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The economic benefits and environmental costs of airport operations: Taiwan Taoyuan International Airport

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A B S T R A C T

This paper compares the economic gains from airports with some of the environmental costs of their operations. The economic effects are divided into direct, indirect, and induced impacts, and the direct impact into employment and income generated by the operation of an airport; while the indirect and induced impacts are the income generated in the supply chain. We focus on evaluating employment benefits and the social costs of both aircraft noise and engine emissions, using Taiwan Taoyuan International Airport as a case study. The results indicate that the economic benefits generated from the operations of the airport outweigh the negative side effects.

1. Introduction

In recent years, national and local governments have often sought the development of airport infrastructure as part of wider economic development initiatives to stimulate employment opportunities and increase household income, as well as to generate more business opportunities. With these economic benefits, however, there are often negative local environmental effects such as aircraft noise nuisance, soil contamination, and air pollution. Here we look at some of the trade-offs between narrowly defined economic gains from airport investment and the wider social costs associated with their environmental impacts

2. Airport economic benefits – employment generation

The economic benefits that an airport can bring to an area range from employment opportunities, income generation, economic diversity, increasing mobility and tax generation, although these are seldom net additions to a national economy because of the trade diversion effects as well as the trade creation effects generated. The abstractions most frequently used to assess the economic benefits generated by an industry in a specific geographical area are the Garin-Lowry and the input-output (I/O) models; we utilize the former.

Employment comes from two types of industries; area-basic and non-basic. The former includes those industrial, business, and administrative activities that are not dependent on a local market for their employment whereas the non-basic sector includes those activities whose employment depends on the local economy; such things as schools, shops, and medical facilities. The economic-based multiplier approach assumes that those employed in the basic sector will result in population increases in a region, which will in turn increase the employment and population of the non-basic sector. The total employment generated by an airport expansion (E), for example, is the sum of the additional basic employment (E_B) and the additional non-basic employment (E_{NB}).

We consider two geographical areas, the "reference area" and the "region", within the reference area; in our case Taoyuan County, where the airport is located, is the region with the reference area being the whole of Taiwan. The base multiplier(M_B), the index of the overall employment as a percentage of the basic industry employment, is thus;

$$M_B = E/E_B \tag{1}$$

Based on this, the simplified Garin-Lowry model for estimating total employment associated with the basic industry is expressed as (Garin, 1966):

$$E = E_B + E_{NB} = E_B + \frac{\alpha\beta E_B}{1 - \alpha\beta} = E_B(1 - \alpha\beta)^{-1} \tag{2}$$

Where, α is the population-employment ratio, $\alpha = N/E_R$, calculated by taking the regional population, N, divided by total employment in the region; β is the population-serving employment ratio; $\beta = E_S/N$, calculated by taking the service industry employment divided by population in the region; N is the population in the region; E_R is the employment in the region; and E_S is the employment in the service industry.

The value of β is determined by using the location quotient approach, which applies the employment data of the region and the

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Table 1
Employment by industry for Taoyuan County and Taiwan – 2007/2008.

Industry	Taoyuan county employment		Taiwan employment		Taoyuan location Quotient
	(000)	%	(000)	%	
Primary industry[a]	12	1.8	535	5.1	0.27
Secondary industry[b]	414	46.3	3832	36.8	1.29
Tertiary industry[c]	449	52.0	6036	58.0	0.89
Total	874	100.0	10,403	100.0	–

[a] includes agriculture, agribusiness, fishing, forestry,miningandquarrying industries.
[b] includes aerospace manufacturing, automobile industry, brewing industry, chemical industry, textile industry, consumer electronics, energy industry, industrial equipment, metalworking, steel production and tobacco industry.
[c] also known as the service industry.
Source: National Statistic, R.O.C (Taiwan).

reference area to understand the characteristics of a specific industry and to analyze the specialization intensity on the local economy,

$$LQ_i = \frac{e_i/E_R}{E_i/E_T} \quad (3)$$

where: LQ_i is the location quotient; e_i is industry i's employment in the region; E_R is the employment in the region; E_i is industry i's employment in the reference area; and E_T is the total employment in the reference area

Depending on the value of LQ_i, an industry could be classified as either basic or non-basic:

- $LQ_i > 1$, shows that industry i has the tendency to be concentrated and specialized, this industry is a basic industry;
- $LQ_i < 1$, shows that industry i has no concentrated and specialized trend; this industry is a non- basic industry;
- $LQ_i = 0$, shows that there is no industry i in this region;

The larger LQ_i is, the more the i-th industry is centralized and specialized, and thus more important; the smaller the LQ_i value, the less important the i-th industry.

The Directorate-General of Budget, Accounting and Statistics (DGBAS) and National Statistic, ROC (Taiwan), divide the industrial activity of the employed population into primary, secondary and tertiary industries (Table 1). The primary and tertiary industries both have LQ values smaller than one. Since we focus on Taiwan Taoyuan International Airport as a basic industry, the tertiary industry for the service industry population is used in our analysis.

3. Aircraft noise and engine emissions

3.1. Aircraft noise

We adopt the widely used hedonic price method (Nelson, 1980, 1981) to value aircraft noise. This method extracts the implicit prices of certain characteristics that determine property values, such as location, attributes of the neighborhood and environmental quality (Lu and Morrell, 2006). By applying the hedonic methods, the annual noise cost C_n can be derived as:

Table 2
Social costs of each exhaust pollutant.

Pollutant	Average (2008€/kg)	Rural	Urban
		(2004€)/kg	
HC	4.47	2.27–5.0	2.7–8.9
CO	0.09	0.01–0.19	
NO_x	10.05	4–13	7–25
PM	167.57	18–200	85–2000
SO2	6.70	3.0–8.5	3.0–50.0
CO_2	0.035	0.01–0.04	

Source: updated from Lu (2009).

$$C_n = \sum_i I_{NDI} P_v (N_{ai} - N_0) H_i \quad (4)$$

where I_{NDI} is the noise depreciation index expressed as a percentage per dBA; P_v is the annual average house rent in the vicinity of the airport; and therefore, $I_{NDI}\,P_v$ is the annual noise cost per residence per dB(A).[1] The noise level above the ambient level is $(N_{ai} - N_0)$, where N_{ai} is the average noise for the ith section of the noise contour; N_0 is the background noise or the ambient noise. This is multiplied by H_i, the residences within the ith zone of the noise contour. The inputs used here for evaluating the annual noise at an airport are,

- the noise depreciation index (NDI): the percentage reduction of house price per dB(A) above background noise. The average NDI 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 which can be derived from the average house value in the area.

To allocate these aggregate costs to individual flights, marginal noise nuisance (noise index) of the incremental effect of an extra flight on the day-night sound level[2] is applied (Lu and Morrell, 2006) based on the average of three International Civil Aviation Organisation (ICAO) noise certification levels: the effective perceived noise level (EPNdB) for take-off, sideline, and approach, for different aircraft/engine combinations.

3.2. Aircraft engine emissions

Differences in aircraft operations, engine types, emission rates and airport congestion are important in influencing the damage level of different pollutants. Givoni and Rietveld (2009), Morrell (2009), and others have, for example, looked at the implications of aircraft size on CO_2. Aircraft operations also impact on local air pollution, at ground level during landings and take-offs. Since we focus only on the local and regional impacts of an airport operation, only the impacts of emissions from landings and take-offs and 30-minute cruise stages are evaluated in the later analysis.

The local external costs of various exhaust pollutants have been studied and Table 2 lists the range of relevant findings. As the monetary evaluation of the impact is still uncertain the unit costs for each pollutant have been averaged across the studies.

HC, CO, NO_x, PM, SO_2 and CO_2 for landings and take-offs are relevant with CO_2 the main concern at the cruise stage. Some

[1] dBA: the A-weighted decibel units, adjusted to conform with the frequency response of the human ear.
[2] Day-night sound levels are a commonly used cumulative noise measurement in the formulation of airport noise contours.