle

Respondents suggested that they did not have any problem visualising the percentage change situation which is similar to the comment from focus group. For the rerouting card which use flight proportional changes of flight movements as attribute level, there is a debriefing question on their perception to the overall noise level change if the number of flights is doubled and the results are reported in Table 8.6, it shows that each individual has different perceptions toward a change in an attribute level in which 7 participants believe that the overall noise level will be more than doubled, the same number believe that the noise level will be doubled. Five respondents believed that the noise will be increased by half and one respondent believe that it will be increased by a quarter. Since a majority of participants believe that the noise level will increase significantly (to either double or more than double the current level), this may have an implication for the valuation of aircraft noise.

Table 8.6: Doubled Number of Flight Movements and Perception on Aircraft Noise

More than doubled	7
Doubled	7
Increased by half	5
Increased by a quarter	1
Others	0

Payment vehicles used for both residents and passengers were found to be easily understood and acceptable. The price range was also acceptable while some of the respondents suggested that they are unlikely to pay for anything above 1,000-1,200 baht to improve the environment.

8.6.4 Non Trading Behaviour

Non trading behaviour was a potential concern. Table 8.7 shows that almost half (49.38%) of the SC cards, ‘as now’ option was the preferred option. Rerouting cards had the highest proportion of ‘as now’ chosen (57.52%) followed by resident percentage change card (46.63%) and passenger cards (45%). Also, approximately one third of resident participants only chose the as now option, representing 35% and 30% of rerouting card and resident comparison card respectively. There was one passenger participant who only chose ‘as now’ option representing 5%. Overall 14 respondents or 23.33% only chose ‘as now’ option.

Table 8.7: Non-trading Behaviour

	Number of 'As now' Chosen	Number of respondent who only chose 'As now'
Passenger	72/160 (45%)	1/20 (5%)
Resident's Comparison Card	73/160 (46.63%)	6/20 (30%)
Resident's Rerouting Card	92/160(57.52%)	7/20 (35%)
Overall	**237/480 (49.38%)**	**14/60 (23.33%)**

When asked why they only chose 'as now' option, the responses were either that the participant believed that it was not their responsibility to pay or they preferred the current situation and did not want to change or think it will be changed. They also suggested that it was not because of fatigue or cognitive burden and they fully considered each card.

8.6.5 Post SC Attitudinal Questions

Table 8.8: Passengers' Attitudinal Statements

Statement	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am willing to pay to improve the environmental condition of airport residents	2	0	10	6	2
It is not my responsibility to pay to reduce the impact caused by my flight	4	5	7	1	2
The price of offsetting scheme is too high	1	1	8	8	5
I don't think that the environmental impact reduction scheme works (unrealistic)	1	5	8	3	3
I don't trust the people who handle the money	0	1	5	4	10
I'm willing to pay to improve the environmental condition in general in Thailand	1	2	6	9	2

The question found that half of the passenger respondents had a neutral feeling about their willingness to pay to improve the condition of airport residents, eight respondents agreed and two indicated that they were strongly disagreed. There was a problem with translation on the second statement as it the logic of Thai language operates in reverse to English and in the actual experiment it will be retranslated as 'It is my responsibility to pay to reduce the impact caused by my flight'. Nine passengers think that it is their responsibility to pay to reduce the impact from their flights, 40% have a neutral feeling and three believe that it is not their responsibility. On the question of offsetting price, half of the passengers think it is too high, nine are neutral and two disagreed. When asked if they think the offsetting scheme will work, 40% stated that they have a neutral feeling, six believed that it is realistic and another six believed that it was not. There was a strong mistrust about the handing of offsetting money with 14 passengers indicating that they don't trust the money to be handled correctly, a quarter had a neutral feeling and only one stated that they trust the people who handle the offsetting money. For the willingness to pay for improvements to the environment in general, eleven passengers stated that they are willing to, six reported to have a neutral feeling and three indicated that they are not willing to do so.

Table 8.9: Residents' Attitudinal Statements

Statement	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am willing to pay to improve the environmental condition in my area	6	14	13	3	1
I am willing to pay to shorten my travel time to work/the shops	8	7	17	7	1
I am willing to pay to improve the environment in Thailand	3	7	18	12	0
It is my not responsibility to pay to improve the environmental condition	5	7	16	10	2
The price of airport environmental relief scheme is too high	2	5	23	7	3
I don't think that any airport relief scheme works (unrealistic)	0	12	23	6	5
I don't trust the people who handle the money	0	3	20	13	4

Table 8.9 shows that half of resident respondents indicated that they were not willing to pay to improve the environmental in their areas and it may explains the high number of ‘as now’ responds and high number of respondent who only chose ‘as now’ options. 13 residents have a neutral feeling. For travel time, 15 are not willing to pay to shorten travel time, 17 have a neutral feeling and eight are willing to pay to have their travel time shortened. The question had the same problem with the passengers questionnaire and it will have to be retranslated into Thai as ‘I am responsible for paying to improve the environmental condition’ as the English version doesn’t conform to Thai language logic. 30% of respondents believe that it is not their responsibility, 16 have no opinion and the remaining 30% think that it is their own responsibility. As for the relief scheme price, 7 stated that it is too high, 23 were neutral and 10 believe that it is not too high. Finally, 17 residents don’t trust the money handling process, 20 neither agree nor disagree and three think they can trust the people who handle the relief scheme money. An additional statement was added in the actual study which is ‘I don’t think the aviation impact relief scheme will happen’.

8.7 Conclusion

This chapter has discussed the SC card design process. The focus group results played an important role in this process in terms of SC card and questionnaire design.

This pilot study achieved the aims of testing question wording and format, SC attribute and level presentations and potential cognitive burden and fatigue. In general, there were no major problems to report in terms of questionnaire wording and format. The only complaint was the length of questionnaire, however, since respondents had no problem completing the questionnaire in terms of cognitive burden and fatigue, it was decided to keep the questionnaire in the same format. There were, however, two debriefing statements that needed to be retranslated as they were awkward in Thai.

The SC card presentation was found to have no problems in terms of respondents’ understanding. It was recommended that a verbal instruction should be given to the resident when handing out the questionnaire. A major concern was the large proportion of non-trading behaviour in which almost a half of responses selected ‘as now’ options. The debriefing question found that residents either for a status quo or as a protest response for those who believed that it’s not their responsibility to pay, this question was also asked in the actual survey. Apart from that, there were no problems in terms of attribute presentation and levels whereby percentage change is reportedly well understood and price ranges are

acceptable. Therefore, the actual experiment will retain the same attributes and levels with eight SC cards for each participant.

The results from the awareness and debriefing sections indicated that passengers are more concerned about air pollution and residents are more concerned about noise. The differences in perception are expected to see higher valuation on pollution and offsetting from passengers and higher valuation on aircraft noise from residents.

9. MAIN SURVEY IMPLEMENTATION

9.1 Introduction

The questionnaire designs and pilot test were discussed in the previous chapter. This chapter details the next stage of the research which is the implementation of the main survey. There are three main phases of survey implementation, namely noise data collection, passenger survey and resident survey. The processes associated with each phase are discussed in this chapter.

9.2. Noise Measurement

9.2.1 Noise Measurement Equipment and Set Up

Given the lack of official noise data, it was necessary to undertake noise monitoring to understand the noise environment around the airport. The noise measuring equipment consists of a CEM DT-8852 Sound Level Meter, a TECP sound calibrator, a tripod and a Toshiba Satellite Pro laptop computer. Noise data logging software was provided by Sound Level Meter manufacturer, CEM. The sound data logger has an ability to log two readings per second.

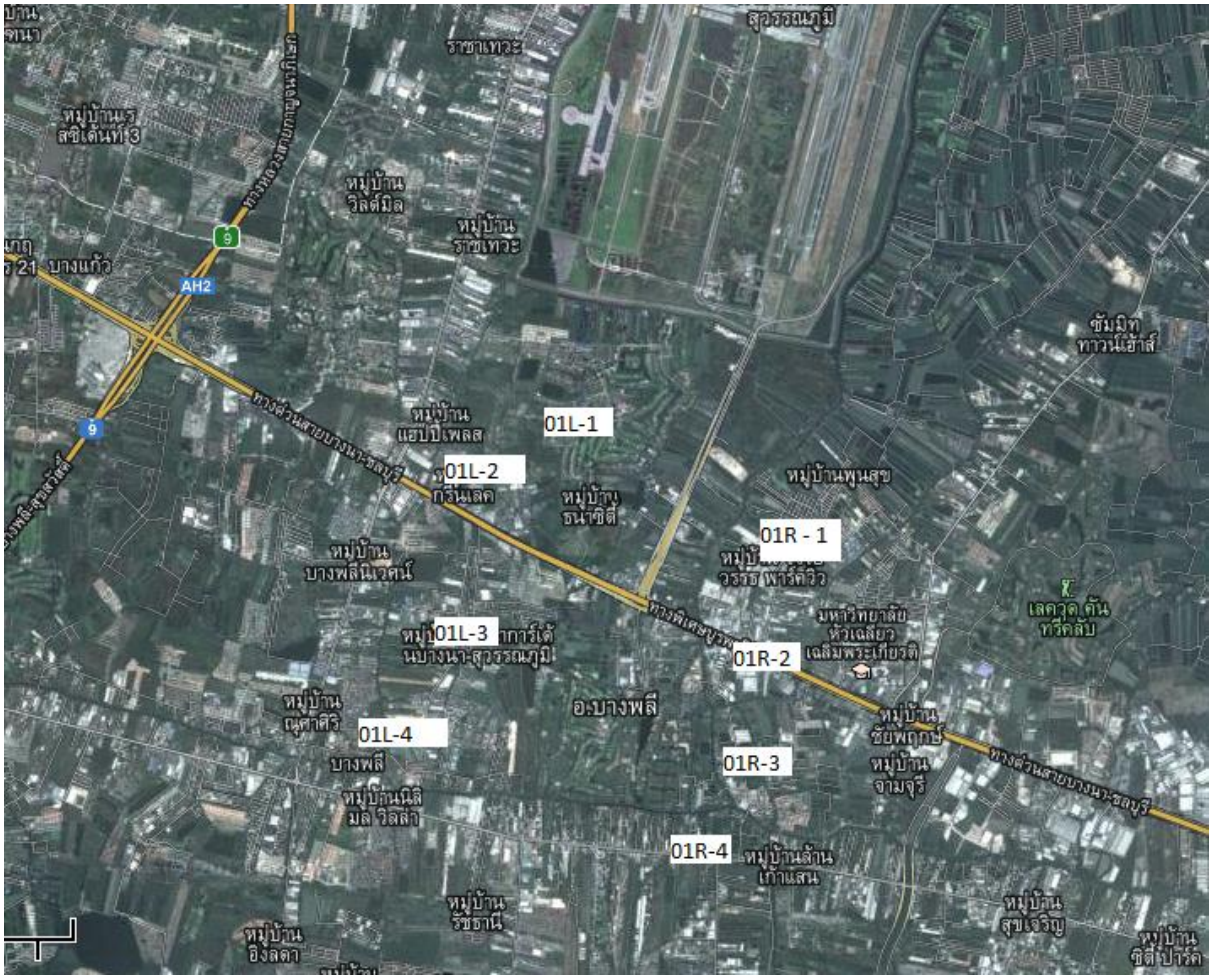
The sound level meter was calibrated before the first sampling of the day using the sound calibrator setting at 94 dB(A). Before each noise sampling one researcher was assigned to sound level meter set up and another was responsible for computer and software set up and a cross-check were conduct once complete. The sound level meter was set at 'fast' reading for varying noise and at dB(A) reading then mounted on a tripod at a height of approximately 1.5 metres facing the direction of aircraft noise with a USB cable plugged into the computer for real-time reading and recording.

9.2.2 Measurement Locations

A total of 16 monitoring locations were chosen based on the communities located under the runway alignments. Each runway had 4 monitoring locations situated under the flight path to measure the noise level of different communities on different distances from the airport. Figure 9.1 shows approximate locations for noise monitoring stations in Bangna area (for runways 01L and 01R) and Figure 9.2 shows approximate locations of noise monitoring stations in Ladkrabang area (for runway 19L and 19R). In general, Ladkrabang experiences mostly arrivals and Bangna mostly departures. However, during the time of measurement

(October-November 2012), it was the end of rainy season with various heavy rainfalls and frequent changes of wind direction making the departing and arriving traffic pattern erratic.

Figure 9.1: Approximate Location of Noise Monitoring Spots in Bangna

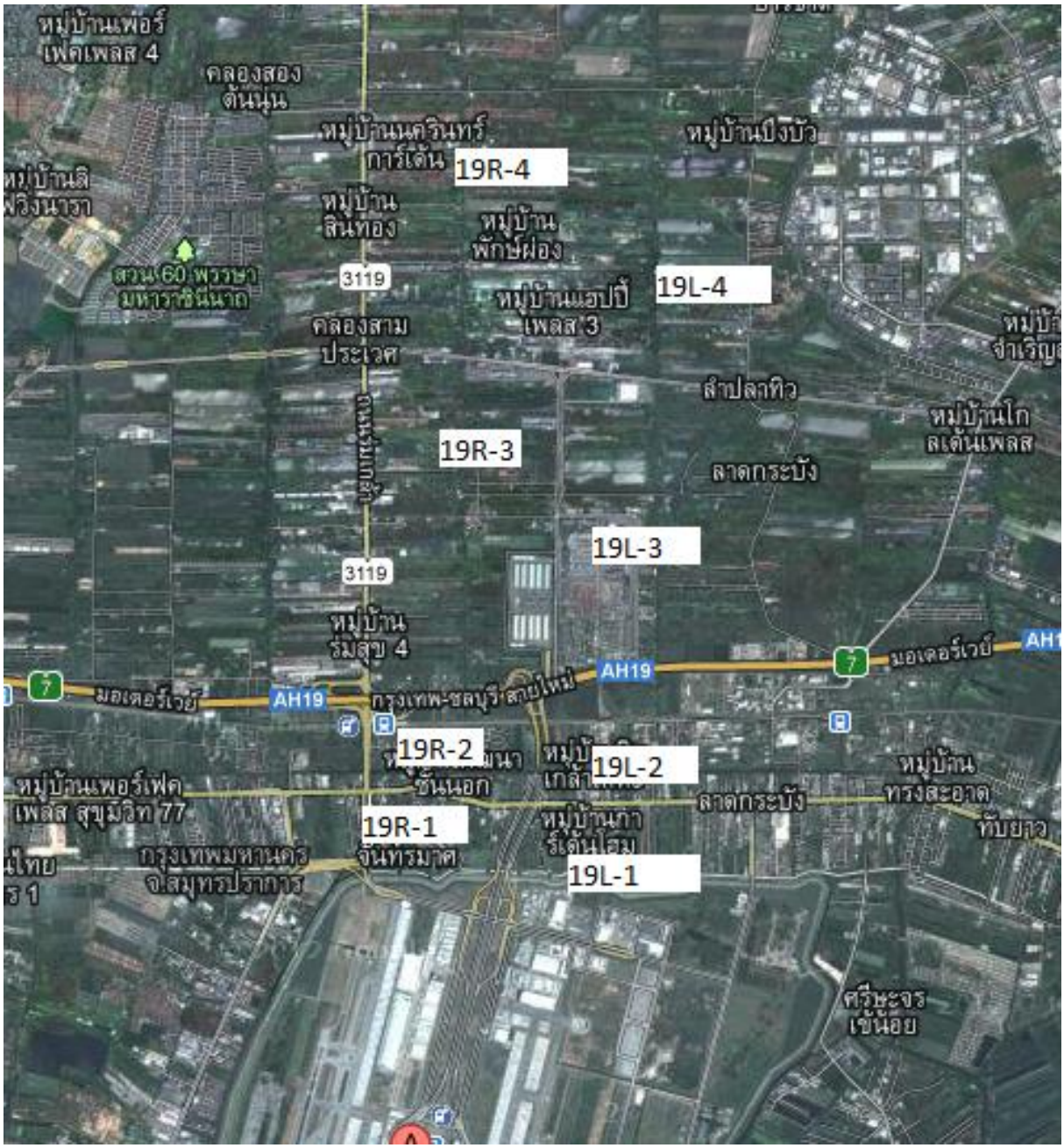


Source: Google Earth

Each location was given two measurements (morning and afternoon) to observe any differences in air traffic and background noise level which was a total of 32 sets of noise data. Noise measurements were taken with consideration of weather condition (i.e. no rain and no strong winds).

Each measuring session lasted 15 minutes and 1800 individual readings (2 per second) were recorded using sound logger software. The maximum, minimum and average noise data was also recorded manually along with the aircraft type and airline observed during the measuring session.

Figure 9.2: Approximate Locations of Noise Monitoring Spots in Ladkrabang



Source: Google Earth

9.2.3 Noise Results

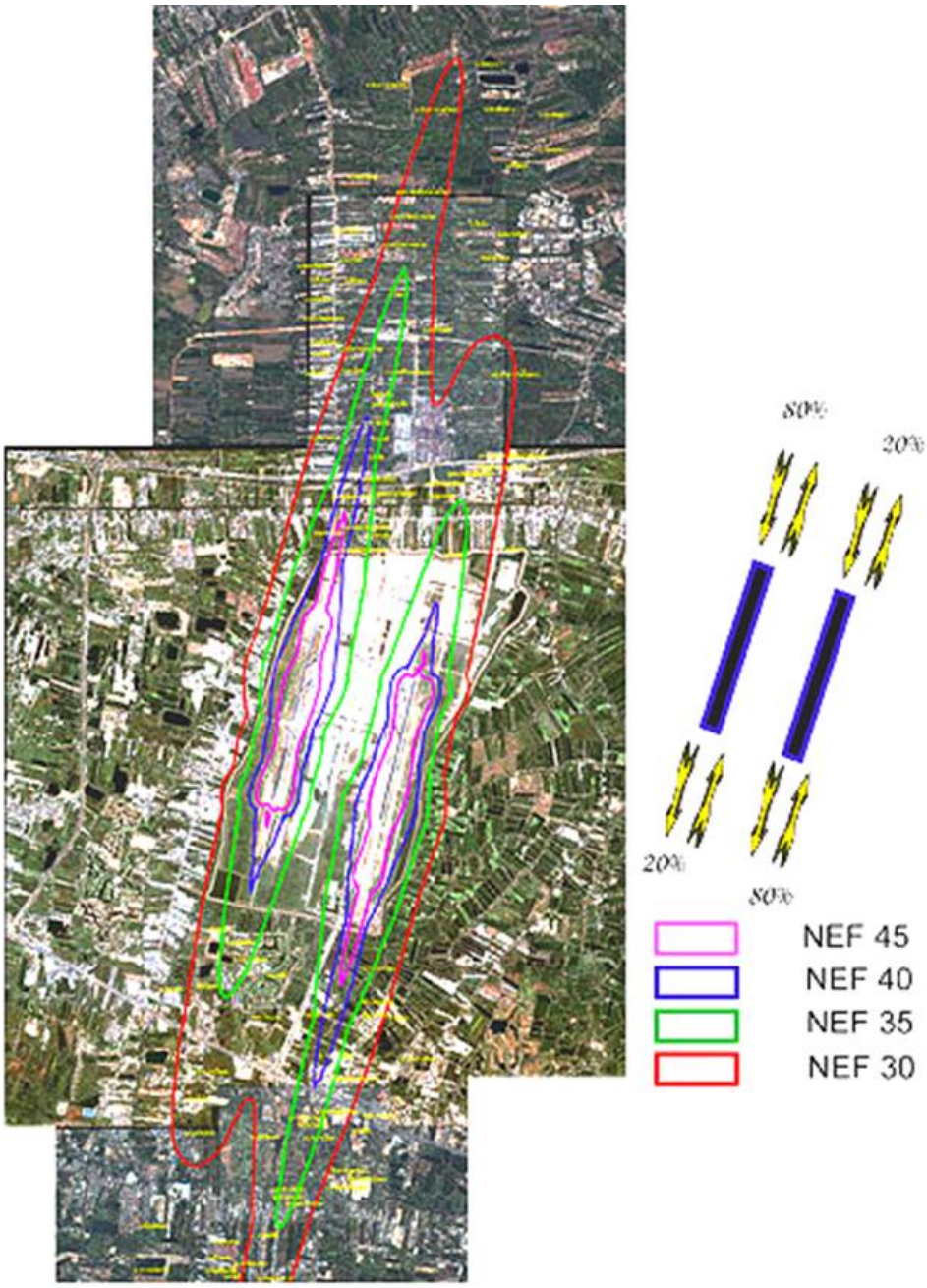
Table 9.1: Noise Monitoring Data (dBA)

Ladkrabang	Morning (standard deviation)	Afternoon (standard deviation)	Bangna	Morning (standard deviation)	Afternoon (standard deviation)
19L-1	57.65 (7.51)	56.00 (8.20)	01L-1	58.21(7.19)	56.29 (8.72)
19L-2	51.39 (8.28)	70.25 (3.87)	01L-2	65.60 (4.88)	66.91 (3.87)
19L-3	61.40 (7.58)	55.65 (5.99)	01L-3	55.56 (7.00)	58.91 (7.33)
19L-4	60.79 (8.13)	53.67 (7.82)	01L-4	61.46 (7.51)	64.31 (6.88)
19L Ave	58.35 (7.17)		01L Ave	60.91 (6.67)	
19R-1	57.33 (4.38)	62.66 (6.89)	01R-1	59.35 (5.40)	53.78 (8.75)
19R-2	51.30 (4.79)	57.47 (7.73)	01R-2	58.16 (6.64)	63.33 (6.55)
19R-3	52.61 (8.62)	50.09 (10.48)	01R-3	55.63 (6.30)	61.31 (6.02)
19R-4	55.46 (7.72)	56.35 (5.55)	01R-4	64.57 (6.84)	52.28 (9.50)
19R Ave	55.41 (7.02)		01R Ave	58.55 (7.00)	
Average	55.99 (7.13)	57.77 (7.07)	Average	59.82 (6.47)	59.64 (7.20)
Northern	56.87 (7.10)		Southern	59.73 (6.83)	

The results of noise monitoring stations are reported in Table 9.1 above. The average values suggests that the noise level in the south (Bangna) was 2.86 dB(A) higher than the north (Ladkrabang) or 59.73 dB(A) in the south against 56.87 dB(A) in the north. This corresponds with the expectation as the southern areas are exposed to take off noise which is perceived by residents to be louder than the landing noise. The difference between morning and afternoon noise level is small in the south where it was found that the noise level is 0.18 dB(A) louder in the morning. In the north, the noise level during the afternoon period was also higher than during the morning.

Per runway average value showed that residents living under the flight path of runway 01L suffered from the highest level of noise of 60.91 dB(A). This runway is mainly used for departure by non-Thai Airways flights. Residents under runway 09R were exposed to the lowest level of noise at 55.41 dB(A), this runway is mainly used for arrival of non-Thai Airways aircraft.

Figure 9.3: Suvarnabhumi Airport Noise Contour Map 2007



Source: AOT (2007) *NEF 45 = Leq 75 dB(A); NEF 40 = Leq 70 dB(A); NEF 36 = Leq 65 dB(A); NEF 30 = 60 dB(A)

In comparison with the noise contour map in Figure 9.3, the noise data gathered for this study is slightly lower than the noise level predicted by the airport operator as the monitored

area were predicted to have an average noise level between 60-65 dB(A). However, it must be noted that the noise data gathered in this study is intended to be an indication to the noise problem in the area rather than an extensive noise data gathering study given that there are no up-to-date noise data in the area available.

9.3. Residential Survey Implementation

9.3.1 Sample Size and Location

A sample size of 400 was chosen. The sample were equally gathered (around 200 from each side) from residents living within the NEF30 and over contour (approximately Leq 65) and over in Ladkrabang (north of the airport) and Bangna (south of the airport). To identify the affected areas, a noise contour map published by AOT in 2007 (airport operator) was used as a reference as it is the latest version available. There are 32 affected communities in the Ladkrabang area and 20 affected communities in Bangna.

Since there were two versions of the SC card, split sampling was used in this study. During the questionnaire distribution the two versions were distributed alternately. This means that all areas were valued by both presentation forms (200 each).

The survey team distributed questionnaires to 200 respondents from each side. In Bangna, the survey team distributed questionnaires to 20 communities. Ten respondents from each community were selected. As for Ladkrabang, the respondents were from 16 communities (half the number of total of 32 communities listed by AOT). They were selected alternately from east to west direction. In each community, 12 or 13 respondents were sampled to meet the quota of 200 respondents from Ladkrabang. Generally, a community is located in a '*soi'* which is a side street connecting with a main road. Within a '*soi'* there are various numbers of 'yaak' which are smaller streets (often dead-ends) branching off from the *soi.* Each soi may contain from a few yaaks to dozens. Each of the '*yaak'* are generally numbered for identification. The study selected the sample by choosing even-numbered '*yaak'* and making a contact at an interval of every third residence. For a smaller *'soi'* that doesn't have a *'yaak'*, the contact was made at every third residence along the *'soi'*.

9.3.2 Questionnaire Distribution Process

The period of questionnaire distribution and collection was from 1st October to 7th November 2012. The resident survey was conducted during the evening hours of weekdays or during the day time during weekends. Potential respondents were approached by the researcher and his assistants working in pairs for practical and safety reasons (one to talk to the respondent and another to note the version of questionnaire given and the address). Residents were told about the study. Those who agreed to participate were given a copy of the questionnaire and told how to complete the SC exercise. They were also given contact details of the researcher should there be any problems. The residents were given one week to complete it. After a week had elapsed, the survey team revisited the resident and asked for the form back. If it was not completed, the resident would be given a new questionnaire (the same version as the original one) and asked to complete it with the assistance of a staff member. There were 60 questionnaires that were not completed as the respondents were not available. The survey team had to repeat the process to collect a full 400 completed questionnaires.

9.3.3 'As Now' Option

As there were concerns about the 'as now' option in the question card and a tendency for respondents to opt for the 'as now' option. Given the flexibility of surveying period, the survey was divided into two stages to allow assessment of 'as now' options. It was expected that the 'as now' option may be an incentive for non-trading behaviour as people may choose if the respondent thinks that the options are too complicated. The first stage involved the distribution of 70 questionnaires using the process described in the previous subsection and these questionnaires were used for a preliminary assessment. The assessment involved counting the number of questionnaires that only chose 'as now' and analysis of results using multinomial logit through Limdep Software. It was found that 8 questionnaires (11.43%) chose all 'as now' options. There were no problems in terms of respondent's bias on choosing 'as now' option nor the option was chosen because of fatigue or the options available were too complicated. So it was decided to continue the second stage involving the remaining 330 respondents.

9.3.4. Air Passengers Survey Implementation

The survey was conducted in the gate areas of departure hall at Suvarnabhumi Airport. The airport operator granted permission for a survey team of five members for a 15-day period between 20th October and 3rd November 2012. The respondents were Thai passengers flying from Bangkok's Suvarnabhumi airport. The sampling quota covered a mixture of the following categories; economy class, business class, low cost airlines and passengers who fly for business purposes.

The same team of 4 assistants and the author administered the questionnaire. Potential respondents were contacted in the departure gate area where they were told about the study and asked to participate in the survey. For each flight, the assistants and the researcher interviewed passengers on one-to-one basis and mostly managed to recruit 3-4 respondents per flight. The researcher read out questions from the questionnaire and wrote down the answers given by passengers. On the SC card section, the researcher explained to the respondents about how to complete the exercise and asked the respondents to complete the card on their own. If the boarding call was made before the completion, the interview would be abandoned and the questionnaire would not be used in the analysis.

9.4 Conclusion

Survey implementation was satisfactory with help from assistants. The number of questionnaires collected met the target of 406 residents and 400 passengers. While there was a concern about non-trading behaviour before the implementation, it was not a problem during the implementation process. Actual noise data, though captured, was limited given the time and resource constraints. Nonetheless, the noise results showed that the noise level may be slightly lower than that predicted by the airport operator and the northern areas are quieter than the south.

10. SURVEY FINDINGS

10.1 Introduction

This chapter reports on the results from the questionnaire surveys in three sub-sections. Firstly, section 10.2 describes respondent's socio economic backgrounds along with the flight characteristics for passengers and residential characteristics for the residents group. In section 10.3, the results from the attitudinal section of the questionnaire are reported. This starts with the questions on general awareness and attitude towards environmental problems in Thailand before proceeding to the aviation-related problems. These results were analysed by using an average score for each category which allows comparisons among different problems and to see the differences between passengers and residents. Section 10.4 employed ordinal regression method to attempt to explain variation in attitudes among the sample. The SC analysis is reported in chapter 11.

10.2 Descriptive Characteristics

The sample size of residents was 406, 211 of whom (51.97%) lived in Ladkrabang to the north of the airport and 195 (48.77%) in Bangna to the south of the airport. The majority of residents lived in detached houses (240, 59.11%), 128 residents (31.53%) lived in townhouses and the remaining 38 residents (9.36%) lived in apartments. Statistics from the Department of Provincial Administration (2006, 2013) showed that population in the area has grown by 19.76% since the airport opened. In the survey, 260 (64.04%) residents had lived in the area before the airport opened and 146 residents (35.96%) have moved in later. The survey found that 109 residents (26.85%) had received compensation from the airport operator. Full details are reported in Table 10.1.

As for residents' socio-economic background, 229 (56.4%) were male and 177 (43.6%) were female. This is in reverse to the gender composition in the area which is reportedly 48% male and 52% female (Department of Provincial Administration, 2013). The average income of residents is 22,602.89 baht and the average age of residents is 43.61 years old.

Table 10.1: Resident's Descriptive Statistics

Residents	N (standard deviation)		
Sample size	406		
Average age	44 (11.11)		
Average monthly income	22,593.30 (15,708.47)		
Average round-trip flights/year	0.49 (0.33)		
Average people in household	4.11 (1.626)		
Gender	Male: 229	Female: 177	
Location	North: 211	South: 195	
Received compensation	Yes: 114	No: 292	
Living before airport opened	Yes: 260	No: 146	
Education	High school: 268	Undergraduate: 106	Postgraduate: 32
Type of residence	Detached house: 240	Townhouse: 128	Apartment: 38

A total of 400 Thai air passengers participated in this survey, 179 (44.75%) of whom were male and 221 (55.25%) were female (see Table 10.1). The average income of air passenger is 38,788.57 baht per month and average age of respondents is 37.99 years old. The average air fare is 18,346.13 baht. Figure 10.2 shows the types of passenger respondents by flight duration and travel class.

Table: 10.2: Passenger's Descriptive Statistics

Passenger	N (standard deviation)		
Sample size	400		
Average age	38 (11.51)		
Average monthly income	38,788.57 baht (24,704.22)		
Average round-trip flights/year	2.558 (0.76)		
Gender	Male: 179	Female: 221	
Travel class	Economy: 349	First/Business: 51	
Awareness of carbon offsetting	Yes: 116	No: 284	
Carrier	LCC: 86	FSC: 314	
Purpose of travelling	Business: 141	Leisure: 198	Visiting friends and relatives: 61
Education	High school: 144	Undergraduate: 212	Postgraduate: 39
Length of flight	Short-haul:224	Medium-haul: 80	Long-haul: 96

Passengers were mainly travelling to short haul destinations (224, 56%), with 96 passengers (24%) travelling to long haul destinations and the remaining 80 (20%) to medium haul destinations. According to aircraft movements statistics published in November's edition of Thailand Airline Timetable (2012), approximately 10.13% of flights at the Airport are long

haul flights, 20.23% are medium haul flights and 63.63% are short haul flights which suggests that the passenger sample is the representative of the passenger population at Suvarnabhumi Airport. In terms of carbon offsetting awareness, 284 passengers (71%) indicated that they had never heard of carbon offsetting and interestingly, none of the passengers had paid for carbon offsetting when travelling by air. Overall, passengers had higher incomes and were more likely to be educated to degree levels than residents.

10.3 Questionnaire Results

10.3.1 Aviation and Environmental Attitudes

In this section, attitudinal questions from the main survey are analysed and presented using average scores. This includes north/south location, living before/after airport opened for residents and income group for both residents and passengers. Independent sample T-test and ANOVA (for income group) were run to identify if the differences between these segments are statistically significant. The significant difference (at 95%) is highlighted in the tables.

Table 10.3: Residents' Attitudes toward Environmental Problems in Thailand

	Average score (Standard Error)							
	Location		Duration		Income			Overall
	North	South	Before	After	Low	Med	High	
Climate Change	3.83 (0.08)	3.83 (0.06)	3.88 (0.06)	3.75 (0.07)	3.82 (0.08)	3.85 (0.07)	3.80 (0.13)	3.83 (0.04)
Deforestation	3.75 (0.07)	3.70 (0.06)	3.77 (0.06)	3.64 (0.07)	3.72 (0.07)	3.73 (0.07)	3.70 (0.12)	3.72 (0.05)
Pollution from road traffic	3.63 (0.07)	3.61 (0.06)	**3.69* (0.06)**	**3.50* (0.06)**	3.62 (0.07)	3.64 (0.07)	3.54 (0.13)	3.62 (0.04)
Aircraft noise	**3.53* (0.05)**	**3.70* (0.07)**	3.66 (0.05)	3.53 (0.06)	3.69 (0.06)	3.54 (0.06)	3.59 (0.11)	3.61 (0.04)
Household waste	**3.36* (0.07)**	**3.65* (0.06)**	3.50 (0.06)	3.52 (0.07)	3.53 (0.08)	3.53 (0.07)	3.41 (0.12)	3.51 (0.05)
Flooding	**3.66* (0.06)**	**3.19* (0.05)**	**3.50* (0.05)**	**3.27* (0.06)**	3.51 (0.07)	3.33 (0.06)	3.38 (0.12)	3.41 (0.04)
Road traffic noise	3.39 (0.07)	3.44 (0.05)	3.45 (0.06)	3.34 (0.06)	3.43 (0.07)	3.40 (0.06)	3.39 (0.12)	3.41 (0.04)
Pollution from factories	3.32 (0.07)	3.42 (0.05)	3.38 (0.06)	3.37 (0.06)	3.42 (0.07)	3.36 (0.07)	3.30 (0.12)	3.37 (0.04)
Water pollution	**3.23* (0.07)**	**3.42* (0.05)**	3.30 (0.06)	3.37 (0.06)	3.41 (0.07)	3.27 (0.07)	3.25 (0.13)	3.33 (0.05)

* The difference in average scores are significant at the 95% level

Table 10.3 shows the result of the first attitudinal question in which respondents were asked '*In your opinion, to what extent do you think Thailand suffers from the following environmental problems?'*. The question is used to examine general attitude towards environmental issues in the country. The attitudinal scale used in this questionnaire is 1-5 ranging from 'not a problem' (1), 'slight problem' (2), moderate problem (3), severe problem (4) to 'extremely severe problem' (5). The results show that overall climate change is of greatest concern followed by deforestation.

Aircraft noise is the fourth biggest problem for residents which is anticipated given that the residents are exposed to it on a daily basis. Sample segmentation in Table 10.3 shows statistical differences in attitudes between resident's location and duration of residency. Firstly, southern residents were found to be concerned more about aircraft noise, water pollution and household waste than the northern residents. These are similar to focus group results in which it found that southern areas (Bangna) are mainly exposed to taking off noise which is considered as louder than landing noise. Also, southern area is consisted of factories and agricultural lands which make it logical for residents in the south to be concerned of water pollution and waste problems as it affects the agricultural yields. On the other hand, the rapid urbanisation of the northern area (Ladkrabang) manifested itself in terms of flooding problem as the airport and the Ladkrabang area were built on the floodway which results in the ensuing flooding problem. This corresponds with the pilot study as the northern residents were also complained about the flooding issue.

In terms of residency duration, residents who have been living before airport opened were found to be more concerned about pollution from road traffic and flooding. The results are anticipated as the long-term residents have been living through the area development which experience increasing road traffic and increasing flooding incidents as the negative aspects of the urbanisation in their area. The ANOVA test found no significant differences by income.

Table 10.4: Passengers' Attitudes toward Environmental Problems in Thailand

	Average score (standard error)			
	Income			Overall
	Low	Med	High	
Deforestation	**4.25** **(0.08)**	4.11 (0.07)	**3.90** **(0.09)**	4.10 (0.05)
Climate change*	**4.12** **(0.08)**	**4.01** **(0.07)**	**3.80** **(0.08)**	3.99 (0.04)
Pollution from road traffic *	**4.10** **(0.08)**	**3.95** **(0.07)**	**3.72** **(0.08)**	3.93 (0.04)
Flooding	3.97 (0.09)	3.86 (0.07)	3.75 (0.08)	3.86 (0.05)
Household waste*	**3.85** **(0.08)**	**3.80** **(0.06)**	**3.57** **(0.07)**	3.75 (0.04)
Pollution from factories	**3.89** **(0.08)**	3.72 (0.07)	**3.59** **(0.08)**	3.74 (0.04)
Water pollution*	**3.77** **(0.08)**	**3.72** **(0.06)**	**3.47** **(0.07)**	3.67 (0.04)
Aircraft noise	3.13 (0.08)	3.10 (0.06)	3.09 (0.07)	3.11 (0.04)

* The differences of low and medium income groups were statistically significant when compared with high income group

Table 10.4 reported the scores from air passengers who were asked the same question as the residents. It was found that deforestation was the perceived most severe problem followed by climate change which is the reverse result from resident group. However, it appears to be logical given that deforestation was often discussed as a main environmental problem in Thailand in Thai education system aircraft noise was, however, ranked at the last place (3.11) in comparison with the fourth place by residents (3.61) .The higher concern by residents is anticipated given that most of the passengers are not exposed to aircraft noise in their house. Every environmental issue received lower scores from residents with the exceptions of aircraft noise may imply the sensitivity of residents on noise exposure from aircraft. Income was found to have an impact on environmental attitudes. The low income group were consistently more concerned more about the environmental problem in Thailand than the high income group. This also applies to the medium income group which also rated various environmental problems higher than the high income group.

Table 10.5: Environmentally Friendly Behaviours

	Passengers	Residents
Recycling	255 (63.75%)	210 (51.72%)
Reuse shopping bags	337 (84.25%)	248 (61.08%)
Using bio-degradable packaging	174 (43.50%)	170 (41.87%)
Using public transport	196 (49.00%)	138 (33.99%)
Lift-sharing	122 (30.5%)	73 (17.98%)
Switching off electrical appliances when they are not in use	312 (78%)	249 (61.33%)
Installing a solar-powered boiler	21 (5.25%)	33 (8.12%)
Using a hybrid vehicle	28 (7.00%)	13 (3.20%)
Participating in re-forestation project	12 (3.00%)	40 (9.85%)
Others	12 (3.00%)	6 (1.48%)

After initial questions about general attitudes towards the environmental problems, respondents were asked about their daily behaviours that help reduce the environmental impact with the question: *'Do you do anything in your daily life to reduce your environmental impact?*' The results in Table 10.5 show that reusing shopping bags is the most common practice among air passengers (84.75%) followed by switching off electrical appliances (78%). Relatively common practices by air passengers also include recycling (63.75%), using public transport (49%), and using bio-degradable packaging (43.5%) whereas participating in reforestation projects was the least common behaviour (with 12 passengers having partaken in the scheme). A similar pattern emerged for the residents with 249 (61.33%) reportedly switching off electrical appliances when they are not in use and 248 (61.08%) reusing their shopping bags. Using a hybrid vehicle is the least common practice for residents (3.2%), however, the number of respondents reportedly using hybrid cars is higher than expected (28 passengers and 13 residents) and there is no reliable statistics on hybrid cars in Thailand to validate this result. All in all, the results indicated that in 7 out of 10 categories, a larger percentage of passengers say they are doing more to protect the environment than residents.

10.3.2 Aviation related problems

Residents were also asked: '*Thinking about the past 12 months, to what extent have you been affected by aircraft operations at Suvarnabhumi Airport?'* This was to examine the perception of the impacts of aviation. As anticipated, aircraft noise received the highest average score of 3.56. The second most severe problem was local air pollution and global emissions; 3.21 and 3.15, respectively. A noteworthy result was found in the fear of aircraft accident category, as there is a low concern among residents (2.06) whereas passengers

rated this category with an average score of 2.59 which is considerably higher than residents. This may be attributed to the perception that they are the ones who fly and have a greater chance of being involved in an accident than those on the ground.

Table 10.6: Residents' Aviation Impact Perceptions

	Average score (Standard Error)							
	Location				Income			Overall
	North	South	Before	After	Low	Med	High	
Aircraft noise	**3.40*** **(0.05)**	**3.73*** **(0.07)**	3.66 (0.05)	3.38 (0.06)	3.60 (0.07)	3.49 (0.06)	3.70 (0.11)	3.56 (0.04)
Local air pollution	3.25 (0.07)	3.18 (0.05)	3.23 (0.06)	3.18 (0.06)	3.27 (0.07)	3.19 (0.06)	3.11 (0.13)	3.21 (0.04)
Global level emissions (carbon emissions)	3.11 (0.07)	3.18 (0.05)	3.14 (0.06)	3.16 (0.07)	3.20 (0.07)	3.10 (0.06)	3.13 (0.13)	3.15 (0.04)
Traffic congestion around the airport	2.94 (0.06)	2.84 (0.06)	2.85 (0.06)	2.97 (0.07)	2.92 (0.07)	2.84 (0.07)	2.93 (0.12)	2.89 (0.05)
Waste from aircraft and airport	2.61 (0.07)	2.73 (0.07)	2.60 (0.06)	2.79 (0.08)	2.64 (0.08)	2.73 (0.07)	2.55 (0.13)	2.67 (0.05)
Fear of aircraft accident	**1.68*** **(0.07)**	**2.41*** **(0.08)**	1.91 (0.07)	2.33 (0.09)	2.01 (0.07)	2.12 (0.08)	2.04 (0.15)	2.06 (0.06)

* The difference in average scores are significant at 95%

T-test identified two significant differences. Firstly, aircraft noise. Those in the south are more concerned about aircraft noise. The scores for local and global emissions among the southern residents were the same (3.18). The scores reflect the characteristic of local area in which the south is exposed to louder aircraft noise. The second difference is fear of accident in which the southern residents suggested that they are more concerned about this category more than the north. This is similar to the pilot study in which southern residents voiced more concern about the safety issue.

Table 10.7 shows the findings of the perceptions and effects of aviation related problems. In this question, passengers were asked: '*Think about your flight and its impacts on the environment, to what extent do you think your flight caused the following problems?*' Air passengers' average score suggests that global emissions are the most severe problem closely followed by aircraft noise (3.25 and 3.24, respectively).

Table 10.7: Passengers' Aviation Impact Perceptions

	Passenger's Average score (standard error)			
	Income			Overall
	Low	Med	High	
Global level emissions (carbon emissions)	3.29 (0.08)	3.27 (0.07)	3.16 (0.07)	3.25 (0.04)
Aircraft noise	3.30 (0.07)	3.27 (0.06)	3.12 (0.06)	3.24 (0.04)
Traffic congestion around the airport	3.06 (0.08)	2.99 (0.07)	2.93 (0.07)	3.00 (0.08)
Waste from aircraft and airport	2.91 (0.09)	3.01 (0.07)	2.88 (0.06)	2.94 (0.04)
Local air pollution	2.95 (0.08)	2.84 (0.08)	2.89 (0.08)	2.89 (0.05)
Fear of aircraft accident	2.50 (0.10)	2.57 (0.09)	2.70 (0.09)	2.59 (0.05)

The comparison between two groups shows that residents placed higher priority on local problems generated by aircraft (noise and local pollution) which is anticipated. Passengers, on the other hand, concerned more about a wider-impact of aircraft such as global pollution, waste and traffic problems. Interestingly, local emissions from aircraft were placed very low at the fifth place, even after aviation-related waste. This may reflect the intangible nature of local emissions from aircraft in which most of the passengers were not exposed to local emissions.

Table 10.8: Residents' Perceptions of Airport Benefits

	Average score (standard error)							
	Location		Living Duration		Income			Overall
	North	South	Before	After	Low	Med	High	
Easy access to the airport	**3.64*** **(0.07)**	**3.21*** **(0.06)**	**3.51*** **(0.06)**	**3.26*** **(0.07)**	3.46 (0.07)	3.38 (0.06)	3.41 (0.13)	3.42 (0.05)
Improved transportation	**3.50*** **(0.07)**	**3.20*** **(0.06)**	**3.42*** **(0.06)**	**3.20*** **(0.07)**	3.37 (0.08)	3.29 (0.06)	3.41 (0.13)	3.34 (0.05)
Improved facilities in the neighbourhood	3.25 (0.08)	3.28 (0.05)	3.25 (0.06)	3.28 (0.06)	3.37 (0.08)	3.14 (0.07)	3.34 (0.13)	3.26 (0.05)
Job/business opportunities	3.08 (0.08)	2.91 (0.07)	3.00 (0.07)	2.97 (0.08)	3.03 (0.08)	2.94 (0.07)	3.05 (0.15)	2.99 (0.05)

* The difference in average scores are significant at 95%

Table 10.8 illustrates the results from the question: *'Think about the Suvarnabhumi Airport and its benefits to you and your local area, please rate the extent to which you benefit from the airport.'* Easy access to the airport had the highest score (3.42). The second most beneficial aspect of Suvarnabhumi Airport was improvement in transportation.

Ladkrabang (North) residents' scores suggest that they perceived that the airport has higher benefits to their livelihood in terms of access to the airport and improvement in transport. This is expected because an express train and a motorway along with many local roads were specifically built for the airport and both the express train and motorway pass through Ladkrabang making it much easier for residents to commute to the city centre and the airport. Similarly, people who have lived before airport opening also have a higher rating for both aspects since they lived through the development of transportation infrastructure in the area.

After the questions on aviation benefits and problems, residents were asked more about noise problems in the area starting with the question; '*Thinking about the last 12 months, when you are at home, how much are you annoyed by these noise sources?'* The results are reported in Table 10.9. Aircraft noise is, as anticipated, the most significant cause of annoyance with average score of 3.32 which is moderate. The second source which follows aircraft noise by a considerable margin is road traffic receiving an average score of 2.99. Emergency sirens were the least annoying noise source given the relative infrequency of emergency service vehicles in the areas.

Table 10.9: Source of Noise Annoyance

	Resident's Average score (standard error)							
	Location		Living Duration		Income			Overall
	North	South	Before	After	Low	Med	High	
Aircraft	3.31 (0.06)	3.32 (0.05)	3.33 (0.05)	3.29 (0.06)	3.29 (0.05)	3.32 (0.05)	3.41 (0.11)	3.32 (0.04)
Road traffic	**3.06* (0.05)**	**2.93* (0.05)**	3.00 (0.04)	2.97 (0.06)	2.98 (0.06)	3.00 (0.05)	3.00 (0.10)	2.99 (0.04)
Construction sites	**2.74* (0.05)**	**2.89* (0.06)**	2.86 (0.06)	2.75 (0.07)	2.84 (0.06)	2.80 (0.06)	2.82 (0.11)	2.82 (0.04)
Animals (e.g. dogs/chickens)	2.81 (0.05)	2.81 (0.06)	2.84 (0.05)	2.75 (0.07)	2.81 (0.05)	2.81 (0.06)	2.79 (0.11)	2.81 (0.04)
Neighbour's arguments/music	2.83 (0.06)	2.80 (0.07)	2.88 (0.06	2.68 (0.07)	2.79 (0.07)	2.79 (0.07)	2.95 (0.14)	2.81 (0.05)
Emergency vehicle sirens	2.52 0.05	2.61 (0.04)	2.62 (0.06)	2.48 (0.08)	2.54 (0.07)	2.28 (0.07)	2.61 (0.14)	2.57 (0.05)

* The difference in average scores are significant at 95%

The north-south segmentation shows that road traffic noise is more annoying in the south than the north (4.07 against 3.92) which corresponds well with the fact that road traffic to and from the airport pass through their area. The perceived higher annoyance of construction sites in the south was not expected given that the majority of construction activities are centred in Ladkrabang.

The next question asked; '*Overall, how noisy do you think your local area is?'* The results are reported in Table 10.10.

Table 10.10: Noise Annoyance Perception in Local Area

	Average score (std error)							
	Location		Living Duration		Income			Overall
	North	South	Before	After	Low	Med	High	
Overall Noise Level in your area	3.11 (0.05)	3.12 (0.04)	**3.17* (0.04)**	**3.07* (0.05)**	3.09 (0.05)	3.10 (0.05)	3.23 (0.08)	3.12 (0.03)

* The difference in average scores are significant at 95%

The average score of 3.12 suggests that the respondents think that their area is moderately noisy with 20.93% believing that their area is extremely noisy and similar proportion (21.18%) thinking that their area are extremely noisy. Only 2 respondents (0.49%) answered that their area is not noisy at all. The T-test on north-south segmentation and income group found no statistical significance among the sample. However, the duration of residence was found to be different whereby those who have moved in later perceived noise levels to be less annoying which is anticipated. Long-time residents, who have lived in the area which was considered rural and have seen a tremendous change in noise levels brought about by the airport and related traffic, were expected to be more annoyed than who have moved in later and hadn't experienced the previous relative quietness of the area.

Table 10.11: Aircraft Noise Annoyance at Different Time Periods

	Weekday (standard error)							
	Location		Living Duration		Income			Overall
	North	South	Before	After	Low	Med	High	
Midnight-6am	**3.15*** **(0.05)**	**3.29** **(0.07)**	**3.28*** **(0.05)**	**3.11*** **(0.62)**	3.23 (0.06)	3.19 (0.06)	3.29 (0.11)	3.22 (0.04)
6am-noon	**3.02*** **(0.04)**	**3.18*** **(0.06)**	**3.16*** **(0.05)**	**2.99*** **(0.05)**	3.08 (0.06)	3.10 (0.05)	3.14) (0.10)	3.10 (0.04)
Noon-6pm	**3.04*** **(0.04)**	**3.17*** **(0.06)**	**3.18*** **(0.05)**	**2.97*** **(0.05)**	3.08 (0.06)	3.11 (0.06)	3.16 (0.10)	3.10 (0.04)
6pm-midnight	**3.19*** **(0.05)**	**3.32*** **(0.06)**	**3.31*** **(0.05)**	**3.16*** **(0.06)**	3.24 (0.06)	3.26 (0.06)	3.29 (0.11)	3.25 (0.04)
	Weekend (standard error)							
	Location		Living Duration		Income			Overall
	North	South	Before	After	Low	Med	High	
Midnight-6am	**3.19*** **(0.06)**	**3.86*** **(0.08)**	**3.70*** **(0.07)**	**3.17*** **(0.07)**	3.61 (0.08)	3.44 (0.08)	3.46 (0.14)	3.51 (0.05)
6am-noon	**3.16*** **(0.05)**	**3.66*** **(0.08)**	**3.58*** **(.07)**	**3.08*** **(0.06)**	3.46 (0.07)	3.40 (0.07)	3.21 (0.14)	3.40 (0.05)
Noon-6pm	**3.23*** **(0.05)**	**3.69*** **(0.09)**	**3.66*** **(0.07)**	**3.09*** **(0.06)**	3.50 (0.08)	3.45 (0.08)	3.34 (0.14)	3.45 (0.05)
6pm-midnight	**3.36*** **(0.05)**	**3.96*** **(0.08)**	**3.80*** **(0.07)**	**3.29*** **(0.06)**	3.72 (0.08)	3.55 (0.07)	3.54 (0.13)	3.62 (0.05)

* The difference in average scores are significant at 95%

The residents' opinion of aircraft noise annoyance in different periods was addressed by the next question which asked; '*Think about aircraft noise level at your home in the past 12 months, please rate how annoying is the aircraft noise in each period.'* The results are depicted in Table 10.11. The pattern of annoyance levels during weekdays and weekend is the same. The midnight to 6 am period has the highest annoyance score followed by 6pm to midnight as these are the periods when most people are at home resting and sleeping. Weekend periods were consistently receiving higher scores than weekends as residents are more likely to be at home. Interestingly, the differences in annoyance were significant in every period for north-south and before-after segmentations. Southern residents rated higher annoyance scores in all periods and those who had lived before the airport opened have higher annoyance scores for aircraft noise in all periods. Again this is due to perceived higher noise for take-off noise which is experienced by southern residents and the changes in noise levels brought about by the airport opening as experienced by long-term residents.

The last question in this section of the questionnaire concerned the effect of aircraft noise on daily activities and the results are reported in Table 10.12. The respondents were asked *'In*

the past 12 months, think about the impact caused by aircraft noise, please rate how much you are affected by aircraft noise?' Sleeping was rated highest (3.63) which is consistent with the pilot study result. The second and third highest rated are television reception and conversation interruptions. The same pattern emerged in north-south and before-after segmentation in which southern residents and long-term residents rated every problem more highly.

Table 10.12: Aircraft Noise-related Problems

	Resident's Average score (standard error)							
	Location		Duration		Income			Overall
	North	South	Before	After	Low	Med	High	
Sleeping	**3.40*** **(0.06)**	**3.89*** **(0.08)**	**3.84*** **(0.07)**	**3.26*** **(0.07)**	3.68 (0.08)	3.60 (0.07)	3.61 (0.14)	3.63 (0.05)
Television reception	**2.95*** **(0.07)**	**3.82*** **(0.08)**	**3.58*** **(0.08)**	**3.00*** **(0.08)**	3.50 (0.09)	3.28 (0.09)	3.27 (0.15)	3.37 (0.06)
Conversation	**2.92*** **(0.08)**	**3.75*** **(0.09)**	**3.53*** **(0.08)**	**2.96*** **(0.09)**	3.33 (0.10)	3.34 (0.09)	3.25 (0.16)	3.32 (0.06)
Family activities	**2.98*** **(0.06)**	**3.58*** **(0.09)**	**3.47*** **(0.07**	**2.91*** **(0.07)**	3.24 (0.08)	3.31 (0.08)	3.23 (0.15)	3.27 (0.05)
Telephone reception	**2.83*** **(0.07)**	**3.71*** **(0.08)**	**3.43*** **(0.08)**	**2.93*** **(0.09)**	3.35 (0.10)	3.21 (0.09)	3.11 (0.17)	3.25 (0.06)
Working concentration	**2.87*** **(0.05)**	**3.58*** **0.08)**	**3.38*** **(0.07)**	**2.91*** **(0.06)**	3.21 (0.08)	3.24 (0.07)	3.11 (0.15)	3.21 (0.05)
Vibrations to furniture	**2.77*** **(0.07)**	**3.58*** **(0.09)**	**3.31*** **(0.08)**	**2.88*** **(0.08)**	3.21 (0.09)	3.16 (0.09)	2.98 (0.17)	3.16 (0.06)

* The difference in average scores are significant at 95%

10.3.3 Debriefing Questions

This section in the questionnaire comes immediately after the choice card exercise to ask about their experience of the exercise and their opinions.

Firstly, the respondents were asked about the attributes in the question cards that they may have ignored during the exercise which will help for the result analysis. The results from Table 10.13 shows that there are similar proportion of passengers and residents who ignored aircraft noise, local air pollution and carbon offsetting whereas 23% of passengers reported that they have ignored the price and 11.17% of residents did so. Almost half of the respondents, 40% for passengers and 47.57% for respondents did not ignore any attributes

in the card. Carbon offsetting is the most ignored by both groups. This may be attributed to the fact that 72.25% of passengers stated that they have never heard of carbon offsetting

Table 10.13: Ignored Attributes for Passengers and Resident Percentage Change Cards

Attributes	Passengers (n=400)	Residents (n=206)
Aircraft noise	90 (22.5%)	45 (21.84%)
Air pollutants from aircraft engines (local air pollution)	49 (12.25%)	26 (12.62%)
Carbon offsetting	107 (26.75%)	52 (25.24%)
Air fare (Impact relief scheme)	92 (23%)	23 (11.17%)
I did not ignore any attributes	160 (40%)	98 (47.57%)

Secondly, the respondents were asked about the attributes that they focused or paid special attention to. Table 10.14 reports the result from that question and show that passengers focused on local air pollution the most with 68.75% followed by aircraft noise (40.5%) then carbon offsetting (31%). This, however, doesn't correspond to the earlier question about the severity of aircraft-related aviation problem in which respondents gave highest average score to carbon emissions then aircraft noise as the second most severe problem and local air pollution at the third. As for residents, the focused attribute results correspond with the earlier question on the severity of aviation problems. Aircraft noise has the highest percentage of residents who focused on the attribute (61.65%) followed by local air pollution (22.33%) and carbon offsetting (20.39%).

Table 10.14: Focused Attributes for Passengers and Resident Comparison Cards

Attributes	Passengers (n=400)	Residents (n=206)
Aircraft noise	162 (40.5%)	127 (61.65%)
Air pollutants from aircraft engines (local air pollution)	275 (68.75%)	46 (22.33%)
Carbon offsetting	145 (36.25%)	42 (20.39%)
Air fare (Impact relief scheme)	124 (31%)	36 (17.47%)
I did not focus on any particular attributes	24 (6%)	41 (19.9%)

For the residents' rerouting card (n=200), a different design with different attributes were used. The debriefing question began by asking; *'If the number of flights is doubled what do you think that the overall aircraft noise level in your residence will be?'* This is to gauge the perception about flight frequencies in relation to the level of noise. The results are shown in Table 10.15. A majority of respondents (112 respondents, 56%) believe that the noise level will be more than doubled from the current situation and 31% believe that it will be doubled.

A small proportion think that the noise increase will be less than doubled which is a total of 12%. This clearly shows that the increased in aircraft movements is perceived to have an adverse impact to noise level in their areas.

Table 10.15: Expected Level of Noise when Flight Frequencies are doubled

More than doubled	112 (56%)
Doubled	63 (31.5%)
Increased by half	20 (10%)
Increased by a quarter	4 (2%)
Others	1 (0.5%)

Respondents were then asked about the attributes in the card that they may have ignored or paid a special attention to. The results are presented in Table 10.16 which shows that travel times is the most ignored attribute at 23% followed by price attribute (impact relief scheme) which was being ignored by 15% of the respondents. In terms of focused attributed, the results are in line with the previous question on severity of aviation problem in which the results show that aircraft routing representing aircraft noise is the most focused attribute (70 respondents or 35%) followed by price attribute at 20.5% and travel time at the last place of 15.5%). This suggests the important of aircraft noise and price over travel time to residents.

Table 10.16: Focused and Ignored Attributes for Resident's Rerouting Cards

Attributes	**Ignored**	**Focused**
Aircraft flying over your residence	37 (18.5%)	70 (35%)
Travel time	46 (23%)	31 (15.5%)
Airport impact relief scheme	30 (15%)	41 (20.5%)
I did not ignore any attributes	106 (53%)	40 (20%)

The last debriefing question explored the attitudes about the respondents' willingness to pay for the improvement of the environmental condition. The respondents were asked; '*Thinking about this exercise, please rate how much you agree or disagree with the following statements.'* The results appear in Tables 10.17 and 10.18.

Table 10.17: Resident's Attitudes toward Willingness to Pay to Improve the Environment

	Resident's Average score (standard error)							
	Location		Living Duration		Income			Overall
	North	South	Before	After	Low	Med	High	
I don't trust the people who handle the money	**3.74*** **(0.07)**	**3.11*** **(0.03)**	**3.60*** **(0.05)**	**3.09*** **(0.04)**	**3.49*** **(0.06)**	3.41 (0.06)	**3.20*** **(0.09)**	3.41 (0.04)
I am willing to pay to improve the environmental condition in my area	**3.37*** **(0.08)**	**3.18*** **(0.05)**	**3.38*** **(0.06)**	**3.10*** **(0.06)**	3.31 (0.07)	3.31 (0.06)	3.05 (0.13)	3.28 (0.05)
I think that the impact reduction scheme doesn't work (unrealistic)	**2.90*** **(0.05)**	**3.22*** **(0.03)**	3.05 (0.04)	3.10 (0.04)	3.01 (0.04)	3.11 (0.04)	3.013 (0.09)	3.07 (0.03)
I am willing to pay to shorten my travel time	**2.69*** **(0.09)**	**3.27*** **(0.04)**	**2.90*** **(0.07)**	**3.16*** **(0.06)**	2.97 (0.08)	2.95 (0.07)	3.18 (0.14)	2.99 (0.05)
It is not my responsibility to pay to improve the environmental condition	**2.76*** **(0.05)**	**3.14*** **(0.03)**	2.93 (0.04)	3.02 (0.04)	2.92 (0.05)	3.01 (0.04)	2.91 (0.08)	2.96 (0.03)
I am willing to pay to improve the environment in Thailand	**2.54*** **(0.06)**	**3.23*** **(0.04)**	**2.82*** **(0.05)**	**3.05*** **(0.05)**	**2.77*** **(0.06)**	**2.99*** **(0.05)**	3.00 (0.13)	2.90 (0.04)

* The difference in average scores are significant at 95%

Table 10.17 shows that residents gave highest score for not trusting the authority who handle money. During the pilot study, both residents and passengers voiced their concerns about potential corruption and this attitude is confirmed in the highest score ranking for both residents and passengers (Table 10.17). It was found that those living in the north and those who have lived longer have a stronger mistrust in money handling. For the latter group, this is understandable given that there have been problems with compensation issues including late payments, corruptions and unfair compensation. Furthermore, those from the low income group are more sensitive about money handling issue which is expected. In terms of willingness to improve the environmental condition, the residents were found to be more willing to pay to improve the local condition (3.28) and slightly unwilling to pay to improve the condition in Thailand as a whole (2.90). In which case, the lower income group was more unwilling to pay than the medium income group which was expected.

10.18: Passengers' Attitudes toward Willingness to Pay to Improve the Environment

	Passenger's Average score (standard error)			
	Income			Overall
	Low	Med	High	
I don't trust the people who handle the money	3.89 (0.08)	3.96 (0.07)	3.49 (0.08)	3.81 (0.05)
The cost (air fare/fee) for environmental improvement is too high	3.46 (0.07)	3.51 (0.07)	3.42 (0.07)	3.47 (0.04)
I think that the impact reduction scheme doesn't work (unrealistic)	3.44 (0.08)	3.46 (0.07)	3.34 (0.07)	3.42 (0.04)
I am willing to pay to improve the environmental condition in my area	3.20 (0.07)	3.08 (0.07)	3.02 (0.06)	3.10 (0.04)
It is not my responsibility to pay to improve the environmental condition	2.89 (0.09)	2.81 (0.08)	2.85 (0.09)	2.87 (0.05)
I am willing to pay to improve the environment in Thailand	2.81 (0.09)	2.83 (0.08)	2.92 (0.08)	2.85 (0.05)

The passenger results show same pattern in terms of their WTP to pay to improve the environmental condition at a national and local level to that of the residents'. The average score of passengers who are willing to pay to improve their local environment is 0.25 points higher than the national level.. In terms of price, more than half of the passengers (58%) think that the air fare increase to reduce the environment is too high and the similar proportion of 60.5% thinks that the aircraft reduction scheme is unrealistic and are higher than resident's average scores. This implies that residents are slightly more optimistic about the possibility of improving the environmental problem and slightly more willing to pay to reduce the aviation impact. Furthermore, passengers appear to be more sceptical about the scheme and become less willing to pay to reduce the environmental impact in general. Furthermore, income segmentation found no statistically significant differences among the differing economic backgrounds.

10.4 Ordinal Regression Analysis

Ordinal regression analysis is now reported with the aim of further exploring attitudinal responses in terms the effects of combination of characteristics rather than one at a time as in the previous sections. Given that the attitudinal questionnaire asked respondents to give a response on an ordinal scale (1-5; from “not a problem” to “extremely severe problem”), ordinal regression, which is a regression analysis used to predict the ordinal variable (attitudes, in this case), was used to analyse the differences in attitudes.

Dependent variables used in the ordinal regression were respondent’s attitudes toward the environmental issues which are exactly the same as reported in the last section. Independent variables were drawn from the socio-economic background of respondents. For passengers, this included demographic, economic, educational background and characteristics of their residential areas. For passengers, the variables included demographic, economic, educational background and their flying characteristics. The full list is reported in Table 10.19 below.

Table 10.19 List of Independent Variables

Resident	**Passenger**
Age	Age
Number of people in the household	Air fare
Number of flights flown in the past 12 months	Purpose of flying
Area of residence (north or south)	Class
Length of residency (before or airport opened)	Awareness of carbon offsetting
Gender	Gender
Income	Income
Education	Education
Type of residence	Type of airline (low cost/legacy)
	Flight duration

IBM SPSS software version 21.0 was used for the ordinal regression analysis. Each attitudinal question was analysed, however, it was found that most of the differences in average scores are not statistically significant. This section, therefore, only reports the regression results from attitudes towards climate change and severity of aircraft noise problem which contains statistically significant variables. These are reported in four groups of eight separate models. Each group contains two models, one is the full model with all independent variables and other the parsimonious model which is the preferred model that only retains the statistically significant variable.

All of the independent variables were tested for correlations and it was found that resident's income is positively correlated with education and age (at 95% significance). Both age and education variable were analysed independently and found to be not significant and therefore removed from analysis. For passengers, income was also found to be positively correlated at 95% significance with class of travel, airfare, age, length of flight, and education. Again, these variables were analysed separately whereby airfare and age variables were retained in the passengers' models as both variables have different effects from income on passenger's attitudes.

10.4.1. Residents' Attitude towards Climate Change

First of all, the ordinal regression was used to examine the factors affecting resident's attitudes toward climate change problems in Thailand which include the number of people living in the household, number of flight flown in the past 12 months, area of residence, type of residence, duration of residence, gender and income (Model RCC1). See equation 10.1. The results are reported in Table 10.20.

$$\boldsymbol{Y_{Climate\ Change} = +\beta_1 PEOPLE + \beta_2 FLIGHTS + \beta_3 AREA + \beta_4 RESIDENCE + \beta_5 DURATION + \beta_6 GENDER + \beta_7 INCOME + \varepsilon} \quad (10.1)$$

Table: 10.20 Residents' Attitudes towards Climate Change

		Model RCC1			Model RCC 2		
		Coefficient	Std Error	P Value	Coefficient	Std Error	P Value
Threshold	Not a problem(1)	-5.230***	0.879	0.000	-5.301***	0.635	0.000
	Slight problem (2)	-3.664***	0.714	0.000	-3.730***	0.376	0.000
	Moderate problem (3)	-0.008	0.662	0.991	-0.147	0.263	0.575
	Severe problem (4)	0.752	0.663	0.257	0.589	0.265	0.026
Continuous variables	No of flights flown	0.573***	0.126	0.000	0.607***	0.125	0.000
	No of people in household	-0.131**	0.062	0.035	-0.119**	0.060	0.050
Area	North	Base					
	South	-0.061	0.221	0.783			
Type of residence	Apartment	Base					
	Detached house	-0.448	0.423	0.289			
	Townhouse	0.354	0.233	0.129			
Duration of residency	BEFORE airport opened	Base					
	AFTER airport opened	0.039	0.227	0.862			
Gender	Female	Base					
	Male	0.298	0.199	0.135			
Income	High	Base					
	Low	0.020	0.326	0.950			
	Medium	-0.009	0.313	0.978			
Psudo R-squared (McFadden)		0.049			0.036		

Note: ***,** ==>significant at 99%, 95%

It was found that only two of the independent variables are statistically significant. Firstly, the number of people in the household with the reported coefficient of -0.131 in the full model (RCC1) and -0.119 for parsimonious model (RCC2) are significant. This suggests that residents who live in a household with higher number people have a tendency to rate the problem of climate change lower. This appears to be logical given that a household with higher number of residents tend to be less affluent and they have other socio-economic concerns that are more pressing than climate change issue. The second variable is number of flights flown. The coefficient of 0.607 implies that residents who have flown more tend to rate climate change more highly.

10.4.2 Residents' Attitudes toward Aircraft Noise Problems

This analysis examines the differences in the attitudes toward severity of aircraft noise. This follows variables presented in Equation 10.2 and the results are presented in Table 10.21 below.

$$Y_{Aircraft\ Noise} = +\beta_1 PEOPLE + \beta_2 FLIGHTS + \beta_3 AREA + \beta_4 RESIDENCE$$

$$+\beta_5 DURATION + \beta_6 GENDER + \beta_7 INCOME + \varepsilon \quad (10.2)$$

Table 10.21: Residents' Attitude toward Aircraft Noise Problems

		Model RAN 1			Model RAN 2		
		Coefficient	Std Error	P Value	Coefficient	Std Error	P Value
Threshold	Not a problem(1)	-	-	-	-	-	-
	Slight problem (2)	-3.141***	0.748	0.000	-3.941***	0.471	0.000
	Moderate problem (3)	1.296*	0.693	0.062	0.442	0.354	0.212
	Severe problem (4)	2.445***	0.701	0.000	1.564***	0.362	0.000
Continuous variables	No of flight flown	-0.208*	0.117	0.075			
	No of people in household	0.053	0.063	0.403			
Area	North	Base			Base		
	South	0.500**	0.229	0.029	0.576***	0.216	0.008
Type of residence	Apartment	Base			Base		
	Detached house	-0.233	0.468	0.619			
	Townhouse	-0.857***	0.249	0.001	-0.842***	0.245	0.001
Duration of residency	BEFORE airport opened	Base					
	AFTER airport opened	-0.345	0.239	0.150			
Gender	Female	Base			Base		
	Male	0.613***	0.206	0.003	0.639***	0.204	0.002
Income	High	Base			Base		
	Low	-0.459	0.331	0.165			
	Medium	-0.796**	0.320	0.013	-0.663**	0.303	0.029
Psudo R-squared (McFadden)		0.071			0.060		

Note: ***,**,* ==>significant at 99%, 95%, 90

There are four statistically significant differences in this model. Firstly, the area of residence. People living in the south (Bangna) rated the aircraft noise problem higher than those living in the north (coefficient of 0.500 in the full model) which is anticipated as the south is exposed to take off noise which is regarded as louder. Secondly, gender difference. Male respondents had a tendency to rate aircraft noise problem higher than females (0.639 in the

Mode RAN 2) was found to be statistically significant. The result for gender difference is unexpected given that female are likely to spend more time at home and be exposed to more aircraft noise than male residents which could equate to higher concern on aircraft noise. Thirdly, difference in the type of residence was also statistically significant. Those living in townhouse are found to rate aircraft noise problem higher than people who live in apartments. One possible explanation is that apartments around the airport tend to be recently built further from the airport perimeter and closer to Ladkrabang town centre which is less affected by aircraft noise. Lastly, medium income residences had a tendency to rate aircraft noise problem lower than the high income group. Additionally, respondents who have flown more tend to rate the aircraft noise problem lower (-0.208) in the full model (RAN 1). However, when the parsimonious model (RAN 2) was analysed, it was found to be statistically insignificant.

10.4.3 Passenger's Attitude toward Climate Change

For comparison with residents, two attitudinal questions were chosen. The first analyses attitudes toward climate change. The function form of the full model (PCC 1) is shown in equation 10.3 which consists of airfare, purpose of travelling, awareness of carbon offsetting, gender, and type of air carrier.

$$\boldsymbol{Y_{Aircraft\ Noise}} = +\boldsymbol{\beta_1 FARE} + \boldsymbol{\beta_2 PURPOSE} + \boldsymbol{\beta_3 AWARENESS} + \boldsymbol{\beta_4 GENDER} + \boldsymbol{\beta_5 CARRIER} + \boldsymbol{\varepsilon} \qquad (10.3)$$

Initially, income was included in the analysis but was not significant and it is positively correlated with airfare. As a result, airfare was included in as an independent variable in this model instead. The results are reported in Table 10.22. The differences in attitudes were found to be statistically significant for airfare and gender. Passengers who paid higher airfare was found to have a tendency to rate climate change problem lower. Male flyers rated climate change to be more severe than females (coefficient value of 0.5390).

Table 10.22: Passengers' Attitudes toward Climate Change

		Model PCC 1			Model PCC 2		
		Coefficient	Std error	Sig	Coefficient	Std error	Sig
Threshold	Not a problem(1)	-5.501***	1.066	0.000	-4.904***	0.728	0.000
	Slight problem (2)	-4.988***	0.997	0.000	-4.391***	0.626	0.000
	Moderate problem (3)	-0.569	0.823	0.489	0.020	0.318	0.951
	Severe problem (4)	0.542	0.025	0.511	1.124***	0.326	0.001
Fare	Fare	-0.020**	0.006	0.001***	-0.019***	0.005	0.000
Purpose	Visiting friends and relatives	Base					
	Business	-0.177	0.307	0.564			
	Leisure	-0.167	0.289	0.563			
Carbon Offsetting	Aware of carbon off setting	Base					
	Unware of carbon offsetting	0.005	0.219	0.983			
Gender	Female	Base			Base		
	Male*	0.507**	0.197	0.010	0.539***	0.192	0.005
Carrier	Low Cost Carrier	Base					
	Full service carrier	0.114	0.259	0.659			
Psudo R-squared (McFadden)		0.073			0.070		

Note: ***,**,* ==>significant at 99%, 95%, 90%

10.4.4 Passenger's Attitude towards Aircraft Noise Problem

In the last attitudinal category which examined the attitudes toward aircraft noise problem using functional form in Equation 10.4. (For model PAN1, the full model) Although income was found to be positively correlated with age, the effect was different and this study therefore decided to include age in the model.

$$Y_{Aircraft\ Noise} = +\beta_1 AGE + \beta_2 PURPOSE + \beta_3 AWARENESS + \beta_4 GENDER + \beta_5 INCOME + \beta_6 CARRIER + \varepsilon \qquad (10.4)$$

It was found that the differences in income are statistically significant in affecting attitudes towards aircraft noise. Low and medium income group were found to rate aircraft noise problems higher than the high income group which is a reverse result in comparison to resident's income group. This is unexpected but it may be simply that high income passengers do not care about aircraft noise at all. They tend to live in the city centre which is

far from aircraft noise exposure and their houses are highly likely to be well-insulated and air-condition which reduce the noise problem in their residences. Age coefficient of 0.031 in the full model suggests that older passengers are more sensitive to aircraft noise and rate the problem higher than younger respondents.

Although most of the differences in attitudes of each variable were found not to be statistically insignificant when analysed by the method of ordinal regression, these models confirms that socio-economic factors such as gender and income do play a role in affecting resident's and passenger's attitude on aircraft noise and climate change. Perhaps, most importantly, it also confirms that southern residents (who are exposed to take-off noise which is considered to be louder) recorded a higher rating for aircraft noise annoyance concern which was statistically significant.

Table 10.23: Passenger's Attitude towards Aircraft Noise

		Model PAN 1			Model PAN 2		
		Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
Threshold	Not a problem(1)	-2.912***	0.920	0.002	-2.345***	0.615	0.000
	Slight problem (2)	-1.191	0.857	0.165	-0.624	0.517	0.227
	Moderate problem (3)	2.195**	0.861	0.011	2.647***	0.531	0.000
	Severe problem (4)	4.301***	0.889	0.000	4.696***	0.578	0.000
Age	Age	0.031***	0.011	0.004	0.030***	0.010.	0.004
Purpose	Visiting friends and relatives	Base					
	Business	0.023	0.318	0.943			
	Leisure	-0.312	0.301	0.301			
Carbon Offsetting	Aware of carbon off setting	Base					
	Unware of carbon offsetting	0.055	0.231	0.812			
Gender	Female	Base					
	Male*	0.292	0.210	0.164			
Income	High	Base			Base		
	Low**	0.841**	0.329	0.011	0.868***	0.315	0.006
	Medium**	0.599**	0.290	0.038	0.656**	0.284	0.021
Carrier	Low Cost Carrier	Base					
	Full service carrier	-0.397	0.277	0.151			
Psudo R-squared (McFadden)		0.035			0.030		

Note: ***,**,* ==>significant at 99%, 95%, 90%

10.5 Conclusions

The sample characteristics provide a description of respondents of both groups and it was found to be a reasonable representation of the population. The awareness and attitude questions between two groups of respondents both share a similar view on the general environmental condition in Thailand and ranked deforestation and climate change as the two most severe problems in Thailand.

For aviation-related problems, residents and passengers have different priorities. Passengers considered global emissions as being the most severe problem followed by aircraft noise and local air pollution while residents ranked aircraft noise as the worst problem followed by local pollution and global emissions. This is an expected view since residents are directly affected by the two problems which are, again, consistent with the pilot study results. Debriefing questions revealed that residents focused most on noise and least on carbon emissions and passengers focused most on local air pollution.

The second-order analysis by sample segmentation shows that the residents in the south perceived that they are suffering from higher aircraft noise and air pollution in comparison with the north. The same is true for those who lived there before the airport opened. This is attributed to the fact that the two groups are accustomed to the rural environment of the area and the aviation activities at Suvarnabhumi have changed their quality of life significantly. Residents in the northern area are more concerned about airport-related development such as traffic and road pollution than those living in the south which is anticipated given that the northern area is rapidly expanding and urbanising from a rural small residential area into a relatively large town.

The results from ordinal regressions discovered that differences in income, location of residence, age and gender have been proven to be statistically significant in influencing respondent's attitudes. The next chapter will proceed to analyse SC data to derive WTP and WTA values.

11. STATED CHOICE ANALYSIS

11.1 Introduction

This chapter presents the results from the analysis of three stated choice exercises which are resident rerouting, resident percentage change and passenger exercises. Questionnaire based interviews were used and each respondent was asked to complete eight choice cards each containing a combination of improving and deteriorating conditions.

200 respondents completed the resident rerouting exercise. This design was based on the qualitative study results in which residents suggested that their preferred method of solving aircraft noise and pollution problems was to have the aircraft flight path rerouted away from their area. In so doing, they believe that they can still enjoy the benefit of living near the airport while avoiding environmental impact. In the resident percentage change exercise, there were 206 respondents. This exercise is devised to provide a comparison in terms of values with passenger respondents since the rerouting exercise is deemed as most relevant to the residents but it is meaningless to the passenger group. Finally, 345 Thai air passengers who used Bangkok's Suvarnabhumi Airport completed the passenger exercise. The design of the passenger exercise is identical to the residents percentage change exercise with the exception of the payment vehicle in which airfare changes were used instead of an airport environmental impact scheme.

The SC data were estimated using Multinomial Logit Model (MNL) Nlogit5 software. In each exercise, a base model with all respondents was estimated. The statistically significant coefficient of each attribute and cost/gain coefficients were then used to calculate willingness to pay (WTP) and willingness to accept (WTA) values. After the base model was estimated in each exercise, a 'restricted' model is then estimated. The model removed any non-traders from the sample (i.e. the respondents who only chose option C in the question card which is a status quo option). The reason for the restricted model estimation is to remove a number of respondents who were possibly not fully engaged with the questionnaire which could be caused by fatigue, disinterest in the study or choice complication, status quo bias or other reasons. It was expected that the restricted model will improve the model fitness and improve coefficient statistical significance in comparison to the base model. The results from the restricted model are then compared with the base model in terms of coefficient values and WTP/WTA valuations.

After the estimations of base and restricted models, the analysis turns its attention to the effect of each independent variable (which includes socio-economic and attitudinal variables) on the model. This is undertaken by interacting independent variables with each attribute

from the environmental attributes to gain and cost attributes. The interaction enables the identification of any variables that, together with an attribute, had and the impact on the probability of choice.

11.2 Resident Rerouting Exercise

The base model contains four attributes as specified in Equation 11.1 where U_i is utility, β_i is the coefficient of each attribute. These are rerouting (ROUTE), travel time to work place/shopping (TIME) and airport environmental impact reduction scheme in which COST represents monthly fee and GAIN represents monthly compensation. Also, there are alternative specific constant coefficients for option A and B (ASC) and ε represents the error term.

$$\boldsymbol{U_i = ASC + \beta_1 ROUTE + \beta_2 TIME + \beta_3 COST + \beta_4 GAIN + \varepsilon} \qquad (11.1)$$

Table 11.1: Rerouting Results

Variables	Base Model, n=200 Coefficients (z-value)	Restricted model, n= 149 Coefficients (z-value)
ROUTE	-.00040 (-.98)	-.00056 (-1.09)
TIME	-.00300*** (-3.55)	-.00352*** (-3.60)
COST	-.00023 (-1.55)	-.00029 (-1.58)
GAIN	.00021* (1.78)	.00020 (1.42)
Option A	-.27651** (-2.15)	.79011*** (4.78)
Option B	-.23345* (-1.70)	.84691 (4.79)
Log-likelihood	-1729.95	-1221.20
Adjusted R^2	.0068	.0106

Note: ***, **, * ==> Significant at 1%, 5%, 10% level.

In the base model, all of the coefficient signs are as anticipated. Rerouting and cost attributes are not statistically significant event at 10% level and it is therefore impossible to derive values. The implication is that an attempt to use a change flight path (rerouting) as a proxy to aircraft noise reduction/increasing has been unsuccessful in this SC exercise. However, with gain coefficient being statistically significant, it allows the calculation of willingness to accept compensation for an increased in travel time which is calculated by using equation 11.2.

$$\boldsymbol{WTA_{time}} = \frac{\boldsymbol{\beta_{time}}}{\boldsymbol{\beta_{gain}}} \qquad (11.2)$$

By dividing the travel time coefficient by gain coefficient, the WTA for increased travel time is obtained. In doing so, the WTA to accept compensation is 14.23 baht per month for 1% increase in travel time or 711.5 baht to increase by a half or 1,423 baht to have travel time doubled per month.

The next step is to estimate the restricted model by removing non-traders (respondents who only chose the 'as now' option) from the sample. In consequence, there are 149 respondents in this restricted sample model. The adjusted R-squared improves considerably to 0.0106 from 0.068 in the base model. As illustrated in Table 11.1, the rerouting attribute coefficient remains statistically insignificant whereas travel time coefficients decreases. Furthermore, by removing non-traders, the coefficient signs of options A and B reverse from negative in base model to positive as expected. Nonetheless, both cost and gain coefficient become insignificant in this restricted model and it is therefore unable to calculate any WTP or WTA values.

11.2.1 Interaction Variables

Interactions were performed to see whether the socio-economic background and attitudes of respondents had an impact on the results in conjunction with some of the attributes. Variables used in the interactions are drawn from the two sections of questionnaires; namely, socio-economic background and debriefing questions about the attributes in the SC cards.

Table 11.2 shows the list of interacted variables. The socio-economic background and behavioural variables include gender, income and age, location of residence (Bangna to the south and Ladkrabang to the north), length of stay, number of people in the household, commuting time, number of children, number of flights taken, and whether respondent work for the airport. These are included to see if household characteristics and the benefits of airport have impact on the results.

Table 11.2: List of Interacted Variables

Variable	Explanation	Type of Variable and Coding
ADD	House Location (North, South)	Dummy (0 = south ,1 = north)
BEFORE	Living before airport opened	Dummy (0 = no, 1 = yes)
GENDER	Gender	Dummy (0 = male, 1 = female)
INCOME	Income	Continuous
REDUCE	Ever done anything to reduce noise	Dummy (0 = no, 1 = yes)
FLYING	No. of flight flown in the past year	Continuous
PEOPLE	No. of people in the household	Continuous
KIDS	No. of children under 18s	Continuous
WORK	Working at the airport	Dummy (0 = no, 1 = yes)
COMMUTE	Travel time to work/shopping	Continuous
HOUSE	Type of House	Dummy
IGROUTE	Ignored rerouting attribute	Dummy (0 = no, 1 = yes)
IGTIME	Ignored travel time attribute	Dummy (0 = no, 1 = yes)
IGAIR	Ignored travel time attribute	Dummy (0 = no, 1 = yes)
IGCOST	Ignored cost attribute	Dummy (0 = no, 1 = yes)
FOROUT	Focused on rerouting attribute	Dummy (0 = no, 1 = yes)
FOAIR	Focused on local air pollution attribute	Dummy (0 = no, 1 = yes)
FOTIME	Focused on travel time attribute	Dummy (0 = no, 1 = yes)
FOCOST	Focused on cost attributed	Dummy (0 = no, 1 = yes
WTP	Statement: I am willing to pay to improve the environmental condition in my area	Dummy (0 = disagreed, 1= agreed)
SCHEME	Statement: I think that environmental relief scheme doesn't work	Dummy (0 = disagreed, 1 = agreed)
TRUST	Statement: I don't trust the people who handle the money	Dummy (0 = disagreed, 1 = agreed)
CLIMATE	Attitude towards climate change	Dummy (0 = no/slight problem, 1= severe problem)
ACNOISE	Attitude towards aircraft noise	Dummy (0 = no/slight problem, 1= severe problem)

Each of these socioeconomic variables was used to interact with each of the attributes. It is anticipated that each of the variable will yield a different impact to each attribute. For example:

- Location, residents in the southern area (Bangna) are expected to be more sensitive to aircraft noise/rerouting attribute as they are mostly exposed to take off noise which is perceived to be louder than landing aircraft.
- Residents moving in after the airport had been opened are expected to be less sensitive to the aircraft related attribute as they were already aware of the problem when they decided to move in.
- Higher income respondents are expected to be less sensitive to cost and more sensitive to environmental attributes as they have more disposable income to pay to reduce the aviation externalities.

- Travel time - respondents who endure higher travel times are expected to be more sensitive to the travel time attribute.

Secondly, the debriefing questions asking whether the respondents had ignored or focused on any particular attribute were used to interact with that given attribute. For example, ignoring the route and focusing on route variables were interacted with the reroute attribute. It was expected that respondents who are focusing on a given attribute will be more sensitive to that particular attribute and those who ignore a given attribute will be less sensitive on that particular attribute. Thirdly, attitudinal interactions that include the attitudes towards the severity of the environmental problem, the perceived realism of environmental problem reduction scheme along with the trust worthiness of people who handle the environmental fee.

Each of the interactions listed in Table 11.2 were interacted with each of the attributes (ROUTE, TIME, GAIN, COST) and six were found to be statistically significant, three on cost and three on gain. Individual interaction models are now reported and discussed before the combined interaction model where all of the significant interactions are estimated in one model is described.

An example of a single interaction term is shown in equation 11.3 which is an interaction of Model RR1 between cost attribute (COST) and gender variable (GENDER). The results are shown in Table 11.3.

$$\boldsymbol{U_i = ASC + \beta_1 ROUTE + \beta_2 TIME + \beta_3 COST + \beta_4 GAIN + \beta_5 (COST * GENDER) + \varepsilon} \tag{11.3}$$

Table 11.3 Rerouting Base Exercise Cost Interactions

Variables	Model RR1 Coefficients (z-value)	Model RR2 Coefficients (z-value)	Model RR3 Coefficients (z-value)
ROUTE	-.00039 (-.94)	-.00037 (-.89)	-.00047 (-1.13)
TIME	-.00299*** (-3.53)	-.00294*** (-3.47)	-.00307*** (-3.61)
COST	-.00049*** (-2.89)	-.00082*** (3.10)	-.00034** (-2.24)
GAIN	.00020* (1.77)	.00021* (1.84)	.00020* (1.74)
COST*GENDER	.00042*** (3.22)		
COST*AGE		-.000024098*** (-4.61)	
COST*FOCOST			.00038*** (2.80)
OPTION A	-.27526** (-2.14)	-.28383** (-2.20)	-.26908** (-2.09)
OPTION B	-.23281* (-1.69)	-.24375* (-1.77)	-.22065 (-1.60)
Log-likelihood	-1724.61	-1718.81	-1725.11
Adjusted R^2	.0095	.0128	.0086

Note: ***, **, * ==> Significant at 1%, 5%, 10% level.

There are three socio-economic and attitudinal characteristics whose interaction with the cost attribute is significant, namely, gender (RR1), age (RR2) and focusing on cost attribute (RR3). Firstly, gender (1 if female, 0 if male) plays a role in influencing cost whereby female interaction coefficient brings the cost coefficient down to almost zero which means that women are indifferent to costs and thereby increasing the WTP value in comparison to men. Secondly, Model RR2 which interacted age with cost found that respondents with higher age are less sensitive to cost but the coefficient value suggests that the difference is extremely small. Lastly, respondents who suggested that they focused on cost attribute during the SC exercise (FOCOST) are more sensitive to cost than those who did not.

11.2.2 Rerouting Exercise Gain Interactions

Table 11.4: Rerouting Exercise Gain Interaction Results

Variables	Model RR4 Coefficients (z-value)	Model RR5 Coefficients (z-value)	Model RR6 Coefficients (z-value)
ROUTE	-.00041 (-.98)	-.00039 (-.95)	-.00040 (-.97)
TIME	-.00302*** (-3.56)	-.00300*** (-3.53)	-.00301*** (-3.55)
COST	-.00023 (-1.56)	-.00023 (-1.55)	-.00023 (-1.55)
GAIN	.00035*** (2.69)	.00043*** (3.06)	.00053** (2.42)
GAINADD	-.00026** (-2.43)		
GAINCOMMUTE		-.00032*** (-2.77)	
GAINAGE			-.0000073717* (-1.73)
OPTION A	-.27372** (-2.13)	-.27654** (-2.15)	-.27692** (-2.15)
OPTION B	-.23173* (-1.68)	-.23270* (-1.69)	-.23259* (-1.69)
Log-likelihood	-1726.99	-1726.00	-1728.44
Adjusted R^2	.0081	.0087	.0073

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

In terms of gain (compensation), there are also three significant interactions (see Table 11.4). Model RR4 interacted location of residence (ADD) with gain and found that those living in the northern (coded as 1) area have a higher value for compensation than those living in the south (coded as 0). The results are as expected since the southern areas are mostly subject to departing aircraft which are deemed to be noisier than approaching aircraft. Model RR5 shows that respondents with higher travel time to work or shopping are more sensitive to receiving compensation (GAIN) which is anticipated. Additionally, age also influences the gain attribute as reported in Model RR6 in which higher age results in higher sensitivity to gain.

The last step of interaction is to estimate a combined interaction model which put all of the significant interaction in a single model as shown in equation 11.4

$$\boldsymbol{U_i = ASC + \beta_1 ROUTE + \beta_2 TIME + \beta_3 COST + \beta_4 GAIN + \beta_5 (COSTxGENDER)}$$

$$\boldsymbol{+\beta_6 (COSTxAGE) + \beta_7 (COSTxFOCOST) + \beta_8 (GAINxADD)}$$

$$+ \boldsymbol{\beta_9}(\boldsymbol{GAINxCOMMUTE}) + \boldsymbol{\beta_{10}}(\boldsymbol{GAINxAGE}) + \boldsymbol{\varepsilon} \qquad (11.4)$$

Table 11.5: Rerouting Combined Interactions Results

Combined Interaction	Coefficient	z-value
ROUTE	-.00040	-.94
TIME	-.00294***	-3.43
COST	.00067**	2.24
GAIN	.00110***	4.54
COSTGENDER	.00043***	3.22
COSTAGE	-.000029156***	-5.23
COSTFOCOST	.00037***	2.65
GAINADDRESS	-.00021*	-1.94
GAINCOMMUTE	-.00029**	-2.48
GAINAGE	-.0000013017***	-2.80
OPTION A	-.27600**	-2.13
OPTION B	-.23138*	-1.67
Log-likelihood	-1698.87	
Adjusted R2	.0228	

Note: ***, **, * ==> Significant at 1%, 5%, 10% level.

Combined interaction results are reported in Table 11.5. The rerouting attribute in this combined model remains insignificant. The cost attribute becomes significant in the combined model. However the cost coefficient is problematic as the positive cost coefficient sign is unexpected and illogical given that gain coefficient is positive as anticipated and the cost coefficient should be in an opposite sign to the gain. Both cost and gain coefficient change significantly while other coefficients are similar to the previous models. Nevertheless, the fitness to model measuring through adjusted R-squared improves considerably. In addition to interaction models, segmentation estimation by segmenting samples by location (north, south) was performed but the results were not statistically significant.

11.3 Resident Percentage Change Exercise

The second design for resident is the percentage change exercise. As the name implies, percentage changes in aircraft noise (NOISE) and local air pollution (AIR) were used as to represent local environment problems relating to Suvarnabhumi Airport. Carbon offsetting option (OFF) was also added to the design making it identical to air passenger exercise to facilitate comparison between the two groups of respondents. COST and GAIN attributes are the same as in the rerouting exercise which represent airport environmental impact reduction

scheme where cost represents fee and gain represents compensation. The base model for percentage change exercise is shown in Equation 11.5 below.

$$U_i = ASC + \beta_1 NOISE + \beta_2 AIR + \beta_3 OFF + \beta_4 COST + \beta_5 GAIN + \epsilon \qquad (11.5)$$

Table 11.6 Resident Percentage Change Exercise Results

Variable	Base Model n = 206 coefficient (z-value)	Restricted model n = 165 coefficient (z-value)
NOISE	-.00480*** (-5.00)	-.00509*** (-5.20)
AIR	-.00208* (-1.91)	-.00022** (-1.98)
OFF	.07591 (1.11)	.07590 (1.09)
COST	-.00055*** (-4.71)	-.00067*** (-4.91)
GAIN	.00023*** (2.03)	.00016 (1.18)
OPTION A	.01280 (0.11)	.79606*** (5.55)
OPTION B	-.41556*** (-3.47)	.34107** (2.33)
Log-likelihood	-1725.82	-1360.30
Adjusted R^2	.0291	.0389

Note: ***, **, * ==> Significant at 1%, 5%, 10% level.

Table 11.6 depicts the results from base and restricted models in the resident percentage change exercise. There were 206 respondents in the base model. With the exception of offsetting (OFF), all other attributes are statistically significant which enable WTP and WTA to be calculated by dividing the coefficient of the relevant attribute by the cost coefficient for WTP and dividing by gain coefficient for WTA (see Equation 11.2). WTP to reduce aircraft noise by 1% is 8.73 baht a month and WTP to reduce local air pollution is 3.78 baht a month. This suggests that residents value the aircraft noise problem more than twice as much as that of local pollution which is in line with the results from the qualitative study and other sections of the questionnaire that suggests aircraft noise is the severest problem. For WTA, residents are willing to accept compensation of 20.87 for every 1% increase of aircraft noise and 9.04 baht for 1% increase in local air pollution per month this means that the WTA values for both noise and local pollution are more than double the WTP values.

A restricted sample was then estimated by removing non-traders from the model. A total of 164 respondents were included in the estimation which sees a slight improvement in adjusted R^2 from 0.0291 to 0.0389 and there is a significant reduction in local air pollution

coefficient. The carbon offsetting attribute (OFF) remains insignificant and the gain coefficient becomes insignificant and therefore unable to calculate WTA in this model. WTP for aircraft noise reduction by 1% is 8.81 baht a month and WTP for 1% reduction which is similar to the based model. The WTP for local air pollution is 1.375 baht which is lower than the value in the base model.

11.3.1 Percentage Change Exercise Interactions

There are two significant interactions in the base model and three in the restricted model. Firstly the base interaction which added the interaction between noise and income and the interaction between local air pollution (AIR) and respondent who focused on local air pollution attribute (FOAIR). The equation form is shown below in equation 11.6

$$\boldsymbol{U_i = ASC + \beta_1 NOISE + \beta_2 AIR + \beta_3 OFF + \beta_4 COST + \beta_5 GAIN + \beta_6 (NOISExINCOME) + \beta_6 (AIRxFOAIR) + \varepsilon} \quad (11.6)$$

Table 11.7: Percentage Change Base Interaction Model (n = 206)

	Coefficient	z-value
NOISE	-.00823***	-4.44
AIR	-.00242**	-2.21
OFF	.07656	1.11
COST	-.00056***	-4.75
GAIN	.00023**	2.00
NOISEINCOME	.00014**	2.16
AIRFOAIR	.02805***	2.69
OPTION A	.01385	0.12
OPTION B	-.43062***	-3.50
Log-likelihood	-1718.90	
Adjusted R^2	.0324	

Note: ***, **, * ==> Significant at 1%, 5%, 10% level.

The results from the base interaction model are depicted in Table 11.7 and show that the offsetting attribute coefficient is still not significant. In terms of the interaction effect, it was found that higher income means lower sensitivity to aircraft noise which is unexpected. However, it may be possible that higher income residents live in a better noise-insulated residence (such as in a closed room with air conditioning) and therefore are less affected by aircraft noise.

The AIRFOAIR interaction which is an interaction between local air pollution (AIR) and respondents who suggested that they focused on the air pollution attribute during the exercise (FOAIR) shows that the interaction coefficient reduces the air coefficient hence the value of those who are focusing on local pollution is reduced. This is contrary to expectations since it was expected that those who focus on the local pollution attribute are the ones who are concerned about this problem and therefore willing to pay more to reduce it.

Table 11.8 Percentage Change Restricted Interaction Model (n=165)

	Coefficient	z-value
NOISE	-.00955***	-4.75
AIR	-.00265**	-2.33
OFF	.06998	1.00
COST	-.00065***	-4.69
GAIN	.00016	1.15
NOISEINCOME	.00018**	2.47
AIRFOAIR	.02416**	2.41
COSTFOCOST	-.00094**	-2.39
OPTION A	.79821***	5.55
OPTION B	.34107**	2.32
Log-likelihood	-1350.67	
Adjusted R^2	.0450	

Note: ***, **, * ==> Significant at 1%, 5%, 10% level.

In the restricted model shown in Table 11.8 above, one additional interaction effect was found to be significant, which is an interaction between those who focused on cost during the exercise and cost coefficient. The coefficient sign was as expected. It was found that those who focused on cost are more sensitive to cost and willing to pay less than those who did

not. The other two interactions had the same effect as in the base model and the fitness to model improves in this restricted model.

11.4 Passenger Exercise

The estimation for passenger exercise started with the basic model containing four attributes as specified in equation 11.6. These are aircraft noise (NOISE), local air pollution (AIR), carbon offsetting (OFF) and changes in airfare (COST). A total of 345 respondents were included in the base model and 325 respondents in the restricted one. As mentioned earlier, the SC card design for passengers is identical to the resident percentage change model to allow comparison between the two groups. The only difference is the payment vehicle in which changes (increases or decreases) in airfares are used in the passenger exercise to represent cost. The utility function is shown in equation 11.7.

$$\boldsymbol{U_i = ASC + \beta_1 NOISE + \beta_2 AIR + \beta_3 OFF + \beta_4 COST + \varepsilon} \quad (11.7)$$

Table 11.9 Passenger Exercise Results

	Base Model n=345 (z-value)	Restricted model n=325 (z-value)
NOISE	-.01037*** (-12.50)	-.01074*** (-12.77)
AIR	-.01435*** (-16.46)	-.01484*** (-16.74)
OFF	.17984*** (3.30)	.18643*** (3.39)
COST	-.00038*** (-13.15)	-.00040*** (-13.37)
OPTION A	-.18399*** (-3.44)	.05332*** (0.89)
OPTION B	-.02650** (-0.49)	.23707*** (3.88)
Log-likelihood	-2818.67	-2608.34
Adjusted R^2	.0611	.0678

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

The results of the passenger exercise are illustrated in Table 11.9 which shows that all of the attributes are statistically significant at 1% confidence interval. The model fitness is the best of all three exercises with adjust R-squared value of 0.0611. WTP for 1% reduction of aircraft noise is 27.29 baht per flight and WTP for 1% reduction in local air pollution is 37.76 baht per flight. These values show a different view of passengers in terms of severity of externalities

in comparison with local residents as passengers valued local air pollution more than aircraft noise. Since the offsetting coefficient is significant in this model, it is possible to calculate the willingness to pay for carbon offsetting and the value is 473.26 baht per flight.

In the restricted model, all of the attribute coefficients remain statistically significant at 1% and the adjusted R-squared increased slightly to 0.0678. There were no substantial changes to any of the coefficient values as only 20 respondents were removed from the original estimation (from 345 to 325 respondents). The WTP to reduce aircraft noise by1% reduces slightly to 26.85 baht per flight. The WTP to reduce local pollution by 1% is also decrease marginally to 37.10 baht per flight from 37.76 baht in the base model. As for carbon offsetting, the WTP to offset carbon emissions is 466.75 baht per flight. All of these values are very similar and there are no significant changes from the base model.

11.4.1 Passenger Exercise Interactions

Five interactions were found to be significant and reported in the combined model as reported in Table 11.10. Since there are only small differences in terms of sample size and basic model results, only base model interaction are estimated in the passenger exercise. The model specification for the passenger interaction is shown in equation 11.8 below.

$$\boldsymbol{U_i = ASC + \beta_1 NOISE + \beta_2 AIR + \beta_3 OFF + \beta_4 COST + \beta_5 (NOISExFARE)}$$
$$\boldsymbol{+\beta_6 (AIRxINCOME) + \beta_7 (COSTxFARE) + \beta_8 (COSTxINCOME)}$$
$$\boldsymbol{+ \beta_9 (COSTxAGE) + \varepsilon} \qquad (11.8)$$

11.10 Passenger Exercise Interaction Results (n=345)

	Coefficient	z-value
NOISE	-.01103***	-11.97
AIR	-.01437***	-14.64
OFF	.23433***	4.44
COST	-.00053***	-5.97
NOISEFARE	-.000047983**	-2.21
AIRINCOME	-.000067482***	-4.86
COSTFARE	-.0000073977***	-7.16
COSTINCOME	-.000021545***	-37.79
COSTAGE	.000021917***	9.59
OPTION A	-.28496***	-5.19
OPTION B	-.09399*	-1.69
Log-likelihood	-3775.56	
Adjusted R^2	.0314	

Note: ***, **, * ==> Significant at 1%, 5%, 10% level.

Five interactions were found to be significant and the results are reported in Table 11.10 above. Firstly, the interaction between noise and airfare (NOISEFARE) indicates that respondents who paid higher airfares are more sensitive to aircraft noise. Secondly, passengers with higher incomes are found to be more sensitive to local air pollution which is to be expected. Three variables were found to have an impact on cost. Firstly, the COSTFARE interaction which interacted cost with airfare show that respondents with higher airfare are more sensitive to cost. Similarly, the interaction of income with cost (COSTINCOME) shows that income has the same effect as airfare. That is to say, passengers with higher income are more sensitive to cost and it was expected that passengers with more disposable income should be less sensitive to cost. Lastly, the COSTAGE interaction shows that interacting age with cost suggests that older passengers are less sensitive to cost. It should be noted that the coefficient values of the interaction terms indicated that the impacts of these variables are extremely small.

11.5 Comparison of Values

11.5.1 Residents v. Passengers

An important aspect of this study is to produce comparable values between residents and passengers to see how the polluters and polluted value the same environmental problem which were addressed by the percentage change exercise to compare with passenger exercise. In these two exercises, the passengers were asked to elicit value per flight whereas the residents were asked to elicit value per month creating discrepancy for comparison. This section attempts to standardise the value by converting WTP/WTA into an annual value.

Firstly, the residents' monthly WTP/WTA values were multiplied by 12. Secondly, average annual trip for passengers (which is 2.588 trips) was multiplied by the original WTP obtained from the base models and the results are reported in Table 11.11.

Table 11.11 Standardised Values (Baht)

	Passenger	Resident	
	WTP/Year	WTP/Year	WTA/Year
Noise Reduction	70.63 /1% reduction	104.76 /1% reduction	250.44 / 1% increase
Local Air Pollution Reduction	97.72 /1% reduction	45.36 / 1% reduction	108.48 / 1% increase
Carbon Offsetting	1,244.80	-	-

The standardised values show that residents' WTP for noise reduction is 48.32% higher than that of passengers. This was expected and was also revealed by other sections of the questionnaire. The air pollution WTP measures shows instead that are passengers had a WTP for pollution reduction which was 115.43% higher than the corresponding figure for local residents.

Standardised values also enable a comparison of the WTP by passengers as a polluter and WTA of residents as the affected party. There is a large difference between passengers' WTP for noise and residents' WTA which is 254.58% higher. For local air pollution, the gap between WTP and WTA is closer at 10.76 baht.

11.5.2 Segmentation Comparison

The second part of this section compares WTP values from sample segmentations. The interaction exercises in the previous section have shown the independent variables influence on WTP/WTA. This subsection attempts to explain the differences of each variable further by reporting the WTP results from subsamples. The subsamples for resident groups include; income, location and duration of residency. Passenger subsamples include income, flight length, awareness of carbon offsetting and class of travel. The SC analysis of these segmentations is available in Appendix D and the WTP results are reported in Table 11.12 and 11.13

Table 11.12: Percentage Change Design WTP Segmentation (Baht/month)

Category		1% Noise reduction	1% Local Pollution reduction	Carbon Offsetting	Adjusted R-squared
Income	Low	9.36	-	-	0.0297
	Medium	7.69	-	-	0.0397
	High	-	-	-	0.0058
Location	North	9.26	-	-	0.0371
	South	5.15	-	186.24	0.0361
Living before airport opened	Before	8.51	-	-	0.0320
	After	5.49	4.59	-	0.0323
Overall		**8.73**	**3.78**	**-**	**0.0291**

The first set of segmentation is the percentage change design for residents. The WTP corroborate the interaction results which show that lower income respondents have a higher WTP. As previously mentioned, one possible explanation is that higher income residents tend to have a better noise insulation and air condition in their homes making them less exposed to aircraft noise. Nonetheless, the cost coefficient of high income group was not significant and this study was unable to derive the WTP value. North-south segmentation shows that northern residents are willing to pay more for noise (9.26 baht per month per 1% reduction in aircraft noise). The WTP is a reverse of pilot and ordinal regressions which shows that residents in the south worried more about aircraft noise. This suggests that they are less willing to pay even if they are more concerned about the noise problem than the northern residents. WTP of residents who have lived before the airport opened is higher than those who moved in after which is consistent to attitudinal results from section 10.2. This is because they have lived in a quiet area before and experienced rapid change in noise level

in their area caused by aircraft and therefore willing to pay more to reduce the noise problem in comparison to those who moved in later and more likely to take the noise problem into consideration before moving in. The rerouting exercise segmentations were also analysed but this study was unable to derive any meaningful comparison of WTP since most of the coefficients were not significant (Result printouts are reported in Appendix D). Passenger segmentations are reported in Table 11.13 below.

Table 11.13: Percentage Change Design WTP Segmentation (Baht/flight)

Category		1% Noise reduction	1% Local Pollution reduction	Carbon Offsetting	Adjusted R-squared
Income	Low	31.17	43.37	-	0.0578
	Medium	26.95	40.79	473.58	0.0850
	High	29.71	34.32	745.03	0.0346
Flight Length	Short-haul	29.32	36.02	411.71	0.0692
	Medium-haul	36.96	51.77	1,005.31	0.0478
	Long-haul	22.79	38.87	607.95	0.0553
Offsetting awareness	Yes	34.63	51.78	965.78	0.0708
	No	26.93	64.95	403.15	0.0595
Cabin	Economy	29.08	41.84	597.92	0.0669
	First/Business	6.03	25.65	-	0.0330
Overall		**27.29**	**37.76**	**473.26**	**0.0611**

Passenger segmentations show several interesting differences among subsamples. Firstly, it found that the low income passengers have the highest WTP to reduce aircraft noise and local pollution followed by the high income group. It was expected that high income group would have a higher willingness to pay given that they have higher disposable income. Flight length segmentation revealed that medium-haul passengers have the highest WTP on for all three attributes. The respondent with the awareness of carbon offsetting were found to have an expected higher WTP to offset carbon emissions from their flight. Interestingly, they are less willing to pay to reduce local emissions which implied that they gave higher priority to global emission problem. Premium class passengers were found to be willing to pay less than economy class passenger to improve noise and local emission problems which is a similar result to low/high income comparisons. It could be that they consider that their fare is already high and are not willing to pay more.

11.6 Conclusions

The resident percentage change exercise provided more encouraging results than the rerouting exercise as it was able to calculate WTP/WTA for aircraft noise and local air pollution changes which facilitate the comparison with passenger's value. The carbon offsetting coefficient was insignificant. Given the fact that most residents are likely to be more concerned with the local impacts of aircraft noise and local pollutions, hence they did not put carbon emissions, which are a global impact as a high priority during the choice exercise. The elicited values indicate that the aircraft noise problem is valued more than local air pollution as anticipated. Restricted sample posed a slight problem with the percentage change exercise as well as the gain coefficient became insignificant in the restricted model even if the adjusted R-square improved.

Of all three SC exercises, the resident rerouting exercise was found to be the most problematic. It was only able to obtain the willingness to accept compensation value for increased travel time as other coefficients were not significant. The attempt to remove non-traders does not improve the situation and the fitness to model only improved slightly. The design was based on the feedback from qualitative study and every attribute was designed specifically for the need of residents. However, as the results indicate, this is the most problematic exercise of the three. This study is unable to find explanation to the low fitness to model given that it has been given a robust pilot test and there were no problems reported during the survey.

The passenger exercise was the most successful as all of the attributes were statistically significant in which passengers give priority to local air pollution more than aircraft noise. The restricted model shows essentially the same results as the base model since only 20 respondents were removed. In terms of interactions, most of the interaction effects were as expected, with the exception of the combined models in the rerouting exercise. Passenger interactions were, however, logical and satisfactory but the small coefficient values in the passenger interactions suggest that the magnitudes of the impact are extremely small. Be that as it may, the interaction allows this study to identify which variables have an impact to the model and what kind of impact they are.

12. DISCUSSION

12.1 Introduction

The results from the SC exercises were reported in the last chapter. This chapter now discusses the WTP/WTA values that were obtained by comparing the results with the qualitative (focus group) study reported in Chapter 7 and findings from previous studies. The chapter then examines the issues and limitations of the study.

12.2 Comparison with Qualitative Study

This section uses the results from qualitative study (focus groups) and the questionnaire in terms of the severity of each aviation-related problem to compare the WTP values obtained from the SC exercises. WTP values are calculated by dividing the attribute coefficient with the cost coefficient (see Equation 11.2). These figures are reported in Table 12.1.

Table 12.1: SC Values

	Passenger	Resident	
	WTP/Year	WTP/Year	WTA/Year
Noise Reduction	70.63 (1% reduction)	104.76 (1% reduction)	250.44 (1% increase)
Local Air Pollution Reduction	97.72 (1% reduction)	45.36 / 1% reduction)	108.48 (1% increase)
Carbon Offsetting	1,244.80	-	-

During the qualitative phrase of this study, it was established that residents perceived aircraft noise as the most severe environmental problem followed by air pollution as the second most severe problem. This was confirmed by the questionnaire. This reflects well in the WTP values in which WTP for noise is higher than local air pollution (97.72 against 45.36 baht per month). This also corresponds well with the debriefing questionnaire as aircraft noise was the most focused attribute by the residents at 61.65%.

The offsetting attribute in the residents' percentage change model was found to be not statistically significant. This appears to be in line with the qualitative study as the participants were concerned about the impact of engine emissions on the air quality of their residential area and none of the participant mentioned global emissions as a concern for them among the aviation externalities. This also applied in the questionnaire where climate change was ranked as the third most important problem by residents after noise and local pollution and

therefore implied that global emission are not their immediate concern when it comes to aviation externalities.

Passengers SC results suggest a different priority of aviation externality in which local air pollution has a higher WTP value than aircraft noise. This corresponds with the questionnaire results which show that passenger perceived global emission from aircraft as the most severe problem followed by local air pollution. Interestingly, aircraft noise was ranked at the fifth place. The focus group study, however, showed that aircraft noise was the most concerned problem, followed by engine emissions. The focus group results were inconclusive on whether passenger participant perceived local air pollution or global emissions are more severe.

Apart from WTP, the SC exercise has obtained a willingness-to-accept value. It was found that residents were willing to accept a compensation of 14.23 baht per month to have their travel time to work/shopping increased by 1%. The comparison of WTP values are discussed in this section. First, the comparison of aircraft noise WTP is reported in Table 12.2. The result from this study is compared with WTP measures estimated by four other studies. The value of each study has been adjusted with local inflation and GDP growth rate. In doing so, the value was first adjusted by adding GDP growth rate of the country of study from the year of study to the year 2013. Secondly, the value was subtracted by inflation rate from the same period. Once this is complete, the value is converted to pound sterling using 2013 exchange rate.

All of the previous studies reported in Table 12.2 are located in Europe. Thune-Larsen (1995) employed both Contingent Valuation and Stated Choice methods for Oslo airport, and that study reports the highest WTP values, while the lowest WTP value was found among Athens airport residents (£16.56 per year).

Table 12.2: WTP for 50% Reduction of Aircraft Noise

Study	Year of study	Location	Remarks	WTP (per year)
Pommerehne (1988)	1988	Basel, Switzerland	CV Method	£31.77
Thune-Larsen (1995)	1994	Oslo, Norway	CV Method	£112.14-£566.96
			SC Method	£128.20-£435.06
Faburel & Luchini (2000)	1998	Paris Orly Airport, France	CV Method	£64.16
Thanos et al (2011)	2005	Athens	SC Method	£7.75
This study	2012	Bangkok	Residents	£50.81
			Passenger	£70.62

According to airport trade organisation Airports Council International (2012), Suvarnabhumi Airport is the largest airport among those examined in these studies in terms of passengers and cargo handled. At £50.81 per year, the WTP of Suvarnabhumi residents is the third highest of the five and the estimated figure is in a comparable range with Paris Orly Airport residents of £59.13. Passenger's WTP from this study is £70.62. Given that this is the only study that obtains air passenger's WTP to reduce aircraft noise, there are no comparable values.

In terms of carbon offsetting, three previous relevant studies were found and compared in Table 12.3. There are two studies in Europe and two in Asia. As values are from various years, the WTP values were adjusted with inflation and GDP growth rate for each studied country from the study period to 2012 using World Bank data (2014). The European studies by Brouwer *et al*. (2008) and Mackerron *et al*. (2009) shows that their values are similar to the European WTP but they are higher than the Asian studies. Although this study did not differentiate the WTP value of flight length, the WTP to offset carbon emissions of £9.46 per flight is within the WTP range of Lu and Shon (2012).

Table 12.3: Carbon Offsetting WTP

Study	Location	Route	WTP (per flight)
Brouwer, et al. (2008)	Amsterdam		£22.68
Mackerron, et al. (2009)	United Kingdom	New York to London	£26.49 (CV) £26.81 (SC)
Lu and Shon (2012)	Taipei, Taiwan	China Far East Asia Southeast Asia Western	£3.30 £5.81 £7.13 £18.88
This study	Bangkok, Thailand		£9.46

Table 12.4 shows voluntary carbon offsetting fee by three airlines on three routes departing from Bangkok. Thai Airways is the only Thai airline that offers carbon offsetting for their passengers. Its carbon offsetting page (THAI, 2013) stated that it has two carbon offset projects in its portfolio, one in is the 'Korat Waste to Energy Project' in Thailand and another is the 'Braco Nore IV Small Hydro' in Brazil. The carbon offsetting calculation is reportedly based on IATA methodology.

Table 12.4 Carbon Offsetting Fee

Route	Thai	Cathay Pacific	Qantas
Bangkok-Singapore	£0.41	£0.26	£0.68
Bangkok-Sydney	£2.35	£1.62	£5.48
Bangkok-London	£3.21	£1.69	£6.19

Qantas's offsetting fee is the most expensive of the three followed by Thai Airways and Cathay Pacific. It shows that the WTP value of £9.46 per flight is much higher than the current offsetting fee offered by the airlines. Interestingly, none of the respondents in this study had actually offset their flights. This therefore raises the question of differences between the obtained WTP value and actual consumer behaviour.

Table 12.5 Value of Time and WTA (Baht/hour)

Motorcycle	Car	Bus	This study
32.35	48.53	16.18	47.43

Source: Gwilliam (1997)

In terms of the travel time value comparison, the WTA to increased travel time by one hour is compared with the value of time values published by World Bank (Gwilliam, 1997) which is the most recent value available. This study reported travel time value per hour by different modes of road transport in Bangkok. The SC results found that the cost coefficient was insignificant. However, that was not the case of the gain coefficient and the WTA value of 14.23 baht/month to have travel time increased by 1% was obtained. The values shown in Table 12.5 above are based on one-hour increase in travel time of people who are currently spend 1 hour each day to travel to their place of work or the shops.

The elicited WTA value is very similar to the value of time for people travelling by car whereby in the questionnaire it was found that 53% of airport residents travel to work or shopping by their own cars and therefore the WTA value appears to be in line with Gwilliam's (1997) value of time for Bangkok.

12.3 Critique and Limitations

12.3.1 Status Quo Answer

One major concern regarding the SC design for this study is the inclusion of the 'as now' option in the SC card (as option C). The concern is that there may be a status quo bias encouraging non-trading behaviours in which residents may have a tendency to choose the current situation rather than other than options. During the pilot study, 23.33% of respondents only chose the 'as now' option. Pilot study respondents suggested a number of reasons for non-trading behaviours. This includes the belief that the situation is unlikely to improve and it is not their responsibility to pay. When asked if they chose status quo because of fatigue or not understanding the SC situation, none of them indicated that they had any problems with that. Given the pilot study results, the 'as now' option was included in the actual study.

In the actual study, the proportion of non-trading respondents is similar to the pilot study which is 25.50% for re-routing, 19.90% for resident percentage change design and 18.75% for respondent. Restricted models were introduced in all of the three SC exercises to address non-trader problems and the attribute coefficients were similar. This implies that the effect of non-traders on estimates is not large in this experiment.

12.3.2 Noise and Pollution Data

Lack of recent noise and local air quality data around the airport prevented the incorporation of these two pieces of information into the SC analysis. The most recent data for air quality was published by the airport operator in 2007 using data from 2001. This map used the noise data before the airport opened. A new noise data and noise contour map was supposed to be published in 2009 but it remains unpublished. This study thus measured noise levels from 16 areas around the airport. Nonetheless, each location was given only 15 minutes measurement twice owing to time and resource constraints, and therefore the results are not conclusive. The average noise value was interacted in the two residents' models, however, none of the noise level interactions were found to be statistically significant.

12.3.3 Rerouting Design

The rerouting design was anticipated to work well with airport residents. It was developed from the aircraft movements design (changes in number of flights in a given period) during the focus group by the suggestion of resident participants specifically for the resident rather than the resident percentage change design which was designed with an aim to compare the results with air passengers.

The re-routing attribute was developed as a proxy for aircraft noise as it was seen by residents as desirable since they still can enjoy the benefits from airport growth while redirecting aircraft path elsewhere. However, as reported in the last chapter, the re-routing attribute was insignificant and therefore it was not possible to obtain a WTP value. The only obtainable value for WTA is for an increase in travel time which is the second attribute in this design. An attempt to remove non-traders by estimating the restricted sample was unsuccessful as both cost and gain coefficients are insignificants in the restricted model and none of the values were obtained.

12.4 Conclusion

The WTP values obtained from Chapter 11 are compared with previous studies in this chapter. It was found that the WTP value reflected the qualitative results. The comparison of value with other studies found that WTP to reduce aircraft noise fits in the middle range of

values by previous studies. As for WTP to offset emissions, the value is lower than those obtained by studies focusing on European airports, but falls in the middle range of the Asian study by Lu and Shon (2012). The WTA for travel time is also corresponds with Gwillam's (1997) value.

In terms of limitations, the 'as now' option, the noise and pollution data and the rerouting exercise were the three key issues for this thesis. The 'as now' option has been an issue since the beginning and it can be concluded that it doesn't have significant impact to the overall results especially when compared with the restricted model with the non-traders removed. Sadly, the lack of recent noise and air pollution data prevented a more precise attribute design and SC data analysis. Some of the noise data collected during the survey period was incorporated in the interaction design but it found to have no effect on the SC results.

13. CONCLUSION

13.1 Aims Revisited

The overarching aim of this study was to obtain valuations of Suvarnabhumi airport's externalities from airport users and residents. Three supporting aims were defined and this section describes how each has been met.

1) *To investigate the Thai air transport users and local residents' perception and awareness of commercial aviation's externalities.*

This aim was addressed through focus groups and SC questionnaire for Suvarnabhumi's residents and passengers. The residents see benefits from the airport as it is a source of economic and urban development in their residential areas. This includes urbanisation of the area and improvements in transport infrastructure. These developments, coupled with the growth in population within the area brought about increased business and employment opportunities for those living near the airport.

This study found that airport residents' awareness and perceptions of negative impacts from aircraft are generally confined to the local impacts which are based on their own experiences of aircraft activity at Suvarnabhumi airport. They have fewer concerns and less awareness of the global impacts than the passenger group. This is exhibited through the focus group as none of the respondents mentioned carbon emissions as a problem caused by aircraft. Furthermore, the SC exercise was also unable to obtain WTP/WTA values for carbon offsetting from the residents as the offsetting attribute was not statistically significant.

The local problems are, as anticipated, concentrated on aircraft noise and its effects. Most of the problems associated with noise are in line with the literature and include annoyance, sleep disturbance, stress and activity disruption. Apart from these problems, concerns about vibration, interruption to television signal and mobile phones were reported as problems associated with aircraft noise. It was found that residents are highly concerned about the noise problem as they ranked aircraft noise as the third severest environmental problem in Thailand whereas passengers ranked the problem at the last place (8th).

Local air pollution was a second concern, the residents were aware that pollution from aircraft can be harmful to their health, but they were found to be unaware of the nature or components of aircraft engine pollutants and their effects on human health. They perceived

local air pollution to be less severe than aircraft noise since the effects from pollution are not tangible and quantifiable in their perceptions. There are a number of unique issues relating to aviation activities at Suvarnabhumi. Firstly residents who engage in agricultural activities claimed that air pollution has impacted on their crop yields but there has yet to be any empirical evidence to substantiate this. Secondly, flooding problems as the airport was built on the swamp which acts as a natural floodway. It now blocks the water path causing flooding in nearby residential areas. Apart from noise and local pollution, traffic congestion caused by airport-related activities and the development of the area were found to be the third most severe problem associated with the airport. This finding led to the addition of a travel time attribute to the SC exercise to obtain values of travel time.

Thai air passengers, as polluters, were found to be aware of adverse effects caused by their air travel. This study found that air passengers have a tendency to regard emissions from aircraft as one problem without differentiating between local and global level effects. As with residents, air passengers are not aware of the components of engine emissions and its specific impacts on the environment and human health but they aware that atmospheric emissions from aircraft contribute to the global warming effect. Participants in this study were unable to reach a consensus on whether local or global pollution are more severe as the opinions were divided among the participants. In contrast to the residents, passengers perceived aircraft noise to be a less severe problem than engine emissions. This is manifested in the form of WTP values and qualitative results where noise was given a lower priority than air pollution. This may be attributed to the fact that most of the passengers are not exposed to aircraft noise in their home and therefore giving air quality a priority over aircraft noise.

2) *To obtain a valuation of aviation environmental externalities in Thailand from the perspectives of air transport users and airport residents who are directly affected by air transport operations.*

The second aim of this study has been achieved by employing stated choice experiments to elicit willingness-to-pay and willingness-to-accept from the two groups. This study drew on an examination of the literature and qualitative study results to formulate and design stated choice experiments, most suited to the context of aviation externalities at Suvarnabhumi airport. Three experiments were designed; two for residents with different treatments of noise nuisance: rerouting and percentage change and one for passengers. The first design was specifically made to address noise and pollution concerns through the rerouting aircraft

attribute to reduce noise levels while the congested traffic around the airport was addressed by the travel time attribute. The last two designs used the same attributes in order to compare valuations between residents and passengers. The attributes included aircraft noise, local air pollution and carbon emissions which address the three main problems of the aviation externalities.

This would appear to be the first study that uses the stated choice method to obtain and compare valuation of aviation externality from residents and passengers at the same airport. It is also the first study to apply the SC methodology to the issue of aircraft externalities in Thailand. It was found that residents are willing to pay more than passengers to reduce aircraft noise by 1% (104.76 baht against 70.63 baht per year). On the other hand, passengers are willing to pay more than residents to reduce local air pollution by 1% (97.72 baht against 45.36 baht per year). These values are in line with the findings on perceptions and awareness of aviation impacts in the focus groups and stated choice survey. Additionally, the comparison designs made this study the first study that obtains local aviation impact values from air transport users specifically for aircraft noise and local pollution. Also, this study managed to obtain the first value of local aircraft pollution from airport residents as the existing studies focus on aircraft noise.

The rerouting exercise results was disappointing since the cost and rerouting coefficients were not statistically significant and this study is therefore unable to obtain WTP/WTA value for rerouting. However, this design was not a complete failure. It has discovered a new value of time for Bangkok through the travel time attribute and gain attribute in the rerouting design which is 47.43 baht per hour. The only available value of time of Bangkok was by (Gwilliam, 1997) which was based on old data from 1975.

3) To use the results to compare with other airports in terms of impacts and policy to address the aviation externalities.

This study of aviation impact has focused on a developing economy which is different from previous studies that tends to involve developed economies. Being a developing country, economic growth is the priority of the Thai Government and citizens. In many cases, the environmental condition is being compromised to make way for growth which translates into more income and business opportunities for Thai people, a large majority of whom are living in poverty and will willingly trade economic benefits with environmental consequences.

Suvarnabhumi airport itself has long been a strategic project to bring businesses and tourism into the country in hope for economic prosperity.

Being a green-field project developed in a rural area far from the populated area, Suvarnabhumi airport was expected to avoid strong opposition regarding environmental problems as faced by other airports, particularly in the developed economy such as Heathrow airport which is surrounded by residential areas. However, people see Suvarnabhumi airport as a potential socio-economic benefit and start to move into the area in hope to find job and business opportunities, relatively cheap housing with good transport infrastructures causing a rapid urbanisation and population growth around the airport.

What makes Suvarnabhumi different from other cases is that the environmental problem is exacerbated by a rapid growth in aviation industry owing to strong economy and tourism industry growth. The aviation growth rate at Suvarnabhumi (as shown in Chapter 2) has been much faster than airports in the developed countries (given that those economies are either stagnant or slowly growing) and it is projected to be so for the foreseeable future. This rapid growth bring about problems not only to the residents who have been living before airport opened and have to experience tremendous change to their livelihood but also those who moved in later to seek a better socio-economic benefit. Those who moved in later, while arguably had taken the airport problem such as noise, traffic and pollution into consideration when making a decision to move, could not foresee such a rapid growth which results in a worse environmental impact than what they were expecting to tolerate as a trade-off for a better opportunity.

In terms of environmental policy on aviation impact, the Thai government doesn't have a specific policy or regulation to address the aviation problems either at a local or global level. Thailand only has regulations restricting local noise and pollution emissions from road traffic and factories and it has no regulations covering global emissions. Furthermore, even though the legal thresholds for noise and pollution exist, there is a lack of up-to-date and reliable data and enforcement. As mentioned earlier, environmental issues, particularly the aviation problem, are not high on the government's agenda which is a contrast to European countries that have placed attention growing on aviation's environmental impacts. The proposed inclusion of aviation in EU-ETS was controversial but it shows that EU members put carbon emissions from aircraft in high priority, regardless of the controversy. Thailand is a member of ASEAN (Association of South East Asian Nations) which will become AEC (ASEAN Economic Community) and can learn the EU's lesson about how to collectively address aviation issues with other 9 AEC member states. Most of the AEC members, including Thailand, are rapidly developing economies with significant aviation growth. A collective

action, particularly targeted at global level emissions, may be better addressed as an AEC-wide policy. However, the first and foremost important priority is the need for reliable environmental data, particularly on aircraft noise for the recognition of the strain on the environment placed by economic development.

13.2 Airport Growth Context

One important issue throughout this study is the conflict between the aviation growth which brings about socio-economic benefits and aviation's impact on the environment. The benefits come in two levels. At a macro level, the growing aviation activities at Suvarnabhumi facilitate growth in tourism and other businesses in Thailand. The improved aviation infrastructure encourages the development of aviation business in Thailand which can easily take advantage of a more-liberalised aviation policy within the ASEAN community as discussed in Chapter 2. The geographical location of Bangkok has enabled it to develop into an increasingly important aviation hub not only within Southeast-Asia but also between Europe and Asia. In other words, Thailand can benefit from growing aviation activities at Suvarnabhumi as a result of increasing traffic, liberalised aviation policy and its location.

At a local level, this research found that residents recognised that the airport brings benefits to local areas in terms of improvement in transportation systems, infrastructures, urbanisation and job opportunities. However, there is also concern regarding the expansion of Suvarnabhumi. The airport has only been in operation since 2006 and it is already exceeding its design capacity by six million passengers a year. The growth is projected to continue given Thailand's popularity as a tourist destination and its growing economy. The airport is already scheduled to build one additional terminal and two more runways which will double the number of flights and accommodate 15 million more passengers each year. This is beneficial on a national level to the airline operators, tourism industry and Thai economy. Nonetheless, in a local level it is much less likely to be welcomed by the local residents owing to environmental impacts, particularly in terms of aircraft noise. The expansion of Suvarnabhumi airport, particularly the planned two new runways, will increase the number of residents and properties affected by aircraft noise creating more tension between the airport and local residents. This study had attempted to obtain valuation of potential airport expansion through rerouting exercise but it was unable to derive the WTP/WTA as the coefficient was not statistically significant. Be that as it may, the questionnaire survey found that a vast majority of residents (87.5%) believed that the noise level in their area will be

doubled or more than doubled if the flight numbers is doubled which suggests their concern about the aircraft noise as a result of airport expansion.

Further to the noise issue, the airport expansion is likely to put the transport infrastructure under more strain. The construction of Suvarnabhumi resulted in the construction of more roads, a motorway, and a direct rail link to city centre. It was found that these are already struggling to cope with the current level of traffic to and from the airport. The airport expansion plan only includes the terminal and new runway to accommodate more passengers and flights but it does not include any provision to improve transportation infrastructure to accommodate traffic to and from the airport. As a result, local residents will only likely to benefit from potential job opportunities but will be adversely affected by worsening traffic congestion, local pollution and noise. Impacts in Bangna (southern area) area will be worse than in Ladkrabang (northern) given that it will be exposed to more take-off noise as a result of expansion and it has not enjoyed the benefits of urbanisation and transportation improvement since the access to motorway, rail link and urban development are centred on Ladkrabang.

13.3 Policy Implications

As discussed in Chapter 3, the current mitigation measures at Suvarnabhumi appear to be inadequate as they were based on outdated growth assumptions. The key to effective policy is transparent and up-to-date monitoring data which will lead to a fair and effective development of measures to control the environmental impact at the airport. The airport is currently pursuing two mitigation approaches.

Firstly, the airport imposes operational mitigation measures on aircraft taking off and landing. These include a ban on thrust-reverser deployments from 2-6am, minimum flap setting on approach, trust reduction on departure from 1,500-3,000 feet along with a ban on Chapter 2 aircraft. However, these measures are still perceived to be ineffective by the airport residents. The airport should actively look for potential operational measures for Suvarnabhumi airport such as continuous descent approach to improve local air quality and reduce aircraft noise. Another possible operational measure is the study and implementation of a runway usage strategy to find the runway and flight path pattern that minimises noise and pollution at Suvarnabhumi Airport. For example, aircraft arriving on runway 19R over Ladkrabang area fly directly over a densely-populated area while on runway 19L the aircraft fly over the university and a business area. It may be possible to use runway 19L during the night time

when the university and businesses are closed and use runway 19R during the day time when people are at work away from their home.

Secondly, AOT (airport operator) uses a financial approach to compensate affected residents. As mentioned earlier, compensation by AOT is based on outdated noise contour map and assumptions. The AOT needs to be more transparent about their environmental impact data and update the data more regularly considering the latest noise contour map was based on a forecast before the airport opened. This will facilitate a fairer and more transparent compensation system. Currently, AOT compensates residents by means of a one off payment.

This study found that residents were not fully informed on how they should spend the money to best reduce the effects of aircraft noise in their homes. Furthermore, Thailand is in a tropical country with a year round temperature of around 30 degrees Celsius. The installation of double glazing and noise insulation often mean that residents need to use air conditioning units to keep them cool. Air conditioning is still considered a luxury item among some of the residents who cannot afford to pay electricity bills for air conditioning in the long run with a one off payment.

Annual compensation based on WTP/WTA values from this study can be used as a compensation guideline by the airport operator as it finds that residents are willing to accept compensation of 25,044 baht (£495.63) and 10,848 (£214.68) per household per annum for noise level and local emissions to be doubled from the current level. It also gives flexibility to the airport operator to review annual compensation rate by comparing the changes in noise level in the area with the payment rate since the value obtained in this study is per 1% change. However, it is imperative that the AOT should update their noise data regularly to make the payment fair and up to date.

As for the global emission problem, this study has shown that air passengers are willing to pay to offset carbon emissions from their flights. However this is acceptable only on a voluntary basis. Any compulsory measure such as the UK air passenger duty and EU-ETS is likely to be a controversial issue and met with strong opposition. Even though this study found that the WTP value is higher than the current offsetting price offered in the market, the value should be treated with caution if the government or airport operator wishes to use as a guideline for any potential carbon offsetting charge as this study found a strong mistrust among passengers and residents alike in terms of offsetting fee handling and transparency of the system. Also, it was found that although participants indicated that they are willing to pay to offset carbon but none actually did so for their flights.

This creates an opportunity for the aviation industry and the Government to promote the carbon offsetting scheme to the Thai flying public given that they are found to be willing to pay but the public are not aware that offsetting opportunity exists and some are not aware of the concept of carbon offsetting at all.

13.3 Recommendations for Future Research

It is recommended that further research of aviation externalities at Suvarnabhumi airport should include actual noise and pollution data. The lack of comprehensive noise and pollution data has prevented this study including them in the attribute design considerations and stated choice interaction analysis. The inclusion of noise and pollution data will enable researchers to examine different valuation of different noise/pollution levels.

The stated willingness to pay and actual payment of carbon offsetting needs to be fully explored. As this study found that the passengers are willing to pay 473.26 baht per flight. However, none of the passenger respondents offset their flight. Although, it could be argued that Thai Airways is the only Thai carrier to offer offsetting and it could only be done when booking online on Thai Airways' website only making it inaccessible to most of the flying public. Nonetheless, there may be other underlying factors to be assessed.

Rerouting exercise may have been problematic in this study but it does not necessarily mean that it is to be abandoned altogether. It was developed specifically based on the desire of the residents group. An improvement in rerouting attribute presentation along with attribute level may be designed to make it works in future research. Lastly, the versatility of stated choice method allows researcher to obtain valuation of aviation externalities on the context of different airport either in Thailand or other countries to assess and explore mitigation measure to address aviation externalities at a particular airport.

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APPENDIX A: PILOT STUDY TOPIC GUIDE AND IMPLEMENTATION PROCESS

Topic Guide for Residents

Opening Discussion: What are the advantages and disadvantages of living near an airport?

Prompt Questions:

- Which of these problems are the most serious?
- Does anyone suffer from physical problems or disease related that may be caused by aircraft noise?
- How has the situation changed since the airport opened?
- Have there been any improvements in commuting time to work?
- Have there been any improvements in employment prospects?
- How has your community developed since the airport opened?

These questions were used to get the discussion started by directly asking for problems and benefits of the airport activities. It was divided into two parts, the advantages and the disadvantages of living near an airport. Disadvantages include air pollution, noise, health concerns, annoyance, aircraft accident and other environmental problems that may be unique to Bangkok Airport. The discussion identified and ranked the severity of the problems. Furthermore, it discussed residents' experiences and perceptions of the effects.

The discussion on the benefits of the airport involved topics concerning quality of life and personal economic situation. This included transportation access, employment opportunities and property values and sought to identify which aspects are more important and how residents trade-off the benefits and environmental impact of the airport.

- What periods of the day do you think are the quietest and noisiest? Are they the same periods for weekends and weekdays?

Prompt Questions

- Which are more annoying or noisy? Landings or take offs?
- Are there any time periods that you wish were quieter?
- Are you annoyed by the frequencies of flights (i.e. the noise incidents) or the overall level of aircraft noise?

This question examined how residents perceive noise levels during different times of the day and days of the week. To identify the perceived lowest and noisiest period, they were asked

if they think there are differences between take-off and landing noise. The information will be used to inform the design of SC question card. The focus groups were also asked if there were any particular time periods that they wish were less noisy. Finally, the group members were asked:

- How do you feel about SC card that you've just answered? (See section 7.7. for SC card design)

Prompt Questions:

- Do you think the payment method is appropriate?
- Is the price range appropriate?
- Are you having any problems imagining the different scenarios displayed in the SC card?
- In your opinion, which of the cards most closely reflect reality? Or which one do you prefer?

The participants were given a number of test cards with three presentation formats including number of flights, noise experience during given times of day and experience of noise before the airport opened (see section 7.7 for details) to test and see which one was most easily understood by the respondents and obtain feedback on different presentation format. It also discussed the payment vehicle to see their attitude toward different payment vehicle and whether the given payment rate is reasonable or, if not, the level it should be set out.

Air Passengers

Passenger focus groups were also conducted to assess air travellers' awareness and attitudes of aviation's impact on the environment along with other environmental problems facing Thailand in general. Three focus groups, with eight participants in each, comprising people who travel for various purposes, distances, and class of service to give the diversity to the discussion as each type of passengers may see the aviation problems differently. Discussions lasted 1 hour and 30 minutes for each group. Details of the sampling and recruitment strategy are provided in section 6.8. The focus group started with:

- What are the environmental problems in your daily life and how do you mitigate them?

Prompt Questions:

- Their awareness and perception of the environment in Thailand.
- The environmental problems the respondents face and create in their daily life
- Which one is the most concern?
- Noise and air pollution problems
- Are you aware of any method to reduce these problems?
- Do you do anything yourself to reduce these problem?

The first question asked participants to identify environmental problems they face in their daily lives to assess their awareness and attitudes towards environmental problems in general. The participants were asked to rank the severity of the identified problems and also discuss the measures that they currently employ to mitigate the problems along with any measures that they are aware of but haven't implemented. This then led to the question:

- What are the environmental problems caused by aircraft and the airport?

Prompt Questions:

- Which one is the most serious?
- Have you ever experienced these problems yourself?

This question asked respondents about their awareness of environmental problems created by aircraft both locally and globally. It assessed attitudes relating to the severity of each problem and which one of them is of most and least concern among air travellers. The discussion proceeded to the area of mitigation to explore whether the participants are aware of any mitigation measures and how do they think about it in term of effectiveness and practicality (e.g. carbon offsetting, travel behaviour change, improvement in emissions). Respondents were explicitly asked:

- Has anyone ever heard of Carbon Offsetting and has any one has paid for it?

Prompt Questions:

- Has anyone ever seen that offered when making a flight reservation?
- Do you think it works?
- Has anyone ever paid for carbon offsetting?

This topic discussed how participants understand carbon offsetting works and gathered opinions of their concern about carbon offsetting programme. It then discussed their attitude towards co-benefits that may come with carbon offsetting (such as environmental

improvement projects and sustainable energy development projects). As with the airport residents, the air passenger groups were asked:

How do you feel about the SC exercise you've just completed? Are there any problems? (For SC card design, see section 7.7)

Contingent Questions:

- Do you think the payment method is appropriate?
- Is the price range too small or too large?
- Are you having problems imagining the different improvements and deteriorations in the scenarios proposed on the SC card?

The participants were given SC question cards for trial and feedback. They were asked to discuss the practicality of each attribute and attribute level. The suitability of different payment vehicles and the how they understand the function of airport departure tax and how might they respond differently if it were to be separated as a carbon offsetting fee was also discussed.

Pilot Study Implementation

Airport Resident Groups
The following process was used to recruit participants;

- Residential areas under the NEF 30 contour were identified from official sources.
- Primary contact was made via telephone (using the local telephone directory) to contact the village chiefs and residential committee within the NEF30 noise contour. They were asked whether they experience problems with aircraft noise. They were asked if there are any suitable locations to arrange the focus group (such as community activity hall or village chief meeting hall which is normally used for public meetings). They were told of the requirements such as the room setting and an environment and location that is easy for potential participants to access.
- Potential participants were contacted in the identified areas by cold calling. Approximately 60 potential participants were contacted. They were asked if they are free and willing to participate in a focus group study on 'airport and your livelihood'. Those who agreed to participate were given a screening questionnaire and were told they would be contacted if they met the quota.
- Participants who met the screening criteria were contacted by telephone to confirm the detail of the focus group meeting.

The socio-economic and demographic characteristics of the participants of the four focus groups are displayed in Tables 1 to 4 inclusive.

Table 1: Bangna 1 Participants

Age	Gender	Income	Working in the area	Lived in the area before 2006
45	F	Low	N	Y
54	F	Mid	N	N
50	F	High	Y	Y
54	M	High	Y	N
37	M	Low	Y	Y
31	M	Mid	Y	N
58	M	High	Y	Y
28	F	Low	Y	Y

The group consisted of 8 residents in Bangna (south of the airport). These residents are mostly exposed to take-off noise throughout the year except during winter when the direction of landings and take offs change due to changes in the prevailing wind direction. The focus group was conducted on 20th August 2011 at 1400hrs.

Table 2: Bangna 2 Participants

Age	Gender	Income	Working in the area	Lived in the area before 2006
55	M	Low	Y	Y
57	F	Low	N	Y
51	F	Low	N	Y
52	F	Low	N	Y
44	F	Low	N	N
45	M	Low	Y	Y
59	F	Low	Y	Y
42	M	Mid	Y	N

The group comprised residents from the Bangna area. Many members of this group were long-term residents for generations and some were engaged in the agricultural sector. The flight pattern is similar to Bangna 1 group. The focus group was conducted on 21th August 2011, 1000hrs.

Table 3: Ladkrabang 1 Participants

Age	Gender	Income	Working in the area	Lived in the area before 2006
55	M	High	N	Y
58	M	High	N	Y
47	F	Mid	N	Y
38	F	Low	N	Y
31	F	Low	Y	N
42	M	Mid	Y	Y
51	M	Mid	N	Y
32	F	Low	N	N

This group comprised residents from the Ladkrabang area (north of the airport) who are exposed to landing noise most of the time except during the winter (November, December, January) when this direction is used for take offs due to wind direction changes. This group lives under the flight path of runway 19R. The focus group was conducted on 27th August 2011, 1000hrs.

Table 4: Ladkrabang 2 Participants

Age	Gender	Income	Working in the area	Lived in the area before 2006
52	F	Low	Y	N
25	F	Low	Y	N
27	M	Low	Y	N
40	M	Low	Y	Y
34	M	Low	Y	Y
36	M	Mid	Y	Y
45	F	Mid	N	Y
42	M	Low	N	N

The group consisted of residents in the Ladkrabang area who live under the flight path of runway 19L. They have similar noise exposure and the flight patterns as the Ladkrabrang 1 group. The focus group was conducted on 28th August 2011, 1000hrs.

Air Passenger Groups

Recruitment Processes

The following steps were taken to recruit respondents to the air passenger focus groups:

- Identify potential participants by asking 12 acquaintances of different backgrounds and demography to briefly explain that I was interested in conducting a focus group studies to investigate the attitude and perceptions of aviation related problems and asked if they were able to provide assistance in recruiting potential participants.
- Each was asked to find around 5-6 potential participants from their workplaces or neighbours (the acquaintances themselves will not be part of the participants). They were given a copy of the screening questionnaire form to identify the participants and research information leaflet (using the format given by the Loughborough University's Ethics Committee). Two participants from each acquaintance that met the quota were recruited.
- Each participant was contacted and informed of the date and time of the meeting.

Focus Groups

Details of the socio-economic and demographic characteristics of the three focus groups are presented in Tables 5-8 inclusive. The results of the focus group discussions are presented in Chapter 7.

Table 5: Passenger 1 Participants (The session was conducted on 23th August 2011, 1200hrs)

Age	Gender	Income
56	F	Low
31	M	Mid
52	F	Mid
45	M	Mid
34	F	Mid
47	F	Low
41	F	Mid
56	M	High

Table 6: Passenger 2 Participants (The session was conducted on 27th August 2011, 1700hrs)

Age	Gender	Income
34	M	High
59	F	Mid
55	F	High
32	F	Mid
43	M	Mid
55	M	High
27	F	Mid
50	M	Mid

Table 7: Passenger 3 (The group consisted of younger participants. This session was conducted on 28th August 2011, 1600hrs)

Age	Gender	Income
23	M	Low
28	F	Mid
26	F	Mid
27	M	Low
24	F	Mid
28	M	Mid
25	F	Mid
27	F	Mid

APPENDIX B: REROUTING QUESTIONNAIRE

Suvarnabhumi Airport and Quality of Life Questionnaire

Thank you for participating in this survey. This survey is a part of a research project by Narudh Cheramakara, a PhD student from Loughborough University (United Kingdom) on aviation and the environment at Suvarnabhumi Airport which seeks to determine the perceived costs and benefits of the airport.

This questionnaire should take about 30 minutes to complete, should you have any questions, please contact a member of the survey staff by calling 083-855-6000 from 8am to midnight daily.

SECTION 1:

1. Your Address:

_____
_____
_____

2. Type of Residence:

Apartment / Detached House / Townhouse / Other:_____

3. Residence ownership: Leased / Owned

4. How long have you lived at this address? _____ years

(If you have always lived at the current address please go to question 7)

5. Where did you live before moving to this address?

District:_____ Province:_____

6. Have you considered moving from this address? Yes/No

If yes, why? _____

7. In your opinion, to what extent do you think Thailand suffers from the following environmental problems? (please circle one number on each line)

	Not a problem	**Slight Problem**	**Moderate Problem**	**Severe Problem**	**Extremely Severe Problem**
Deforestation	1	2	3	4	5
Air pollution from road traffic	1	2	3	4	5
Climate change	1	2	3	4	5
Household waste management	1	2	3	4	5
Road traffic noise	1	2	3	4	5
Water pollution	1	2	3	4	5
Aircraft noise	1	2	3	4	5
Air Pollution from factories	1	2	3	4	5
Flooding	1	2	3	4	5
Other (please specify) **:** _____	1	2	3	4	5

8. Do you do anything in your daily life to reduce your environmental impact? (tick all that apply)

Recycling	
Reuse shopping bags	
Using bio-degradable packaging	
Using public transport	
Lift-sharing	
Switching off electrical appliances when they are not in use	
Installing a solar-powered boiler	
Using a hybrid vehicle	
Participating in re-forestation project	
Others (please specify): _____ _____	

9. Thinking about the past 12 months, to what extent have you been affected by aircraft operations at Suvarnabhumi Airport?

(please circle one number on each line)

	Level of Severity				
	Not at all	**Slight**	**Moderate**	**Very**	**Extremely**
Aircraft noise	1	2	3	4	5
Local air pollution	1	2	3	4	5
Global level emissions (carbon emissions)	1	2	3	4	5
Waste from aircraft and airport	1	2	3	4	5
Traffic congestion around the airport	1	2	3	4	5
Fear of aircraft accident	1	2	3	4	5
Others: (please specify) _____	1	2	3	4	5

10. Think about the Suvarnabhumi Airport and its benefits to you and your local area, please rate how much have you benefited from the airport. (please circle one number on each line)

	Not at all	**Slightly**	**Moderately**	**Very**	**Extremely**
Easy access to the airport	1	2	3	4	5
Improved transportation	1	2	3	4	5
Job/business opportunity	1	2	3	4	5
Improved facilities in the neighbourhood	1	2	3	4	5
Others: (please specify) _____	1	2	3	4	5

11. Thinking about the last 12 months, when you are at home, how much are you annoyed from these noise? (please circle one number on each line)

	Not at all annoyed	**Slightly annoyed**	**Moderately annoyed**	**Very annoyed**	**Extremely annoyed**
Aircraft	1	2	3	4	5
Road traffic	1	2	3	4	5
Trains	1	2	3	4	5
Animals (e.g. dogs/chickens)	1	2	3	4	5
Construction sites	1	2	3	4	5
Neighbour arguments/music	1	2	3	4	5
Emergency vehicle siren	1	2	3	4	5
Others: (please specify) _____	1	2	3	4	5

12. Overall, how noisy do you think your local area is?

	Not at all noisy	**Slightly noisy**	**Moderately noisy**	**Very noisy**	**Extremely noisy**
Overall noise level in your area	1	2	3	4	5

13 Please state the time periods that you are usually at home.

Weekdays:_____

Weekend: _____

14. Think about aircraft noise level at your home in the past 12 months, please rate how annoying is the aircraft noise in each period. (please circle one number on each line)

WEEKDAYS	**Not at all annoyed**	**Slightly annoyed**	**Moderately annoyed**	**Highly annoyed**	**Extremely annoyed**
6am-noon	1	2	3	4	5
Noon-4pm	1	2	3	4	5
4pm-7pm	1	2	3	4	5
7pm-10pm	1	2	3	4	5
10pm-1am	1	2	3	4	5
1am-6am	1	2	3	4	5

WEEKEND	**Not at all annoyed**	**Slightly annoyed**	**Moderately annoyed**	**Highly annoyed**	**Extremely annoyed**
6am-noon	1	2	3	4	5
Noon-4pm	1	2	3	4	5
4pm-7pm	1	2	3	4	5
7pm-10pm	1	2	3	4	5
10pm-1am	1	2	3	4	5
1am-6am	1	2	3	4	5

15. In the past 12 months, think about the impact caused by aircraft noise, please rate how much you are affected by aircraft noise (please circle one number on each line)

	Level of Severity				
	Not a problem	**Slight problem**	**Moderate problem**	**Serious problem**	**Extremely serious problem**
Working concentration	1	2	3	4	5
Vibration to furniture	1	2	3	4	5
Television reception	1	2	3	4	5
Telephone reception	1	2	3	4	5
Conversation	1	2	3	4	5
Sleeping	1	2	3	4	5
Family activities	1	2	3	4	5
Other: (please specify) _____	1	2	3	4	5

SECTION 2:

This section requires information on travelling behaviour.

If you are EMPLOYED, please complete questions 16-19,

If you are NOT EMPLOYED, please proceed to complete questions 20-23 on page 9

Travelling to work

16. Address of your work place? District:_____ Province:_____

17. How long does it takes to travel to your work place?

_____ hours _____minutes

18. How often do you travel to work? _____times/week

19. How do you travel to work? (please tick all that apply)

Walking	
Cycling	
Motorbike	
Private car	
Minivan	
Bus	
Trains	
Airport Link trains	
Other (please specify**:**_____	

After completing question 19, please proceed to instruction on page 10.

Travelling to shopping

If you do not work, please complete questions 19-22

Think about the main place that you usually go for shopping for example, fresh market, shopping mall, or supermarket and please provide the detail about your travel to your shopping place.

20. Where do you normally go for shopping?

Shopping place name:_____

District:_____

21. How long does it takes to travel to the shops.

_____ hours _____minutes

22. How often do you travel the shops? _____times/week

23. How do you travel to the shops? (please tick all that apply)

Walking	
Cycling	
Motorbike	
Private car	
Minivan	
Bus	
Trains	
Airport Link trains	
Other (please specify **:**_____	

Suvarnabhumi Airport Scenario Exercise

We are going to ask you to look at some hypothetical scenarios for Suvarnabhumi Airport. There are 8 cards of scenarios with three options in each card (A, B and C) and you are asked to choose the option you desire the most.

Each card contains 3 attributes;

1) Aircraft flying over your residence, you are asked to consider the cases of taking off and landing aircraft being **rerouted** elsewhere (thereby releasing you from aircraft noise) or the case of **same flight path** (taking off and landing route remain the same) and Suvarnabhumi Airport being **expanded** to handle more flights.

2) Travel time

- **If you are employed**, please consider the given travel time to your WORKPLACE.

- **If you are NOT working,** please consider travel time to THE SHOPS

3) Airport Impact Relief Scheme

In this scheme, you can choose to pay to reroute aircraft elsewhere (removing noise) and/or shorten your travel time. Alternatively, you can accept compensation for more aircraft flying over residence and/or an increase in your travel time. The given rate is **per household per month**

As you are about to complete the question cards, please consider the following issue, firstly, please think about your household's monthly income and determine the price that your household can afford to pay to reduce the aircraft noise and travel time. Secondly, previous studies show that the amount that people say that they are willing to pay are sometimes different from the actual amount that they will be willing to pay when changes are actually made, please imagine that your household is actually paying them

Example:

Consider the card below. It contains three options (A, B, C). You are asked to choose (by circling) the option that is **most preferable** to you.

For example, if you prefer that all aircraft are rerouted and your travel time is halved and you have to pay 1,500 bath/month per household, you would **CIRCLE option A**.

Attribute	OPTION A	OPTION B	OPTION C
Aircraft flying over your residence	**All aircraft rerouted elsewhere** (you will not hear aircraft noise)	**Half of the flights re-routed elsewhere** (you will not hear rerouted aircraft noise)	As now (200 flight/day)
Travel time to work/ the shops	Travel time **reduced** by half	Travel time **doubled**	As now
Airport Impact Relief Scheme	You would **pay** 1,500 baht/month	You would **receive** 1,100 baht/month compensation	No payment/ compensation
I would choose	**A**	**B**	**C**

Please complete cards 1 to 8 on the following pages

CARD 1

Attribute	OPTION A	OPTION B	OPTION C
Aircraft flying over your residence	Same flight path with **airport expanded for a half more flights** (300 flights/day)	As now (200 flights/day)	As now (200 flight/day)
Travel time to work/ the shops	Travel time **doubled**	Travel time **reduced** by half	As now
Airport Impact Relief Scheme	You would **receive** 700 baht/month compensation	You would **pay** 700 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 2

Attribute	OPTION A	OPTION B	OPTION C
Aircraft flying over your residence	As now (200 flights/day)	**Half of the flights re-routed elsewhere** (100 flights/day)	As now (200 flight/day)
Travel time to work/ the shops	Travel time **reduced** by half	Travel time **reduced by** a quarter	As now
Airport Impact Relief Scheme	You would **pay** 700 baht/month	You would **pay** 1,100 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 3

Attribute	OPTION A	OPTION B	OPTION C
Aircraft flying over your residence	**Half of the flights re-routed elsewhere** (100flight/days)	Same flight path with **airport expanded with double number of flights** (400 flights/day)	As now (200 flight/day)
Travel time to work/ the shops	Travel time **reduced by** a quarter	Travel time **reduced** by half	As now
Airport Impact Relief Scheme	You would **pay** 1,100 baht/month	You would **pay** 1,500 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 4

Attribute	OPTION A	OPTION B	OPTION C
Aircraft flying over your residence	Same flight path with **airport expanded with double number of flights**(400 flights/day)	**Half of the flights re-routed elsewhere** (100 flights/day)	As now (200 flight/day)
Travel time to work/ the shops	Travel time **reduced** by half	As now	As now
Airport Impact Relief Scheme	You would **pay** 1,500 baht/month	You would **pay** 1,100 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 5

Attribute	OPTION A	OPTION B	OPTION C
Aircraft flying over your residence	**Half of the flights re-routed elsewhere** (100 flights/day	Same flight path with **airport expanded for a half more flights** (300 flights/day)	As now (200 flight/day)
Travel time to work/ the shops	As now	Travel time **reduced** by a quarter	As now
Airport Impact Relief Scheme	You would **pay** 1,100 baht/month	You would **receive** 1,100 baht/month compensation	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 6

Attribute	OPTION A	OPTION B	OPTION C
Aircraft flying over your residence	Same flight path with **airport expanded for a half more flights** (300 flights/day)	**Half of the flights re-routed elsewhere** (100 flights/day)	As now (200 flight/day)
Travel time to work/ the shops	Travel time **reduced** by a quarter	Travel time **increased** by a half	As now
Airport Impact Relief Scheme	You would **receive** 1,100 baht/month compensation	You would **receive** 700 baht/month compensation	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 7

Attribute	OPTION A	OPTION B	OPTION C
Aircraft flying over your residence	**Half of the flights re-routed elsewhere** (100 flights/day)	Same flight path with **airport expanded for a half more flights** (300 flights/day)	As now (200 flight/day)
Travel time to work/ the shops	Travel time **increased** by a half	As now	As now
Airport Impact Relief Scheme	You would **receive** 700 baht/month compensation	You would **receive** 1,500 baht/month compensation	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 8

Attribute	OPTION A	OPTION B	OPTION C
Aircraft flying over your residence	Same flight path with **airport expanded for a half more flights** (300 flights/day)	Same flight path with **airport expanded for a half more flights** (300 flights/day)	As now (200 flight/day)
Travel time to work/ the shops	As now	Travel time **doubled**	As now
Airport Impact Relief Scheme	You would **receive** 1,500 baht/month compensation	You would **receive** 700 baht/month compensation	No payment/ compensation
I would choose	**A**	**B**	**C**

SECTION 3:

24. If the number of flights is doubled what do you think that the overall aircraft noise level in your residence will be? (please tick)

More than doubled	
Doubled	
Increased by half	
Increased by a quarter	
Other changes (please specify) : _____ _____	

25. Did you ignore any attributes offered in the scenario cards? (tick all that apply)

Aircraft flying over your residence	
Travel time	
Airport impact relief scheme	
I did not ignore any attributes	

26. Did you focus on any particular attributes in the scenario cards? (tick all that apply)

Aircraft flying over your residence	
Travel time	
Airport impact relief scheme	
I did not focus on any particular attributes	

27. Thinking about this exercise, please rate how much you agree or disagree with the following statements.

Statement	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am willing to pay to improve the environmental condition in my area	1	2	3	4	5
It is my not responsibility to pay to improve the environmental condition	1	2	3	4	5
I don't think that any airport relief scheme works (unrealistic)	1	2	3	4	5
I am willing to pay to shorten my travel time to work/the shops	1	2	3	4	5
The price of airport environmental relief scheme is too high	1	2	3	4	5
I am willing to pay to improve the environment in Thailand	1	2	3	4	5
I don't trust the people who handle the money	1	2	3	4	5

28. Has your property been damaged by Aircraft vibration? Yes/No

If so, what damage was caused:

_____

29. Have you ever complained about aircraft noise? Yes/No

If yes, who did you complain to?

District Office/ AOT (The airport owner)/ Village Chief/ Others:_____

30. Have you been compensated by the AOT? Yes/No

If yes, how much?: _____baht

What did you do with the compensation fund?

_____

31. Have you done anything to reduce the aircraft noise experienced in your household? Yes/No

If yes, what did you do? _____

32. On average, how many round trips per year do you take from Suvarnabhumi Airport? _____ trips per year

33. Gender: Male/Female

34. Date of Birth: _____/_____/_____

35. Highest level of education attained (please circle):

Primary School / High school Diploma / Vocational Diploma / Bachelor Degree/ Master Degree / PhD Other:_____

36. Occupation: _____

37. Household Monthly Income: _____baht (before tax)

38. How many people live in your household (Including yourself)?_____ How many of these are under 18 years old_____

39. Do you work at the airport?: Yes/No

40. Does anyone else in your household work at the airport?: Yes/No

41. Do you have any further comments

_____
_____
_____
_____

APPENDIX C: RESIDENT PERCENTAGE CHANGE QUESTIONNAIRE

Suvarnabhumi Airport and Quality of Life Questionnaire

Thank you for participating in this survey. This survey is a part of a research project by Narudh Cheramakara, a PhD student from Loughborough University (United Kingdom) on aviation and the environment at Suvarnabhumi Airport which seeks to determine the perceived costs and benefits of the airport.

This questionnaire should take about 30 minutes to complete, should you have any questions, please contact a member of the survey staff by calling 083-855-6000 from 8am to midnight daily.

SECTION 1:

1. Your Address:

_____
_____
_____

2. Type of Residence:

Apartment / Detached House / Townhouse / Other:_____

3. Residence ownership: Leased / Owned

4. How long have you lived at this address? _____ years

(If you have always lived at the current address please go to question 7)

5. Where did you live before moving to this address?

District:_____ Province:_____

6. Have you considered moving from this address? Yes/No

If yes, why? _____

7. In your opinion, to what extent do you think Thailand suffers from the following environmental problems? (please circle one number on each line)

	Not a problem	**Slight Problem**	**Moderate Problem**	**Severe Problem**	**Extremely Severe Problem**
Deforestation	1	2	3	4	5
Air pollution from road traffic	1	2	3	4	5
Air pollution from factories	1	2	3	4	5
Household waste management	1	2	3	4	5
Water pollution	1	2	3	4	5
Road traffic noise	1	2	3	4	5
Aircraft noise	1	2	3	4	5
Climate change	1	2	3	4	5
Flooding	1	2	3	4	5
Other (please specify**:** _____	1	2	3	4	5

8. Do you do anything in your daily life to reduce your environmental impact? (tick all that apply)

Recycling	
Reuse shopping bags	
Using bio-degradable packaging	
Using public transport	
Lift-sharing	
Switching off electrical appliances when they are not in use	
Installing a solar-powered boiler	
Using a hybrid vehicle	
Participating in re-forestation project	
Other (please specify**:** _____	

9. Thinking about the past 12 months, to what extent have you been affected by aircraft operations at Suvarnabhumi Airport?

(please circle one number on each line)

	Level of Severity				
	Not at all	**Slight**	**Moderate**	**Very**	**extremely**
Aircraft noise	1	2	3	4	5
Local air pollution	1	2	3	4	5
Global level emissions (carbon emissions)	1	2	3	4	5
Waste from aircraft and airport	1	2	3	4	5
Traffic congestion around the airport	1	2	3	4	5
Fear of aircraft accident	1	2	3	4	5
Others: (please specify) _____	1	2	3	4	5

10. Think about the Suvarnabhumi Airport and its benefits to you and your local area, please rate how much have you benefited from the airport. (please circle one number on each line)

	Not at all	**Slightly**	**Moderately**	**Very**	**Extremely**
Easy access to the airport	1	2	3	4	5
Improved transportation	1	2	3	4	5
Job/business opportunity	1	2	3	4	5
Improved facilities in the neighbourhood	1	2	3	4	5
Others: (please specify) _____	1	2	3	4	5

11. Thinking about the last 12 months, when you are at home, how much are you annoyed from these noises? (please circle one number on each line)

	Not at all annoyed	Slightly annoyed	Moderately annoyed	Very annoyed	Extremely annoyed
Aircraft	1	2	3	4	5
Road traffic	1	2	3	4	5
Trains	1	2	3	4	5
Animals (e.g. dogs/chickens)	1	2	3	4	5
Construction sites	1	2	3	4	5
Neighbour arguments/music	1	2	3	4	5
Emergency vehicle siren	1	2	3	4	5
Others: (please specify) _____	1	2	3	4	5

12. Overall, how noisy do you think your local area is?

	Not at all noisy	Slightly noisy	Moderately noisy	Very noisy	Extremely noisy
Overall noise level in your area	1	2	3	4	5

13 Please state the time periods that you are usually at home.

Weekdays:_____

Weekend: _____

14. Think about aircraft noise level at your home in the past 12 months, please rate how annoying is the aircraft noise in each period. (please circle one number on each line)

WEEKDAYS	Not at all annoyed	Slightly annoyed	Moderately annoyed	Highly annoyed	Extremely annoyed
6am-noon	1	2	3	4	5
Noon-4pm	1	2	3	4	5
4pm-7pm	1	2	3	4	5
7pm-10pm	1	2	3	4	5
10pm-1am	1	2	3	4	5
1am-6am	1	2	3	4	5

WEEKEND	Not at all annoyed	Slightly annoyed	Moderately annoyed	Highly Annoyed	Extremely annoyed
6am-noon	1	2	3	4	5
Noon-4pm	1	2	3	4	5
4pm-7pm	1	2	3	4	5
7pm-10pm	1	2	3	4	5
10pm-1am	1	2	3	4	5
1am-6am	1	2	3	4	5

15. In the past 12 months, think about the impact caused by aircraft noise, please rate how much you are affected by aircraft noise (please circle one number on each line)

	Level of Severity				
	Not a problem	**Slight problem**	**Moderate problem**	**Serious problem**	**Extremely serious problem**
Working concentration	1	2	3	4	5
Vibration to furniture	1	2	3	4	5
Television reception	1	2	3	4	5
Telephone reception	1	2	3	4	5
Conversation	1	2	3	4	5
Sleeping	1	2	3	4	5
Family activities	1	2	3	4	5
Other: (please specify) _____	1	2	3	4	5

SECTION 2

Suvarnabhumi Airport Scenario Exercise

We are going to ask you to look at some hypothetical scenarios for Suvarnabhumi Airport and your home. You are given with 8 cards each 3 options (A, B and C), you are asked to choose the option you desire the most.

Each card contains 4 types of attributes;

1) Aircraft Noise, which is presented in the form of a percentage change (either quieter or noisier)

2) Local air pollution from aircraft, this represents emissions from aircraft that fly over your house

3) Carbon Offsetting, this represents CO_2 emissions from aircraft into the atmosphere which attributes to the global warming problems. You can either consider the case of YES (carbon emissions from aircraft are offset) or NO (carbon emissions from aircraft are not offset).

What is carbon offsetting?

Aircraft emits CO_2 into the atmosphere which contributes to climate change The CO_2 emissions from the aircraft can be compensated or offset by paying to offset the emission, the money will be used on projects that compensate the CO_2 emitted by the aircraft (i.e. making the flight carbon neutral); for example, tree-planting projects or renewable energy scheme.

4) Airport Impact Relief Scheme, this is a scheme in which you can choose to pay to reduce different impacts from Suvarnabhumi airport and aircraft or you can choose to accept compensation for worsening environmental situation at your residence relating to Suvarnabhumi's activities. The given rate is **per household per month**

As you are about to complete the question cards, please consider the following issues. firstly, please think about your household's monthly income and determine the price that your household can afford to pay to reduce the impact from aircraft on your household. Secondly, previous studies show that the amount that people say that they are willing to pay are sometimes different from the actual amount that they will be willing to pay when changes are actually made, please imagine that your household is actually paying them

Example:

Consider the given card, containing three options (A, B, C). You are asked to choose (by circling) the option that is **most preferable** to you.

For example, if you preferred that aircraft noise are 25% quieter while also emitting 25% less pollutants and carbon emissions from the aircraft is offset while you are asked to pay 1,500 bath/month per household for these situation to happen, you would **CIRCLE option A**.

Attribute	**OPTION A**	**OPTION B**	**OPTION C**
Aircraft are	25% quieter	25% louder	As now
Aircraft engines produce	25% less air pollution	50% less air pollution	As now
Carbon offsetting	Yes	No	No
Airport Impact Relief Scheme	You would **pay** 1,500 baht/month	You would **receive** 1,500 baht/month compensation	No payment/ compensation
I would choose	**A**	**B**	**C**

Please complete cards 1 to 8 on the following pages

CARD 1

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	25% louder	50% quieter	As now
Aircraft engines produce	25% less air pollution	25% more air pollution	As now
Carbon offsetting	Yes	Yes	No
Airport Impact Relief Scheme	You would **pay** 1,500 baht/month	You would **pay** 1,100 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 2

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	50% quieter	50% quieter	As now
Aircraft engines produce	25% more air pollution	50% less air pollution	As now
Carbon offsetting	Yes	No	No
Airport Impact Relief Scheme	You would **pay** 1,100 baht/month	You would **pay** 300 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 3

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	50% quieter	25% louder	As now
Aircraft engines produce	50% less air pollution	25% less air pollution	As now
Carbon offsetting	No	No	No
Airport Impact Relief Scheme	You would **pay** 300 baht/month	You would **receive** 1,100 baht/month compensation	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 4

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	25% louder	As now	As now
Aircraft engines produce	25% less air pollution	25% more air pollution	As now
Carbon offsetting	No	Yes	No
Airport Impact Relief Scheme	You would **receive** 1,100 baht/month compensation	You would **receive** 1,100 baht/month compensation	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 5

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	As now	25% quieter	As now
Aircraft engines produce	25% more air pollution	As now	As now
Carbon offsetting	Yes	No	No
Airport Impact Relief Scheme	You would **receive** 1,100 baht/month compensation	You would **pay** 700 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 6

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	25% quieter	50% quieter	As now
Aircraft engines produce	As now	As now	As now
Carbon offsetting	No	Yes	No
Airport Impact Relief Scheme	You would **pay** 700 baht/month	You would **pay** 1,500 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 7

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	50% quieter	25% quieter	As now
Aircraft engines produce	As now	As now	As now
Carbon offsetting	Yes	Yes	No
Airport Impact Relief Scheme	You would **pay** 1,500 baht/month	You would **pay** 300 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

CARD 8

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	25% quieter	25% louder	As now
Aircraft engines produce	As now	25% less air pollution	As now
Carbon offsetting	Yes	Yes	No
Airport Impact Relief Scheme	You would **pay** 300 baht/month	You would **pay** 1,500 baht/month	No payment/ compensation
I would choose	**A**	**B**	**C**

SECTION 3:

16. Did you ignore any attributes offered in the scenario cards? (tick all that apply)

Aircraft noise	
Air pollutants from aircraft engines	
Carbon offsetting	
Aviation Impact relief scheme	
I did not ignore any attributes	

17. Did you focus on any particular attributes in the scenario cards? (tick all that apply)

Aircraft noise	
Air pollutants from aircraft engines	
Carbon offsetting	
Aviation Impact relief scheme	
I did not focus on any particular attributes	

28. Thinking about this exercise, please rate how much you agree or disagree with the following statements?

Statement	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am willing to pay to improve the environmental condition in my area	1	2	3	4	5
I am willing to pay to improve the environment in Thailand	1	2	3	4	5
It is my not responsibility to pay to improve the environmental condition	1	2	3	4	5
The price of airport environmental relief scheme is too high	1	2	3	4	5
I don’t think that any airport relief scheme works (unrealistic)	1	2	3	4	5
I don’t trust the people who handle the money	1	2	3	4	5

19. Has your property been damaged by Aircraft vibration? Yes/No

If so, what damage was caused:

_____

20. Have you ever complained about aircraft noise? Yes/No

If yes, who did you complain to?

District Office/ AOT (The airport owner)/ Village Chief/ Others:_____

21. Have you been compensated by the AOT? Yes/No

If yes, how much?: _____baht

How did you use the money?

_____

22. Have you done anything to reduce the aircraft noise experienced in your household? Yes/No

If yes, what did you do? _____

23. On average, how many round trips per year do you take from Suvarnabhumi Airport? _____ trips per year

24. Gender: Male/Female

25. Date of Birth: _____/_____/_____

26. Highest level of education attained (please circle):

Primary School / High school Diploma / Vocational Diploma / Bachelor Degree/ Master Degree / PhD Other:_____

27. Occupation: _____

28. Household Monthly Income: _____baht (before tax)

29. How many people live in your household (Including yourself)?_____ How many are under 18 years old_____

30. Do you work at the airport?: Yes/No

31. Does anyone else in your household work at the airport?: Yes/No

32. Do you have any further comments

_____

APPENDIX D: PASSENGER QUESTIONNAIRE

Air Passenger Environmental Attitudes and Valuation Questionnaire

Thank you for participating in this survey. This survey is a research project by Loughborough University in the UK which is examining aviation externalities at Suvarnabhumi Airport in terms of attitudes, perceptions along with valuation of benefits and costs of the airport.

A member of survey team will guide you through the process of completing this questionnaire. If you have any question, please ask your interviewer.

Section 1: Today's Flight

1. Where are you flying to today?

_____

2. Which airline are you flying with?

_____

3. How much does the ticket cost?

_____Baht (one-way/return)

4. Purpose of this trip?

Business/ Leisure/Visiting Friends/Relative

5. Which class are you travelling?

First/Business/Premium Economy/Economy

6. Who paid for this trip?

Self-paid/Employer/Family Member/ Other:_____

7. Have you ever heard the term 'Carbon Offsetting'? Yes/No

If yes, what do you understand the term carbon offsetting to mean?

_____

8. Were you offered carbon offsetting when booking the ticket? Yes/No

If yes, did you pay for carbon offsetting? Yes/No

How much did it cost? _____baht

Section 2: Aviation and Environmental Attitudes

9. In your opinion, to what extent do you think Thailand suffers from the following environmental problems? (please circle one number on each line)

	Not a problem	**Slight Problem**	**Moderate Problem**	**Severe Problem**	**Extremely Severe Problem**
Deforestation	1	2	3	4	5
Air pollution from road traffic	1	2	3	4	5
Air pollution from factories	1	2	3	4	5
Household waste management	1	2	3	4	5
Water pollution	1	2	3	4	5
Road traffic noise	1	2	3	4	5
Aircraft noise	1	2	3	4	5
Climate change	1	2	3	4	5
Flooding	1	2	3	4	5
Other (please specify **:** _____	1	2	3	4	5

10. Do you do anything in your daily life to reduce your environmental impact? (tick all that apply)

Recycling	
Reuse shopping bags	
Using bio-degradable packaging	
Using public transport	
Lift-sharing	
Switching off electrical appliances when they are not in use	
Installing a solar-powered boiler	
Using a hybrid vehicle	
Participating in re-forestation project	
Other (please specify**:** _____	

11. Think about your flight and its impacts on the environment, to what extent do you think your flight have caused on the following problems?

(please circle one number on each line)

	Level of Severity				
	Not at all	**Slightly**	**Moderately**	**Very**	**Extremely**
Aircraft noise	1	2	3	4	5
Local air pollution	1	2	3	4	5
Global level emissions (carbon emissions)	1	2	3	4	5
Waste from aircraft and airport	1	2	3	4	5
Traffic congestion around the airport	1	2	3	4	5
Airport resident's fear of aircraft accident	1	2	3	4	5
Others: (please specify) _____	1	2	3	4	5

Section 3:

We are going to ask you to look at the hypothetical scenarios about your flights to and from Suvarnabhumi Airport. You are given with 8 cards. There are 3 options in each card (A, B and C), you are asked to choose the option you desire the most.

Each card contains 4 types of attributes;

1) Aircraft Noise, which is presented in the form of a percentage change (either quieter or noisier)

2) Local air pollution from aircraft

3) Carbon Offsetting, this represents CO_2 emissions from aircraft into the atmosphere which attributes to the global warming problems. You can either consider the case of YES (carbon emissions from aircraft are offset) or NO (carbon emissions from aircraft are not offset).

What is carbon offsetting?

Aircraft emits CO_2 into the atmosphere which contributes to climate change The CO_2 emissions from the aircraft can be compensated or offset by paying to offset the emission, the money will be used on projects that compensate the CO_2 emitted by the aircraft (i.e. making the flight carbon neutral); for example, tree-planting projects or renewable energy scheme.

4) Air fare, the given rate is **per flight per passenger**

As you are about to complete the question cards, please consider following issues, firstly, please think about your travel budget and determine the price that you can afford to pay to reduce the environmental impact from your flight. Secondly, previous studies show that the amount that people say that they are willing to pay are sometimes different from the actual amount that they will be willing to pay when changes are actually made. Please imagine that you are actually paying them when you fly.

Example:

Consider the given card, containing three options (A, B, C). You are asked to choose (by circling) the option that is **most preferable** to you.

For example, if you preferred that aircraft noise are 25% louder while emitting 25% less pollutants and carbon emissions from the aircraft is offset while you are asked to pay 1,500 bath more per flight for these situation to happen, you would **CIRCLE option A**.

Attribute	**OPTION A**	**OPTION B**	**OPTION C**
Aircraft are	25% quieter	25% louder	As now
Aircraft engines produce	25% less air pollution	50% less air pollution	As now
Carbon offsetting	Yes	No	No
Air fare	**increased by** 1,500 baht/flight	**Reduced** by 1,500 baht/flight	No change
I would choose	**A**	**B**	**C**

Please complete cards 1 to 8 on the following pages

CARD 1

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	25% louder	50% quieter	As now
Aircraft engines produce	25% less air pollution	25% more air pollution	As now
Carbon offsetting	Yes	Yes	No
Air fare	**Increased** by 1,500 baht/flight	**increased** by 1,100 baht/flight	No change
I would choose	**A**	**B**	**C**

CARD 2

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	50% quieter	50% quieter	As now
Aircraft engines produce	25% more air pollution	50% less air pollution	As now
Carbon offsetting	Yes	No	No
Air fare	**increased** by 1,100 baht/flight	**Increased** by 300 baht/flight	No change
I would choose	**A**	**B**	**C**

CARD 3

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	50% quieter	25% louder	As now
Aircraft engines produce	50% less air pollution	25% less air pollution	As now
Carbon offsetting	No	No	No
Air fare	**Increased** by 300 baht/flight	**Reduced** by 1,100 baht/flight	No change
I would choose	**A**	**B**	**C**

CARD 4

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	25% louder	As now	As now
Aircraft engines produce	25% less air pollution	25% more air pollution	As now
Carbon offsetting	No	Yes	No
Air fare	**Reduced** by 1,100 baht/flight	**Reduced** by 1,100 baht/flight	No change
I would choose	**A**	**B**	**C**

CARD 5

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	As now	25% quieter	As now
Aircraft engines produce	25% more air pollution	As now	As now
Carbon offsetting	Yes	No	No
Air fare	**Reduced** by1,100 baht/flight	**Increased** by 700 baht/flight	No change
I would choose	**A**	**B**	**C**

CARD 6

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	25% quieter	50% quieter	As now
Aircraft engines produce	As now	As now	As now
Carbon offsetting	No	Yes	No
Air fare	**Increased** by 700 baht/flight	**Increased** by 1,500 baht/flight	No change
I would choose	**A**	**B**	**C**

CARD 7

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	50% quieter	25% quieter	As now
Aircraft engines produce	As now	As now	As now
Carbon offsetting	Yes	Yes	No
Air fare	**Increased** by 1,500 baht/flight	**Increased** by 300 baht/flight	No change
I would choose	**A**	**B**	**C**

CARD 8

Attribute	OPTION A	OPTION B	OPTION C
Aircraft are	25% quieter	25% louder	As now
Aircraft engines produce	As now	25% less air pollution	As now
Carbon offsetting	Yes	Yes	No
Air fare	**Increased** by 300 baht/flight	**Increased** by 1,500 baht/flight	No Change
I would choose	**A**	**B**	**C**

Section 4: Debriefing

12. Thinking back to your scenario card exercise, please rate how much you agree or disagree with the following statements?

Statement	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am willing to pay to improve the environmental condition	1	2	3	4	5
I am willing to pay to improve the environment in Thailand	1	2	3	4	5
It is my not responsibility to pay to improve the environmental condition	1	2	3	4	5
The airfare increase for environmental reduction is too high	1	2	3	4	5
I don't think that the aircraft environmental reduction scheme works (unrealistic)	1	2	3	4	5
I don't trust the people who handle the money	1	2	3	4	5

13. Did you ignore any attribute when completing the exercise? (tick all that apply)

Aircraft noise	
Air pollutants from aircraft engines	
Carbon offsetting	
Air fare	
I did not ignore any attributes	

14. Did you focus on any particular attribute when completing the exercise?

Aircraft noise	
Air pollutants from aircraft engines	
Carbon offsetting	
Air fare	
I did not focus on any particular attributes	

Section 5: Background

15. Home Address: District_____
Province:_____

16. Gender: Male/Female

17. Date of Birth: _____/_____/_____

18. Education (please circle):

Primary School / High school Diploma / Vocational Diploma / Bachelor Degree/ Master Degree/ PhD Other:_____

19. Occupation: _____

20. Monthly Income: _____ baht (before tax)

21. How many return flights have you taken in the past 12 months? How many of these where for? _____ return trips

22. Do you have any further comments?

_____

APPENDIX E: SEGMENTATION RESULTS FOR SC EXERCISE

This appendix reports the SC segmentation printout results from the three SC exercises; resident's percentage change, resident's rerouting and passenger. WTP values of segmentations are reported and discussed in section 11.5.

1 Resident's Comparison Exercise

1.1 Northern Residents

```
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -496.04820
Estimation based on N =    560, K =   7
Inf.Cr.AIC  =   1006.1 AIC/N =    1.797
Model estimated: Mar 01, 2014, 14:25:23
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -518.3913  .0431 .0371
Chi-squared[ 5]          =     44.68621
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   560, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00741***      .00201    -3.69  .0002     -.01134   -.00348
     AIR|    -.00166         .00235     -.70  .4814     -.00627    .00296
     OFF|    -.23439         .15279    -1.53  .1250     -.53385    .06507
    GAIN| .63292D-04         .00022      .29  .7696 -.36018D-03  .48676D-03
    COST|    -.00080***      .00023    -3.47  .0005     -.00125   -.00035
    A_A1|    -.72926***      .21759    -3.35  .0008    -1.15573   -.30279
    A_A2|    -.88094***      .22678    -3.88  .0001    -1.32542   -.43646
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

1.2 Southern Residents

```
Discrete choice (multinomial logit) model
Log likelihood function      -863.33022
Estimation based on N =    848, K =   7
Inf.Cr.AIC  =   1740.7 AIC/N =    2.053
Model estimated: Mar 01, 2014, 14:32:23
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -899.3852  .0401 .0361
Chi-squared[ 5]          =     72.11000
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   848, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00402***      .00121    -3.31  .0009     -.00640   -.00164
     AIR|    -.00206         .00138    -1.50  .1347     -.00477    .00064
     OFF|     .14527*        .08603     1.69  .0913     -.02335    .31389
    COST|    -.00078***      .00017    -4.50  .0000     -.00111   -.00044
    GAIN| .29151D-04         .00017      .17  .8638 -.30384D-03  .36214D-03
    A_A1|    1.02235***      .18328     5.58  .0000      .66312   1.38158
    A_A2|     .48242**       .18754     2.57  .0101      .11486    .84999
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
----------------------------------------------------------------------------
```

1.3 Residents Living Before Airport Opened

```
Discrete choice (multinomial logit) model
Log likelihood function      -910.24143
Estimation based on N =    896, K =   7
Inf.Cr.AIC  =   1834.5 AIC/N =    2.047
Model estimated: Mar 01, 2014, 15:51:40
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -944.0489  .0358 .0320
Chi-squared[ 5]          =     67.61495
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   896, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00519***      .00137    -3.79  .0001     -.00787   -.00251
     AIR|    -.00106         .00157     -.68  .4985     -.00414    .00201
     OFF|     .00557         .09894      .06  .9551     -.18836    .19950
    COST|    -.00061***      .00016    -3.76  .0002     -.00093   -.00029
    GAIN|     .00024         .00016     1.52  .1295     -.00007    .00054
    A_A1|    -.17392         .16073    -1.08  .2792     -.48895    .14112
    A_A2|    -.67036***      .16761    -4.00  .0001     -.99887   -.34186
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
----------------------------------------------------------------------------
```

1.4 Residents Living After Airport Opened

```
Discrete choice (multinomial logit) model
Log likelihood function      -530.11423
Estimation based on N =    512, K =   7
Inf.Cr.AIC  =   1074.2 AIC/N =    2.098
Model estimated: Mar 01, 2014, 15:55:41
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -551.5926  .0389 .0323
Chi-squared[ 5]          =     42.95677
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   512, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00434***      .00155    -2.81  .0050     -.00737   -.00131
     AIR|    -.00363**       .00178    -2.04  .0414     -.00711   -.00014
     OFF|     .14430         .11151     1.29  .1957     -.07426    .36286
    COST|    -.00079***      .00022    -3.65  .0003     -.00122   -.00037
    GAIN| .21710D-04         .00022      .10  .9196 -.39981D-03  .44323D-03
    A_A1|     .87334***      .23099     3.78  .0002      .42061   1.32607
    A_A2|     .47837**       .23660     2.02  .0432      .01464    .94210
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
----------------------------------------------------------------------------
```

1.5 High Income Residents

```
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -218.88250
Estimation based on N =    208, K =   7
Inf.Cr.AIC  =    451.8 AIC/N =    2.172
Model estimated: Mar 01, 2014, 15:58:02
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -223.9230  .0225 .0058
Chi-squared[ 5]          =     10.08105
Prob [ chi squared > value ] =   .07297
Response data are given as ind. choices
Number of obs.=   208, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|     .00095         .00275      .34  .7307     -.00444    .00633
     AIR|    -.00290         .00303     -.96  .3381     -.00884    .00304
     OFF|     .21093         .19336     1.09  .2753     -.16805    .58991
    COST|    -.00049         .00032    -1.55  .1208     -.00112    .00013
    GAIN|     .00012         .00032      .39  .7001     -.00050    .00074
    A_A1|    -.24984         .33167     -.75  .4513     -.89991    .40022
    A_A2|    -.44579         .33854    -1.32  .1879    -1.10932    .21773
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
----------------------------------------------------------------------------
```

1.6 Medium Income Residents

```
Discrete choice (multinomial logit) model
Log likelihood function      -889.40180
Estimation based on N =    856, K =   7
Inf.Cr.AIC  =   1792.8 AIC/N =    2.094
Model estimated: Mar 01, 2014, 16:06:21
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -927.4317  .0410 .0371
Chi-squared[ 5]          =     76.05976
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   856, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00492***      .00133    -3.71  .0002     -.00752   -.00233
     AIR|    -.00192         .00153    -1.26  .2085     -.00492    .00107
     OFF|     .00890         .09648      .09  .9265     -.18019    .19799
    COST|    -.00064***      .00017    -3.90  .0001     -.00097   -.00032
    GAIN|     .00026*        .00016     1.64  .1000     -.00005    .00057
    A_A1|     .07487         .16493      .45  .6498     -.24838    .39812
    A_A2|    -.35575**       .17087    -2.08  .0373     -.69065   -.02085
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

1.7 Low Income Residents

```
Discrete choice (multinomial logit) model
Log likelihood function      -356.55395
Estimation based on N =    344, K =   7
Inf.Cr.AIC  =    727.1 AIC/N =    2.114
Model estimated: Mar 01, 2014, 16:11:09
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -371.2521  .0396 .0297
Chi-squared[ 5]          =     29.39627
Prob [ chi squared > value ] =   .00002
Response data are given as ind. choices
Number of obs.=   344, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00730***      .00203    -3.60  .0003     -.01127   -.00332
     AIR|    -.00218         .00232     -.94  .3472     -.00673    .00237
     OFF|     .16111         .14596     1.10  .2697     -.12497    .44719
    COST|    -.00078***      .00026    -3.02  .0025     -.00129   -.00028
    GAIN|-.30983D-04         .00026     -.12  .9038 -.53325D-03  .47129D-03
    A_A1|     .56977**       .26978     2.11  .0347      .04101   1.09853
    A_A2|    -.06105         .28046     -.22  .8277     -.61075    .48865
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

2. Resident Rerouting

2.1 Northern Residents

```
Discrete choice (multinomial logit) model
Log likelihood function      -968.58789
Estimation based on N =    904, K =   6
Inf.Cr.AIC  =   1949.2 AIC/N =    2.156
Model estimated: Mar 01, 2014, 16:13:24
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -977.1883  .0088 .0055
Chi-squared[ 4]          =     17.20075
Prob [ chi squared > value ] =   .00177
Response data are given as ind. choices
Number of obs.=   904, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   ROUTE|     .00034         .00056      .62  .5379     -.00075    .00144
    TIME|    -.00291**       .00115    -2.53  .0114     -.00516   -.00065
    COST|    -.00011         .00020     -.58  .5600     -.00050    .00027
    GAIN|     .00022         .00016     1.41  .1586     -.00009    .00053
    A_A1|    -.51988***      .17323    -3.00  .0027     -.85941   -.18035
    A_A2|    -.31910*        .18292    -1.74  .0811     -.67761    .03940
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

2.2 Southern Residents

```
Discrete choice (multinomial logit) model
Log likelihood function      -751.02431
Estimation based on N =    696, K =   6
Inf.Cr.AIC  =   1514.0 AIC/N =    2.175
Model estimated: Mar 01, 2014, 16:17:20
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -760.9713  .0131 .0088
Chi-squared[ 4]          =     19.89400
Prob [ chi squared > value ] =   .00052
Response data are given as ind. choices
Number of obs.=   696, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   ROUTE|    -.00138**       .00062    -2.22  .0265     -.00259   -.00016
    TIME|    -.00313**       .00127    -2.47  .0134     -.00561   -.00065
    COST|    -.00036         .00022    -1.64  .1009     -.00079    .00007
    GAIN|     .00019         .00017     1.08  .2818     -.00015    .00053
    A_A1|     .02396         .19439      .12  .9019     -.35704    .40495
    A_A2|    -.12890         .21077     -.61  .5408     -.54199    .28420
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

2.3 Residents Living Before Airport Opened

```
Discrete choice (multinomial logit) model
Log likelihood function     -1094.04561
Estimation based on N =   1032, K =   6
Inf.Cr.AIC  =   2200.1 AIC/N =    2.132
Model estimated: Mar 01, 2014, 16:21:47
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -1107.4987  .0121 .0093
Chi-squared[ 4]          =     26.90626
Prob [ chi squared > value ] =   .00002
Response data are given as ind. choices
Number of obs.=  1032, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   ROUTE|    -.00047         .00051     -.92  .3574     -.00146    .00053
    TIME|    -.00293***      .00106    -2.78  .0055     -.00500   -.00086
    COST|    -.00033*        .00018    -1.83  .0671     -.00068    .00002
    GAIN|     .00022         .00014     1.52  .1273     -.00006    .00050
    A_A1|    -.39449**       .15909    -2.48  .0131     -.70629   -.08269
    A_A2|    -.45243***      .17218    -2.63  .0086     -.78990   -.11496
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

2.4 Residents Living After Airport Opened

```
Discrete choice (multinomial logit) model
Log likelihood function      -617.74459
Estimation based on N =    568, K =   6
Inf.Cr.AIC  =   1247.5 AIC/N =    2.196
Model estimated: Mar 01, 2014, 16:24:44
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -621.9913  .0068 .0016
Chi-squared[ 4]          =      8.49335
Prob [ chi squared > value ] =   .07509
Response data are given as ind. choices
Number of obs.=   568, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   ROUTE|-.60068D-04         .00073     -.08  .9344 -.14910D-02  .13709D-02
    TIME|    -.00267*        .00145    -1.84  .0656     -.00552    .00017
    COST| .52455D-04         .00025      .21  .8369 -.44708D-03  .55199D-03
    GAIN|     .00030         .00020     1.49  .1354     -.00009    .00069
    A_A1|    -.12892         .22159     -.58  .5607     -.56323    .30538
    A_A2|     .04901         .23308      .21  .8335     -.40782    .50583
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

2.5 High Income Residents

```
Discrete choice (multinomial logit) model
Log likelihood function      -254.89116
Estimation based on N =    240, K =   6
Inf.Cr.AIC  =    521.8 AIC/N =    2.174
Model estimated: Mar 01, 2014, 16:31:38
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -260.8354  .0228 .0104
Chi-squared[ 4]          =     11.88850
Prob [ chi squared > value ] =   .01820
Response data are given as ind. choices
Number of obs.=   240, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   ROUTE|    -.00182*        .00105    -1.74  .0821     -.00388    .00023
    TIME|    -.00468**       .00214    -2.19  .0288     -.00888   -.00049
    COST|    -.00082**       .00037    -2.23  .0258     -.00154   -.00010
    GAIN|-.79769D-04         .00030     -.27  .7892 -.66458D-03  .50504D-03
    A_A1|     .54531         .34814     1.57  .1173     -.13703   1.22765
    A_A2|     .86026**       .36883     2.33  .0197      .13737   1.58316
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

2.6 Medium Income Residents

```
Discrete choice (multinomial logit) model
Log likelihood function      -602.84582
Estimation based on N =    560, K =   6
Inf.Cr.AIC  =   1217.7 AIC/N =    2.174
Model estimated: Mar 05, 2014, 12:48:04
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -614.2401  .0186 .0133
Chi-squared[ 4]          =     22.78860
Prob [ chi squared > value ] =   .00014
Response data are given as ind. choices
Number of obs.=   560, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   ROUTE|    -.00031         .00070     -.45  .6556     -.00168    .00106
    TIME|    -.00519***      .00145    -3.58  .0003     -.00804   -.00235
    COST|    -.00017         .00025     -.67  .4999     -.00066    .00032
    GAIN|     .00033         .00020     1.64  .1020     -.00006    .00072
    A_A1|    -.22732         .22044    -1.03  .3025     -.65938    .20474
    A_A2|    -.14623         .23503     -.62  .5338     -.60688    .31443
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

2.7 Low Income Residents

```
Discrete choice (multinomial logit) model
Log likelihood function      -840.36938
Estimation based on N =    792, K =   6
Inf.Cr.AIC  =   1692.7 AIC/N =    2.137
Model estimated: Mar 05, 2014, 12:48:53
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -843.7262  .0040 .0002
Chi-squared[ 4]          =      6.71366
Prob [ chi squared > value ] =   .15182
Response data are given as ind. choices
Number of obs.=   792, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   ROUTE|-.80824D-04         .00060     -.13  .8934 -.12625D-02  .11009D-02
    TIME|    -.00114         .00122     -.93  .3528     -.00353    .00126
    COST|    -.00011         .00021     -.53  .5961     -.00053    .00030
    GAIN|     .00019         .00017     1.12  .2610     -.00014    .00051
    A_A1|    -.54076***      .18329    -2.95  .0032     -.90001   -.18151
    A_A2|    -.59660***      .19774    -3.02  .0026     -.98416   -.20903
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
-----------------------------------------------------------------------------
```

3. Passengers

3.1 Low Income Passengers

```
Discrete choice (multinomial logit) model
Log likelihood function     -1005.81824
Estimation based on N =    984, K =   6
Inf.Cr.AIC  =   2023.6 AIC/N =    2.057
Model estimated: Mar 05, 2014, 14:04:57
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -1070.7361  .0606 .0578
Chi-squared[ 4]          =    129.83576
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   984, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.01091***      .00142    -7.68  .0000     -.01369   -.00812
     AIR|    -.01413***      .00147    -9.64  .0000     -.01701   -.01126
     OFF|     .14620         .09316     1.57  .1165     -.03638    .32878
    COST|    -.00035***   .5047D-04    -6.90  .0000     -.00045   -.00025
    A_A1|    -.32456***      .09711    -3.34  .0008     -.51489   -.13423
    A_A2|    -.04397         .09709     -.45  .6506     -.23428    .14633
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

3.2 Medium Income Passengers

```
Discrete choice (multinomial logit) model
Log likelihood function     -1327.23552
Estimation based on N =   1336, K =   6
Inf.Cr.AIC  =   2666.5 AIC/N =    1.996
Model estimated: Mar 05, 2014, 14:07:55
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -1453.7938  .0871 .0850
Chi-squared[ 4]          =    253.11658
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=  1336, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.01159***      .00125    -9.31  .0000     -.01404   -.00915
     AIR|    -.01754***      .00126   -13.87  .0000     -.02002   -.01506
     OFF|     .20364***      .07864     2.59  .0096      .04951    .35778
    COST|    -.00043***   .4358D-04    -9.80  .0000     -.00051   -.00034
    A_A1|    -.06531         .08383     -.78  .4359     -.22961    .09899
    A_A2|     .03020         .08572      .35  .7246     -.13780    .19821
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

3.3 High Income Passengers

```
Discrete choice (multinomial logit) model
Log likelihood function      -925.96210
Estimation based on N =    880, K =   6
Inf.Cr.AIC  =   1863.9 AIC/N =    2.118
Model estimated: Mar 05, 2014, 14:10:47
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -962.4041  .0379 .0346
Chi-squared[ 4]          =     72.88403
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   880, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00921***      .00141    -6.51  .0000     -.01198   -.00644
     AIR|    -.01064***      .00154    -6.92  .0000     -.01365   -.00763
     OFF|     .23096**       .09631     2.40  .0165      .04221    .41972
    COST|    -.00031***   .4954D-04    -6.25  .0000     -.00041   -.00021
    A_A1|    -.19885**       .09990    -1.99  .0465     -.39466   -.00304
    A_A2|    -.08323         .10420     -.80  .4244     -.28745    .12099
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

3.4 Short Haul Passengers

```
Discrete choice (multinomial logit) model
Log likelihood function     -1817.88095
Estimation based on N =   1792, K =   6
Inf.Cr.AIC  =   3647.8 AIC/N =    2.036
Model estimated: Mar 05, 2014, 14:14:47
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -1956.3463  .0708 .0692
Chi-squared[ 4]          =    276.93062
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=  1792, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.01202***      .00107   -11.20  .0000     -.01412   -.00991
     AIR|    -.01477***      .00108   -13.68  .0000     -.01689   -.01266
     OFF|     .16880**       .06863     2.46  .0139      .03428    .30331
    COST|    -.00041***   .3728D-04   -10.89  .0000     -.00048   -.00033
    A_A1|    -.12571*        .07140    -1.76  .0783     -.26565    .01423
    A_A2|    -.00125         .07367     -.02  .9864     -.14564    .14314
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

3.5 Medium Haul Passengers

```
Discrete choice (multinomial logit) model
Log likelihood function      -662.12690
Estimation based on N =    640, K =   6
Inf.Cr.AIC  =   1336.3 AIC/N =    2.088
Model estimated: Mar 05, 2014, 14:21:15
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -698.6617  .0523 .0478
Chi-squared[ 4]          =     73.06968
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   640, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00961***      .00168    -5.72  .0000     -.01290   -.00632
     AIR|    -.01346***      .00176    -7.66  .0000     -.01690   -.01002
     OFF|     .26138**       .11253     2.32  .0202      .04083    .48194
    COST|    -.00026***   .6154D-04    -4.29  .0000     -.00038   -.00014
    A_A1|    -.25478**       .11903    -2.14  .0323     -.48808   -.02149
    A_A2|    -.10013         .12020     -.83  .4048     -.33573    .13547
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

3.6 Long Haul Passengers

```
Discrete choice (multinomial logit) model
Log likelihood function      -785.31254
Estimation based on N =    768, K =   6
Inf.Cr.AIC  =   1582.6 AIC/N =    2.061
Model estimated: Mar 05, 2014, 14:56:08
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -834.5639  .0590 .0553
Chi-squared[ 4]          =     98.50261
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   768, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00866***      .00155    -5.57  .0000     -.01171   -.00561
     AIR|    -.01481***      .00171    -8.64  .0000     -.01817   -.01145
     OFF|     .23102**       .10372     2.23  .0259      .02773    .43431
    COST|    -.00038***   .5388D-04    -7.10  .0000     -.00049   -.00028
    A_A1|    -.27670**       .11059    -2.50  .0124     -.49346   -.05994
    A_A2|    -.03184         .11107     -.29  .7744     -.24954    .18586
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

3.7 Heard of Carbon Offsetting

```
Discrete choice (multinomial logit) model
Log likelihood function      -924.11666
Estimation based on N =    928, K =   6
Inf.Cr.AIC  =   1860.2 AIC/N =    2.005
Model estimated: Mar 05, 2014, 14:58:50
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -997.7093  .0738 .0708
Chi-squared[ 4]          =    147.18533
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   928, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.01108***      .00143    -7.75  .0000     -.01388   -.00828
     AIR|    -.01657***      .00153   -10.86  .0000     -.01956   -.01358
     OFF|     .30905***      .09311     3.32  .0009      .12655    .49155
    COST|    -.00032***   .4761D-04    -6.77  .0000     -.00042   -.00023
    A_A1|     .15598         .10219     1.53  .1269     -.04431    .35626
    A_A2|     .17442         .10661     1.64  .1018     -.03452    .38337
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

3.8 Never Heard of Carbon Offsetting

```
Discrete choice (multinomial logit) model
Log likelihood function     -2326.81251
Estimation based on N =   2272, K =   6
Inf.Cr.AIC  =   4665.6 AIC/N =    2.054
Model estimated: Mar 05, 2014, 15:08:33
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -2477.4056  .0608 .0595
Chi-squared[ 4]          =    301.18614
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=  2272, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.01077***      .00093   -11.54  .0000     -.01260   -.00894
     AIR|    -.01398***      .00096   -14.54  .0000     -.01587   -.01210
     OFF|     .16126***      .06095     2.65  .0082      .04180    .28072
    COST|    -.00040***   .3340D-04   -11.87  .0000     -.00046   -.00033
    A_A1|    -.31996***      .06327    -5.06  .0000     -.44397   -.19594
    A_A2|    -.10333         .06398    -1.62  .1063     -.22873    .02207
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

3.9 Economy Class Passengers

```
Discrete choice (multinomial logit) model
Log likelihood function     -2841.26219
Estimation based on N =   2792, K =   6
Inf.Cr.AIC  =   5694.5 AIC/N =    2.040
Model estimated: Mar 05, 2014, 15:12:09
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -3048.0955  .0679 .0669
Chi-squared[ 4]          =    413.66653
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=  2792, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.01076***      .00084   -12.80  .0000     -.01241   -.00911
     AIR|    -.01548***      .00087   -17.81  .0000     -.01718   -.01378
     OFF|     .22123***      .05470     4.04  .0001      .11403    .32844
    COST|    -.00037***   .2951D-04   -12.57  .0000     -.00043   -.00031
    A_A1|    -.22098***      .05747    -3.85  .0001     -.33362   -.10834
    A_A2|    -.07134         .05856    -1.22  .2232     -.18612    .04344
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

3.1 First and Business Classes Passengers

```
Discrete choice (multinomial logit) model
Log likelihood function      -424.05121
Estimation based on N =    408, K =   6
Inf.Cr.AIC  =    860.1 AIC/N =    2.108
Model estimated: Mar 05, 2014, 15:15:02
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -441.7772  .0401 .0330
Chi-squared[ 4]          =     35.45205
Prob [ chi squared > value ] =   .00000
Response data are given as ind. choices
Number of obs.=   408, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
  CHOICE|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   NOISE|    -.00960***      .00205    -4.69  .0000     -.01361   -.00559
     AIR|    -.00872***      .00224    -3.90  .0001     -.01311   -.00434
     OFF|     .03528         .13837      .25  .7987     -.23592    .30648
    COST|    -.00034***   .7222D-04    -4.67  .0000     -.00048   -.00020
    A_A1|     .05974         .14684      .41  .6841     -.22806    .34755
    A_A2|     .27912*        .15214     1.83  .0666     -.01907    .57731
--------+--------------------------------------------------------------------
Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
---------------------------------------------------------------------------
```

APPENDIX F: EXPERIMENTAL DESIGNS

This appendix shows experimental designs used in the SC exercises as described in Section 8.4. Each designs contains 32 scenarios of three options (A, B and C, option C is as now where all values are zero).

Rerouting Design

Scenario 1	**Rerouting**	**Travel Time**	**Fee**
A	**0**	**50**	**-1500**
B	**0**	**-50**	**1500**
Scenario 2	**Rerouting**	**Travel Time**	**Fee**
A	**300**	**25**	**300**
B	**300**	**0**	**700**
Scenario 3	**Rerouting**	**Travel Time**	**Fee**
A	**100**	**25**	**-1500**
B	**0**	**-50**	**1500**
Scenario 4	**Rerouting**	**Travel Time**	**Fee**
A	**100**	**50**	**300**
B	**300**	**-50**	**-700**
Scenario 5	**Rerouting**	**Travel Time**	**Fee**
A	**400**	**-25**	**-300**
B	**300**	**25**	**300**
Scenario 6	**Rerouting**	**Travel Time**	**Fee**
A	**100**	**50**	**-1500**
B	**0**	**-50**	**1500**
Scenario 7	**Rerouting**	**Travel Time**	**Fee**
A	**400**	**-25**	**-300**
B	**200**	**50**	**300**
Scenario 8	**Rerouting**	**Travel Time**	**Fee**
A	**300**	**0**	**700**
B	**400**	**0**	**-300**
Scenario 9	**Rerouting**	**Travel Time**	**Fee**
A	**100**	**0**	**1100**
B	**100**	**-50**	**-1100**
Scenario 10	**Rerouting**	**Travel Time**	**Fee**
A	**0**	**-25**	**-1100**
B	**200**	**0**	**700**

Scenario 11	Rerouting	Travel Time	Fee
A	0	-50	-700
B	200	25	-300
Scenario 12	Rerouting	Travel Time	Fee
A	300	-50	-1500
B	0	25	1100
Scenario 13	Rerouting	Travel Time	Fee
A	200	50	-300
B	300	-25	700
Scenario 14	Rerouting	Travel Time	Fee
A	400	-25	-700
B	200	25	1100
Scenario 15	Rerouting	Travel Time	Fee
A	0	-50	1500
B	100	50	-1500
Scenario 16	Rerouting	Travel Time	Fee
A	0	-50	1500
B	0	50	-1500
Scenario 17	Rerouting	Travel Time	Fee
A	100	-50	-1100
B	100	25	300
Scenario 18	Rerouting	Travel Time	Fee
A	0	50	700
B	400	-50	-1100
Scenario 19	Rerouting	Travel Time	Fee
A	400	-25	-70
B	100	25	1100
Scenario 20	Rerouting	Travel Time	Fee
A	200	25	1100
B	400	-25	-700
Scenario 21	Rerouting	Travel Time	Fee
A	100	25	1100
B	400	-25	-700
Scenario 22	Rerouting	Travel Time	Fee
A	400	-25	-1100
B	100	0	1500

Scenario 23	Rerouting	Travel Time	Fee
A	100	-50	1500
B	100	50	-1500
Scenario 24	Rerouting	Travel Time	Fee
A	300	-50	-1100
B	100	50	300
Scenario 25	Rerouting	Travel Time	Fee
A	200	0	1500
B	400	0	-700
Scenario 26	Rerouting	Travel Time	Fee
A	200	0	700
B	0	-25	-1100
Scenario 27	Rerouting	Travel Time	Fee
A	300	-25	700
B	200	50	-300
Scenario 28	Rerouting	Travel Time	Fee
A	0	-25	1100
B	300	-50	-1500
Scenario 29	Rerouting	Travel Time	Fee
A	200	0	300
B	0	-25	-1100
Scenario 30	Rerouting	Travel Time	Fee
A	400	0	-300
B	300	0	700
Scenario 31	Rerouting	Travel Time	Fee
A	300	25	300
B	400	-25	-300
Scenario 32	Rerouting	Travel Time	Fee
A	200	50	-700
B	200	-25	1100

Resident Percentage Change design

Scenario 1	Noise	Local Pollution	Carbon Offset	Fee
A	25	25	0	-300
B	-25	-25	1	300
Scenario 2	Noise	Local Pollution	Carbon Offset	Fee
A	-25	50	0	-1100
B	25	-50	1	1100
Scenario 3	Noise	Local Pollution	Carbon Offset	Fee
A	25	25	0	-700
B	-25	-52	1	1100
Scenario 4	Noise	Local Pollution	Carbon Offset	Fee
A	50	-50	1	1100
B	-50	50	0	-1100
Scenario 5	Noise	Local Pollution	Carbon Offset	Fee
A	-25	50	1	1500
B	0	-50	0	1500
Scenario 6	Noise	Local Pollution	Carbon Offset	Fee
A	0	50	1	1500
B	0	-50	0	-1500
Scenario 7	Noise	Local Pollution	Carbon Offset	Fee
A	50	0	0	-300
B	-50	-25	1	700
Scenario 8	Noise	Local Pollution	Carbon Offset	Fee
A	0	-50	0	1500
B	-25	50	1	-1500
Scenario 9	Noise	Local Pollution	Carbon Offset	Fee
A	-50	-25	1	300
B	50	0	0	-300
Scenario 10	Noise	Local Pollution	Carbon Offset	Fee
A	-25	-25	0	700
B	25	25	1	-700
Scenario 11	Noise	Local Pollution	Carbon Offset	Fee
A	0	50	1	1500
B	0	-50	0	1500
Scenario 12	Noise	Local Pollution	Carbon Offset	Fee
A	-25	-25	0	700
B	50	25	1	-300

Scenario 13	Noise	Local Pollution	Carbon Offset	Fee
A	25	-50	0	-1100
B	-25	50	1	1100
Scenario 14	Noise	Local Pollution	Carbon Offset	Fee
A	-25	50	1	1100
B	25	-50	0	-1100
Scenario 15	Noise	Local Pollution	Carbon Offset	Fee
A	-50	25	0	-1100
B	50	-25	1	1100
Scenario 16	Noise	Local Pollution	Carbon Offset	Fee
A	-50	-50	1	700
B	25	25	0	-300
Scenario 17	Noise	Local Pollution	Carbon Offset	Fee
A	-25	-25	1	700
B	25	25	1	-700
Scenario 18	Noise	Local Pollution	Carbon Offset	Fee
A	-25	-50	0	1100
B	25	25	1	-300
Scenario 19	Noise	Local Pollution	Carbon Offset	Fee
A	50	0	0	-300
B	-50	0	1	700
Scenario 20	Noise	Local Pollution	Carbon Offset	Fee
A	-50	0	0	1500
B	50	0	1	-1100
Scenario 21	Noise	Local Pollution	Carbon Offset	Fee
A	25	0	1	300
B	-50	-25	1	700
Scenario 22	Noise	Local Pollution	Carbon Offset	Fee
A	50	0	1	300
B	-50	0	0	300
Scenario 23	Noise	Local Pollution	Carbon Offset	Fee
A	50	25	1	-300
B	-50	-25	0	300
Scenario 24	Noise	Local Pollution	Carbon Offset	Fee
A	25	0	1	1100
B	-25	0	1	1500
Scenario 25	Noise	Local Pollution	Carbon Offset	Fee
A	-50	-25	1	1100
B	50	0	0	-700

Scenario 26	Noise	Local Pollution	Carbon Offset	Fee
A	0	25	1	-1500
B	0	-25	1	1100
Scenario 27	Noise	Local Pollution	Carbon Offset	Fee
A	50	-50	1	-1500
B	-50	50	0	1500
Scenario 28	Noise	Local Pollution	Carbon Offset	Fee
A	-25	-50	1	1100
B	0	50	0	700
Scenario 29	Noise	Local Pollution	Carbon Offset	Fee
A	25	25	0	-300
B	-25	-25	1	700
Scenario 30	Noise	Local Pollution	Carbon Offset	Fee
A	0	-50	0	1500
B	-25	50	1	1500
Scenario 31	Noise	Local Pollution	Carbon Offset	Fee
A	-50	50	0	-1100
B	50	-50	1	1100
Scenario 32	Noise	Local Pollution	Carbon Offset	Fee
A	0	-25	1	700
B	0	25	0	-700

Passenger Experimental Design

Scenario 1	Noise	Local Pollution	Carbon Offset	Fee
A	25	25	0	-300
B	-25	-25	1	300
Scenario 2	Noise	Local Pollution	Carbon Offset	Fee
A	-25	50	0	-1100
B	25	-50	1	1100
Scenario 3	Noise	Local Pollution	Carbon Offset	Fee
A	25	25	0	-700
B	-25	-50	1	1100
Scenario 4	Noise	Local Pollution	Carbon Offset	Fee
A	50	-50	1	1100
B	-50	50	0	-1100
Scenario 5	Noise	Local Pollution	Carbon Offset	Fee
A	-25	50	1	1500
B	0	-50	0	1500

Scenario 6	Noise	Local Pollution	Carbon Offset	Fee
A	0	50	1	-1500
B	0	-50	0	1500
Scenario 7	Noise	Local Pollution	Carbon Offset	Fee
A	50	0	0	-300
B	-50	-25	1	700
Scenario 8	Noise	Local Pollution	Carbon Offset	Fee
A	0	-50	0	1500
B	-25	50	1	-1500
Scenario 9	Noise	Local Pollution	Carbon Offset	Fee
A	-50	-25	1	300
B	50	0	0	-300
Scenario 10	Noise	Local Pollution	Carbon Offset	Fee
A	-25	-25	0	700
B	25	25	1	-700
Scenario 11	Noise	Local Pollution	Carbon Offset	Fee
A	0	50	1	1500
B	0	50	0	1100
Scenario 12	Noise	Local Pollution	Carbon Offset	Fee
A	-50	-25	0	700
B	50	25	1	-300
Scenario 13	Noise	Local Pollution	Carbon Offset	Fee
A	25	-50	0	-1100
B	-25	50	1	1100
Scenario 14	Noise	Local Pollution	Carbon Offset	Fee
A	-25	50	1	1100
B	25	-50	0	1100
Scenario 15	Noise	Local Pollution	Carbon Offset	Fee
A	-50	25	0	1100
B	50	-25	1	-1100
Scenario 16	Noise	Local Pollution	Carbon Offset	Fee
A	-50	-50	1	700
B	25	25	0	-300
Scenario 17	Noise	Local Pollution	Carbon Offset	Fee
A	-25	-25	1	300
B	25	25	0	-1100
Scenario 18	Noise	Local Pollution	Carbon Offset	Fee
A	-25	-25	0	700
B	25	25	1	-700

Scenario 19	Noise	Local Pollution	Carbon Offset	Fee
A	50	0	0	-300
B	-50	0	1	700
Scenario 20	Noise	Local Pollution	Carbon Offset	Fee
A	-50	0	0	1500
B	50	0	1	1100
Scenario 21	Noise	Local Pollution	Carbon Offset	Fee
A	25	0	0	-300
B	-50	-25	1	1100
Scenario 22	Noise	Local Pollution	Carbon Offset	Fee
A	50	0	1	300
B	-50	0	0	300
Scenario 23	Noise	Local Pollution	Carbon Offset	Fee
A	50	25	1	-300
B	-50	-25	0	700
Scenario 24	Noise	Local Pollution	Carbon Offset	Fee
A	25	0	1	1100
B	-25	0	0	-1500
Scenario 25	Noise	Local Pollution	Carbon Offset	Fee
A	-50	-25	1	700
B	50	0	0	-1100
Scenario 26	Noise	Local Pollution	Carbon Offset	Fee
A	0	25	1	-1500
B	-25	-25	1	1500
Scenario 27	Noise	Local Pollution	Carbon Offset	Fee
A	50	-50	1	1500
B	-50	50	0	-1500
Scenario 28	Noise	Local Pollution	Carbon Offset	Fee
A	-25	-50	1	1100
B	0	50	0	-700
Scenario 29	Noise	Local Pollution	Carbon Offset	Fee
A	25	25	0	-300
B	-25	-25	1	700
Scenario 30	Noise	Local Pollution	Carbon Offset	Fee
A	0	-50	0	1500
B	-25	50	1	1500
Scenario 31	Noise	Local Pollution	Carbon Offset	Fee
A	-50	50	0	-1100
B	50	-50	1	1100

Scenario 32	Noise	Local Pollution	Carbon Offset	Fee
A	0	-25	1	700
B	2	25	0	-700