The review of market-based measures in mitigating aircraft noise and the applications for Taiwan

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ABSTRACT

Despite the economic downturns and unexpected drawbacks, the air transport industry is still forecast to experience a 5-6 % annual growth for the next 20 years, with the Asian markets taking the lead. The International Civil Aviation Organization, other international aviation organizations and national governments have stated the importance of applying market-based measures (MBMs) as one of the policy options for achieving the sustainable development of the industry. The MBMs cover environmental charges, taxes, trading and offset, generally applied at the international, national or airport levels, mainly for the purposes of mitigating aircraft noise and/or engine emissions. This paper reviews the current applications of MBMs in mitigating aircraft noise worldwide and investigates the differences and purposes of various measures, with a view for the applications in Taiwan. The current state of noise management measures, covering both regulations and economic instruments, at Taiwanese airports is also described in the paper. Theoretical evaluations of the social costs of aircraft noise have been assessed for comparison against the charge levels of different MBMs where applicable. The outcomes will assist policy makers in applying adequate MBMs for given purposes.

Keywords: Market-based measures, aircraft noise social costs, charges

1 INTRODUCTION

Sustainable development, which seeks the balance among social, economic and environmental impacts/benefits, has been globally recognized as the main objective of any industry's growth (Caves 1994a, b). The externalities generated from commercial flights have various impacts on air quality, climate change, noise, water quality, fuel consumption and energy, waste and the ecology. Apart from aircraft engine emissions, noise nuisance undoubtedly has the largest social impact on the community surrounding the airport. Noise causes both annoyance (nuisance) and health effects, for instance sleep deprivation (Franssen et al. 2004), stress and hypertension (Issarayangyun et al. 2005; Jarup et al. 2005). The costs of these externalities must be internalized and paid for by the aviation industry and its users (European Commission 1999, 2002).

More and more airports in the world, often through government pressure, have implemented noise-related charges on commercial flights. In 1999, only 14 countries in the world had some form of noise charge; by 2007, 24 countries, 18 European, 4 Asian and 2 North American, have applied such noise-related charges. The schemes for applying these charges vary greatly from country to country, and even between airports in a given country.

In Taiwan, the Civil Aeronautics Administration (CAA), Ministry of Transportation and Communications (MOTC) has been putting lots of effort into mitigating noise pollution in the past years. The current aircraft noise charge has been prevailing for more than 12 years at selected Taiwanese airports now, the CAA recognized that there is a need for revising the noise charge mechanism which aims to find a balance among all parties involved. Section 2 reviews and compares the noise charge schemes at airports worldwide, together with the use of the revenues collected. Section 3 proposed a systematic generic approach to setting up noise charge mechanisms with the consideration of various related factors. Using Taiwanese airports as case studies, Section 4 firstly describes the aircraft noise charge and house insulation schemes in Taiwan, followed by the estimation of noise social costs at 11 Taiwanese airports. Conclusions and recommendations are given in Section 5.

2 NOISE CHARGES SCHEMES AT WORLD AIRPORTS

2.1 Noise charge principles

Airports in eleven European and four Asian countries, as well as some airports in Canada and the United States, currently apply aircraft noise related surcharges or discounts. The charge mechanisms can be classified into four groups as follows:

- Noise surcharges: for example, Sydney, Vienna, Helsinki, Budapest and Warsaw airports, as well as some airports in Germany, Japan, Italy, Sweden, Switzerland and Taiwan.
- Landing fee based on aircraft noise acoustic levels/categories: for example, Brussels, Tokyo-Narita, Seoul-Gimpo and the UK BAA (British Airports Authority) London airports.
- Noise surcharges and Landing fee based on aircraft noise acoustic categories: for example, ten French airports and Amsterdam Airport Schiphol.
- Other schemes: such as night surcharges at Toronto and Luxembourg airports.

Most airports apply a specific noise surcharge. Some airports apply a percentage surcharge or discount on the Maximum Take-Off Weight (MTOW) based landing fee, depending on the aircraft acoustic category. In the case of BAA London airports, the total landing fee varies according to aircraft acoustic noise category, such that it is impossible to separate out the noise element of the charge. In addition to noise charges/taxes, landing fees at 10 French airports and Amsterdam Airport Schiphol also vary with aircraft acoustic categories.

2.2 Use of charges

The purpose of collecting noise surcharges is mainly to mitigate the impact of noise nuisance on the community. Even with the same composition of aircraft movements, the impacts of noise could be reduced by properly investing the money collected into various noise insulation schemes, mitigating measures or even introducing economic incentives for helping airlines in accelerating the use of quieter aircraft.

Table 1 compares the use of revenues from noise charges at various airports. All the selected airports have invested the money on noise related insulation schemes especially on residential houses, schools, hospitals and public buildings. Sydney Airport has invested in building community centers or care centers; whilst Schiphol and Narita airports have used the money in obtaining the land surrounding the airport.

Tokyo Narita Airport had the highest cumulative investment, compared to other airports in Table 1. This was due to the densely populated area and high cost of obtaining the land surrounding the airport. Schiphol and Sydney airports have comparatively high investment in the noise mitigating related measures as well. Taiwan Taoyuan International Airport, being a medium sized airport compared to others, has huge noise impacts on the surrounding area. There was a cumulative amount of US $ 104 million invested in house insulation between year 1985 and 2006.

Table 1: The use of noise revenues at selected airports

Country	Airport	Airport code	House insulation schemes	Region and care centers	Obtaining land	Cumulative investment (million US dollars)	Households within a certain noise contour
Australia	Sydney	SYD	✓	✓		346 (up to 2004)	--
Czech Republic	Prague	PRG	✓			25 (up to 2006)	4,288 *
France	Charles de Gaulle	CDG	✓			67 (up to 2003)	--
Germany	Hamburg	HAM	✓			48 (up to 2003)	14,000
Japan	Narita	NRT	✓		✓	2,682	5,489
Netherlands	Schiphol	SPL	✓		✓	835	17,000
Taiwan	Taoyuan Int'l	TPE	✓			104 (up to 2006)	25,130
United Kingdom	London-Heathrow	LHR	✓			10 (estimated annual spending)	22,522 **

Source: summarized from the Boeing website, www.boeing.com , June 2007; BAA (2007);

Note: * Assuming 2.5 persons per household

** Households within Leq(dBA) noise countour.

3 SYSTEMATIC APPROACH TO SETTING UP NOISE CHARGE MECHANISMS

While easing noise nuisance on the local community is a vital task for the majority of the airports in the world, a wider scope of confronting economic, social and environmental issues is necessary and beneficial for the long-term sustainable development of the aviation industry. Section 3.1 presents the generic approach to setting up the noise charge scheme. Two of the important elements of the scheme, namely noise social costs and the use of charges, are further described in Sections 3.2 and 3.3 respectively.

3.1 The generic approach

Based on the findings of theoretical research and the review of the current noise charge schemes worldwide, a generic approach to setting up noise charge mechanisms is proposed here, as illustrated in Figure 1. The application of aircraft noise charges involves airports, the surrounding neighborhood, government authorities, airlines and even passengers. The theoretical basis behind noise charges is for internalizing this externality. Hence, the noise social costs should be firstly estimated in order to have a clearer understanding about the true costs of the impacts.

In practical terms, the actual noise charge levels should be then related to the total costs of related noise insulation and mitigating measures. Meanwhile, the charge schemes and levels as well as the equity of the scheme should be accepted by all the actual payers concerned, namely airlines. As the noise charge is part of the airport user charges, the competitiveness of an airport in terms of airport user charge levels should also be investigated while determining the proper charge level for different types/categories of aircraft.

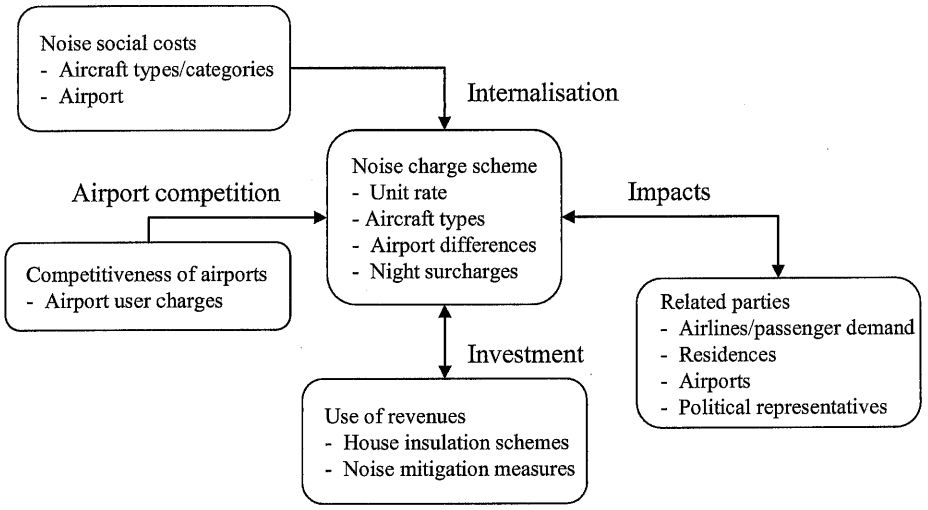

Figure 1: The structure of noise charge mechanisms

3.2 Noise social costs

The hedonic price method (HPM) is the most commonly used technique for estimating noise damage costs (Lu 2009). This method extracts the implicit prices of certain characteristics that determine property values, such as location, attributes of the neighborhood and environmental quality. By applying the HPM, the annual total noise social cost at an airport could be derived by having the following inputs,

- the noise depreciation index (NDI): the percentage reduction of house price per dBA above background noise. The average NDI from literature review is assumed to be 0.6 %;
- the number of residences within each zone of the noise contour;
- the annual average house rent in the vicinity of the airport: could be derived from the average house value in the area.

After calculating the aggregate noise social cost, it is necessary to decide how to allocate this total external cost to individual flights. The principle of this process should be based on the real impact of noise nuisance generated dynamically from each specific flight. A simplified approach to deriving the marginal noise nuisance (noise index), caused by each specific aircraft/engine combination flight, is developed for the purpose of the research (Lu & Morrell 2006). The calculation of noise index is based on the average of three ICAO (International Civil Aviation Organisation) noise certified levels, namely the Effective Perceived Noise Level (EPNdB) for take-off, sideline and approach, for different aircraft/engine combinations.

With the composition of aircraft movements by aircraft type and engine combinations, the annual noise index could be aggregated. Considering the noise index for different aircraft type and engine combinations, the noise social cost per aircraft movement could then be derived.

3.3 Costs of noise mitigation measures

In addition to the charging methods and charge level, a further vital step of establishing an environmental charge mechanism is the use and the implications of revenues, which have been collected from environmental charges.

The ICAO Council identified key policy issues regarding environmental charges and taxes on aviation, and strongly recommended that any environmental levies on air transport should be in the form of charges rather than taxes. In addition, the revenues collected should be applied in the first instance to mitigating the adverse environmental impacts of aircraft emissions.

As this research focuses on the environmental charges imposed by individual airport authorities instead of world-wide or region-wide, the use of charges to supplement government income is eliminated from the analysis. Revenues can be applied in the following ways:

- To compensate for damages from noise nuisance and emissions impacts: the mitigation options include various noise insulation schemes, real monetary compensation for both noise and emissions issues etc.
- To cover the cost of mitigation measures for environmental reasons: such as aircraft noise monitoring system, air quality measuring equipment etc.
- To invest in air traffic control (ATC) improvement: this can reduce the delay of flights due to inefficient ATC systems and heavy traffic demand, and results in the reduction of aircraft engine emissions.
- To invest in more environmentally friendly aircraft and engines: these could be done in two ways: by sponsoring the research of aircraft manufacturers and by creating financial incentives for airlines' purchase of greener aircraft types.

However, the overall use of charges should be based on the cost benefit analysis for each implementation option in order to make the most use of the revenues, which in turn would lead to a better correction of the market failure due to the existing externalities.

4 CASE STUDY OF TAIWANESE AIRPORTS

According to "Standards of Charges for the Use of Airport Airfield Navigation Aids and Related Facilities," amended on 29 September 2006, the current noise charge per flight (landing and take-off) can be expressed as the following formula,

$$\text{Noise charge (NT dollar/flight)} = 17x + 95(y - 73) \quad (1)$$

Where x is Maximum Take-off Weight (MTOW) in thousand kilograms,

y is take-off noise in EPNdB

Currently, the same formula applies to 11 airports in Taiwan that have applied aircraft noise charges. In other words, the same aircraft type flying to Taiwan Taoyuan International Airport, the biggest airport, or to Tainan Airport, a small domestic airport, pays the same noise charge disregarding its actual impacts on residents. Since the same aircraft noise charge has been prevailing for more than 12 years now, the CAA recognized that there is a need for revising the noise charge mechanism so as to take into account: the social costs imposed on residents; the actual expenditure needed for noise insulation schemes; the latest trend of noise charges at world-wide airports; and the competitiveness of Taiwanese international airports. Hence, the revision of noise charge mechanisms is currently a high priority on the agenda of the CAA's work.

4.1 Noise control fee for house insulation schemes

The noise charge collected at each of the 11 airports is called "the noise control fee" with the dedicated purpose solely for house insulation schemes. According to the Regulation of Aircraft Noise Control Fee Assignation and Use, the airport must subsidize the sound proofing installation with the following orders of priority (Lin & Liao 2006):

1. The schools, libraries, medical institutions and dwellings in Class 3 aircraft noise control zone, and schools in Class 2 and 1 zones;
2. The libraries and medical institutions in Class 2 zone;
3. The dwellings in Class 1 zone;
4. The libraries, medical institutions and dwellings in Class 1 zone.

Where, aircraft noise control zone classification criteria :

- Class 1 : areas between 60-65 dBA of aircraft noise day-night average sound level (L_{dn});
- Class 2 : areas between 65-75 dBA;
- Class 3 : areas exposed to noise higher than 75 dBA.

Table 2 lists the average annual noise control fees collected at each of the 11 airports, number of households entitled for noise insulation schemes, together with the annual aircraft movements and passengers. (Appendix 1 further lists the households within each noise control zone.) The number of households is clearly not directly related to the traffic volume of the respective airport at all. For Taipei Songshan and Kaohsiung airports, both are very much in the city center, hence, resulting in higher impacts of noise nuisance on the community. Nevertheless, despite less commercial flights, Tainan and Hualian airports have comparatively high noise impacts because of the frequent military aircraft operations. Since the amount collected of the noise control fee is determined from the total commercial flights of an airport concerned, and is not in proportion to the number of households affected, the progress of subsidization at each airport differs greatly.

Table 2: The noise control fee and households entitled for noise insulation schemes

Airport	Commercial aircraft movements 2006	Passengers 2006 (000)	Annul average noise control fee		Households
			million NT $	million €	
Taiwan Taoyuan Int'l	157,703	22,857	400	8.9	25,912
Taipei Songshan	87,955	6,729	100	2.2	75,800
Kaohsiung Int'l	78,603	7,130	100	2.2	51,884
Magong*	34,822	1,749	23	0.5	1,409
Kinmen	22,898	1,435	15	0.3	1,265
Taichung*	18,666	693	17	0.4	9,080
Tainan*	14,114	1,231	26	0.6	116,169
Hualian*	12,888	705	22	0.5	68,285
Taitung	11,129	485	7.5	0.2	3,370
Chiayi*	8,727	312	15	0.3	8,443
Pingtung*	1,560	62	12	0.3	2,315

Source: CAA (2007b)

Note: * These are military-civil joint use airports. The annual average noise control fee includes the input from the military.

4.2 Noise social costs at Taiwanese airports

Applying the hedonic price method described in Section 3.2, this section further estimates the noise social costs at Taiwanese airports. For simplifying the calculation, all the aircraft types operating at these airports are categorized into eight categories, based on their ICAO certified noise levels.

With the data on households within each noise contour zone, annual house rents and the NDI value, the annual noise social costs are estimated for each airport. Comparing with the noise control fee collected at each airport, Table 3 shows that some airports, such as Taipei Songshan, Kaohsiung and Tainan, have higher noise social costs than the actual fee collected. This implies that there could be an increase of noise charges for these airports in order to actually reflect their real social costs. By doing so, the process of insulating houses could be accelerated (instead of taking decades with the current speed of insulation) and resulted in less noise nuisance on the community. On the contrary, the noise control fee collected at some airports (namely Magong, Chiayi and Pingtung) is even higher than their respective noise social cost, implying that there could be a reasonable reduction of noise charges for the flights operating from these airports.

Table 3: The annual noise social costs and noise control fees for year 2006

Airport	Noise social cost (A) in €	Noise control fee (B) in €	(A)/(B)
Taiwan Taoyuan Int'l	10,074,219	8,366,807	1.2
Taipei Songshan	64,845,722	1,439,215	45.1
Kaohsiung	17,637,513	1,585,262	11.1
Tainan	4,196,948	264,300	15.9
Hualian	615,884	162,021	3.8
Taitung	825,648	124,132	6.7
Magong	154,172	355,439	0.4
Chiayi	21,991	75,599	0.3
Taichung	378,897	121,306	3.1
Kinmen	344,448	272,277	1.3
Pingtung	28,505	36,364	0.8
Total	99,123,947	12,813,621	7.5

5 CONCLUSIONS AND RECOMMENDATIONS

More than 100 airports in the world have applied noise-related charges, either through noise surcharges or landing fees varying with aircraft noise levels/categories. The schemes for applying these charges, a great diversity between airports, have been compared and examined in the paper. With different airport operating characteristics, and historical development of noise related charges and other airport user charges, even different cultures of the country, there is no single scheme which suits all the airports in the world. However, the proposed systematic generic approach to

setting up noise charge mechanisms and charge levels could be applied to any airport which wishes to revise their current noise charge schemes or set up a new one. The approach has combined theoretical research results with practical consideration.

With the application of the proposed approach, the results for the revision of noise charges at Taiwanese airports are presented and discussed. The social costs for different airports are served as good reference points for understanding the actual impacts of noise nuisance on the community. With regard to the setting up of noise charge schemes and levels, the practical consideration, such as the costs of house insulation schemes, the administrative procedures and the impacts on airlines, has turned out to be the essential issues, even as constraints, which need to be examined thoroughly. The aim of the revision or setting up of noise charge schemes is to serve the welfare of all parties involved, namely residents, airlines and government authorities etc.

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