STUDY ON AIRCRAFT ALLOCATION BETWEEN ACROSS STRAIT AIR ROUTES

Suiling Li,National Penghu University of Science and Technology,suiling@npu.edu.tw

ABSTRACT

To promote the development of cross-strait economic and trade relations, airline to the current charter flights and boosting the number of weekly round-trip flights across the Taiwan Strait from 108 to 270, with 135 flights operated by carriers from each side. It pays to assess or concerns economic efficiency or effect of these airline's competing in air cross-strait market before Taiwanese airlines or Chinese airlines increasing flight service. To airlines' allocating routes' aircraft involved air fleets, crew and fuel costs, and flight aircraft capacity constraints. It will impact the airline's operating costs, revenues and service level. To passenger's demand involved flight's loading factor, route's preference and fare. Therefore, this study considered the objectives of passengers and airline, the constraints of airline's route capacity and demand to propose a multi-objectives programming to compare the route strategies of allocating aircraft type for each airline. The outcome shows the multi-objectives model is useful not only as the planning of route's strategies of aircraft allocation, but also the evaluation of routes' profits and costs. The outcome shows that if the airlines allocate A320, all strategies of scenarios will still make profits. This study also demonstrates that allocating principle of A330-300 aircraft, and B747-400 is assigned to the routes of high profits, high passenger load factor.

Keywords: operational cost, multi-objectives programming, spoiled cost, across-strait

INTRODUCTION

International flights constantly face to compete, reform, expand in the process of international development, especially shorter life cycle of internalization and diversification product. The Taiwan air transportation industries should how to know well the trade characteristic of cross-strait transportation and find their competing abilities. These important issues pay to study for international carriers. Industries gradually choose competing strength of carriers to make more profits. In the Cross-strait market, owing to liberalization, there are the problems which routes are economic efficiency or not. It's important issues such that social-economic variables and carrier operating variables. To promote the development of cross-strait economic and trade relations, and facilitate contacts between the peoples on the two sides of the Taiwan Strait, two sides established the Straits Exchange Foundation(SEF) and the Association for Relations Across the Taiwan Strait(ARATS), until 2008 had arranged for cross-strait flight paths, undertaking carriers, flight point for direct flights, regular flights, cargo charter flights, passenger charter flights, business charter flights and effective concerning direct cross-strait air transportation. Now, the Taiwan side opens the eight flight points of Taoyuan, Kaohsiung, Taichung, Taipei, Penghu, Hualien, Kinmen and Taitung for passenger charter flights. The Mainland side agrees, on the basis of the five flight points of Beijing, Shanghai, Guangzhou, Xiamen and Nanjing already opened for weekend charter flights, to open the additional 21 flight points of Chengdu, Chongqing, Hangzhou, Dalian, Guilin, Shenzhun, Wuhan, Fuzhou, Qingdao, Changsha, Haikou, Kunming, Xian, Shenyang, Tianjin, Zhengzhou, Hefei, Harbin, Nanchang, Jinan, Ningbo, and Guiyang for passenger charter flights(Yu-Chun Chang ,2010). Therefore, adding scheduled passenger flights to the current charter flights and boosting the number of weekly round-trip flights across the Taiwan Strait from 108 to 270, with 135 flights operated by carriers from each side. This study considers it pays to assess which aircraft type of this air market before increased service.

Taiwan domestic passenger airline market has been rapid annual average growth rate of nearly 20% since deregulation in 1987. In this highly competitive environment, all airlines try to acquire and retain customers to get the competitive advantages of market shares in the long term. Especially, today domestic aviation face high speed railway competition and impact, Taiwan airlines all turn to cross-strait market to enhance the relative strength to its competitors. Therefore, Taiwan airline route networks can carry fast growing traffic volumes by using larger regional airplanes, adding frequencies on existing routes. It's important for airlines to get their relative competitive advantages especially on direct flight between China and Taiwan air routes. However, the flight frequency strategies of air routes for airlines always depend on uncertain customers' preferences, economic cycles and flight safety to influence passenger load factors and the investment efficiency of airline routes. In order to deceasing uncertain factors' influences, the airline should control the dynamic and uncertain movement of market share and passengers load factor to modify the strategies of air route planning in the different stage, to achieve the objective of airlines' profits and small costs. At the mean time, the airline depends on the uncertain change of demand factors to propose the relative strain planning in the each stage.

Basically, adding schedule flight on existing or new routes for the airline is resources utility issues. These issues shall construct the relation between airline oneself profits and market competitors to realize the characteristic and problems of air route planning, to analyze the correlated influence on each one. The influence effects of adding scheduled flight on routes need to measure and evaluate which routes to be suitable exploring to make more profits. Owing the issue involves correlated influence characteristic of different decision-making objective between the airline and market competitors, this is suitable to propose the multi-objectives programming model to develop strategies for decision-making problem of planning scheduled flight on the routes. Therefore, this study will consider the measurement of decision-making aspects, which involves the profit of airline management and the competition of market share. At the same time, this study also considers the current the capacity of airline routes and flight demand.

Therefore, this study attempts to propose the score report of cross-strait passenger charter flights and reflect the operation cost and profit for this market of different airlines. These works need to measure and evaluate which routes of airline operation are competitive. This study imply the mathematic tools to analyzes the import and export routes of cross-straits and applies airline route's operation costs and profits to evaluate how to add which flights on which routes to reach the maximum passenger number and minimum the difference between airline's profit, cost and quota. Owing to the method of traditional evaluation is always can not reflect how to improve fairness. This study uses mathematic programming to measure the competition potentiality for airlines routes. The merits of this method can reflect the relative competitive degrees of regional transportation, improve the weakness route. In this study, in order to develop the multi-objectives programming for the management of airline resource, a model for evaluating direct flight on existing or new routes will be proposed including the airline's profits and airline's market share as well as timetable demand constraints. This study firstly reviews the route planning and approach for the scheduled flight. The multi-objectives programming model is applied to evaluate a reasonable approach between airlines' equity and airlines' profit. Second, it proposes a suitable allocation model for adding scheduled flight on existing or new route. This paper first reviews the competition characteristic of cross-strait air routes to apply suitable transportation amount and fares for different routes. Third, the paper proposes multi-objectives programming model to measure and analyze the equity, cost and profits between airlines on cross-strait air routes. Fourth, this study uses the quantified data of each route such as passenger number of per flight, the seat of per flight, fares of per flight, travel time of flight, the revenue of per flight, and the fuel cost of per flight. Meanwhile, this study applies the correction analysis to select suitable input and output variables by the flight information of Civil Aeronautics Administration (CAA) report in Taiwan and price information of direct flight from travel agency. Then, employed Lingo software and put the suitable equity, cost, profit formulation and decision making variables into to multi-objectives programming model. Finally, the paper sums up which approach are suitable to management flight frequency on cross-strait air routes. These finding can improve the planning of new flight path, or cancel the weak performance of flight path, the pricing reference of flight path.

THE FACTORS OF AIRCRAFT ALLOCATION ON AIR ROUTS

In the air transportation market, owing to liberalization, there are possible development such increased number of airlines serving a city pair, increase number of frequencies offered between city pairs, decease in the average aircraft size used between city pairs, and decrease in the air fare charge between city pairs (Janic, Milan 1997), that not only create the air route structures, but also influence route operating costs and market share on routes. There are some competition characteristics and factors including carrier choice, frequency levels, average aircraft size and air fares. The analyzing model (Janic, Milan 1997; Zhi-Chun Li,2010) of airline relationship on the air route network main focuses the market share on a route, concentration on a route, passenger demand on a route, quality of service on a route, and pricing policy on a route. Earlier studies had concentrated that reduction in unit cost of airline have been primarily due to change in operating characteristics, such as route scale, density ,utilization, and technical efficiency.

However, most airlines are constant returns to scale(swan,2002).High traffic density has been found to bring significant economies to airlines. Route development has shown persistent increases in frequencies, new routes, and new airports. In the air transportation market (Weber,2001), larger airplanes usually dominate long-haul flight, the long-haul flight grow much faster than short-haul. Long-haul air route must take the geography regulation, manufacture, passengers and airlines perspective to gain the configuration range of regional route network. The regional route network configuration range from typical linear networks, radial networks, combined with a large amount of point-to-point routes to concentrated radial network. The regional route network configuration has been stable than those of national carriers in Europe(Guillaume,2003). Most of the regional airlines concentrated their network in some extent around one or two central hub airports. As geo-economic factors (income-related variables), location factor (travel time), service-related factors (Jorge-Calderon,1997)approaches can effectively evaluated the air route structure, airlines' costs, and market share of airlines to propose the competing strategies for air route planning.

The above most literatures consider the important social-economic variables and airline operating variables on route development, but little study and construct the relation between airline oneself profits and market share competition, to analyze the correlated influence on each one. The influence effects of adding scheduled flight on routes need to measure and evaluate which route to be suitable exploring to make more profits. Therefore, this study considers allocating schedule flight on existing or new routes for airlines' is resources utility issues. There are two important decision-making objectives for the airline manager, which one is maximum competing strength of market share and the other is the maximum of profits. Owing the issue involves correlated influence characteristic of different decision-making objective between the airline and the market competitors, this is suitable to propose the multi-objectives programming model to develop strategies for decision-making problem of planning scheduled flight on route. At the same time, the airline should consider the current the capacity of airline routes and flight demand

THE MODEL OF AIRCRAFT ALLOCATION ON AIR ROUTES

This study constructs a multi-objectives programming model to formulate minimum cost function. The notation and description of the parameters and variables is as follows:

Notation and Descriptions

X_{ij} :if aircraft i allocate j routes, then $X_{ij}=1$,otherwise $X_{ij}=0$

FC_{ij} : the fuel consumption cost for aircraft i allocate j routes

CB_{ij} : the carbon cost for aircraft i allocate j routes

SP_{ij} :the spoiled seats cost for aircraft i allocate j routes

P_{ij} : the fare for aircraft i allocate j routes

L_{ij} : the load factor for aircraft i allocate j routes

S_{ij} :the number of seats for aircraft i allocate j routes

Model assumption and Formulation

Firstly, this study use three objectives of fuel consumption costs, carbon cost and spoiled cost to measure the operation costs of allocating aircraft on different routes. The minimum costs between the fuel consumption cost , carbon cost and spoiled costs to decide the optimal aircraft allocation. The function (1)represent to the minimum operation costs for running between cross-strait routes. The function (2) represent the profit of each airline operation must be larger equal than zero,The function (3) represent each route j must be larger equal than 1 aircraft type. The function (4) represent select aircraft allocate different routes is 0-1integer variable.

$$MIN \quad \sum_{i=1}^{n}\sum_{j=1}^{m} FC_{ij} X_{ij} + \sum_{i=1}^{n}\sum_{j=1}^{m} CB_{ij} X_{ij} + \sum_{i=1}^{n}\sum_{j=1}^{m} SP_{ij} X_{ij} \tag{1}$$

$S.T.$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} P_{ij} \cdot L_{ij} \cdot S_{ij} \cdot X_{ij} - \sum_{i=1}^{n}\sum_{j=1}^{m} FC_{ij} X_{ij} - \sum_{i=1}^{n}\sum_{j=1}^{m} CB_{ij} X_{ij} \geq 0 \tag{2}$$

$$\sum_{i=1}^{n} X_{ij} \leq 1 \tag{3}$$

$$X_{ij} \in 0-1 \text{int}\, eger \tag{4}$$

THE MODEL APPLICATION

This section will separate three parts as follows: air transportation amount for air cross-strait passenger transportation, the performance of applied multi-objectives programming model for air cross-strait passenger transportation, and result analysis.

4.1 Taiwan International Air Transportation Distribution

From CAA data show the number of total flight frequency is 29,602, the amount of total passenger is 5,367,327 persons from August 2009 open cross-strait till August 2010. February 2010 is during Chinese-new-year, this month is very high flight frequencies more than the other months. Therefore, the international flight on February is 12,870 flights, China area are occupied half rate of February month flights and almost direct flights. The passenger volumes also in China area are highest, but the load factor figures are lower than other areas, no matter in scheduled or charter flight in China area. Therefore, this study employ the multi-objectives model to analyze why higher market-share rate of air cross-strait routes but poor load factor, and to find out which routes are potential development and pay to supporting management.

4.2 Route Structure for the Cross-strait Airlines

The Civil Aviation Administration of China (CAAC) decentralized the airline industry into six aviation bureaus in 1987,the six regions are: north China; east China; central and south China; the northeast; the southwest ; the northwest. North China includes Beijing, Tianjin, Hebei, Shanxi and Nei Mongol, which the major cities are Beijing and Tianjin. This region itself has only the third largest market share in terms of aircraft movements, passenger throughput and cargo throughput. The eastern region includes Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi and Shandong, which the major cities such as Shanghai, Nanjing, Hangzhou and Xiamen. East China is the busiest aviation region of flight frequencies between china and Taiwan. Central and south China includes Hunan, Guangdong, Hainan and Guangxi covering major cities such as Guangzhou, Shenzhen and Haikou. This region has the second number region of flight frequencies between china and Taiwan. Xian is the hub of the northwest which includes Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. This region has only a few flight frequencies. Shenyang is the hub of the northeast region which includes Liaoning, Jilin and Heilongjiang. The flight frequency in the northwest region is the lowest among the six regions. Chengdu is the hub in the southwest, which includes the provinces of Sichuan, Guizhou, Yunnan and Tibet and which covers major cities such as Chongqing and Kunming. Travel routes of this region attracts Taiwanese' tourism.

There are mainly Taiwan international gate of cross-strait air transportation market. Such Taichung(CCK),Taipei(TPE), Taoyuan(TSA) and Kaohsiung(KHH) airport (Yu-Chun Chang, 2010),The other airport of China is such as Beijing(PEK), Shanghai(SHA), Guangzhou(CAN), Xiamen(XMN),Nanjing(NKG),Chengdu(CTU),Chongqing(CKG),Hangzhou(HGH), Dalian (DLC),Guilin(KWL), Shenzhun(SZX), Wuhan(WUH), Fuzhou(FOC),Qingdao(TAO), Chang sha(CSX),Haikou(HAK),Kunming(KMG),Xian(SIA),Shenyang(SHE),Tianjin(TSN), Zhengz hou(CGO),Hefei(HFE),Harbin(HRB),Nanchang(KHN),Jinan(TNA),Ningbo(NGB),and Guiy ang (KWE). There are scheduled and charter flight service of Taiwan 5 airlines and China 8 airlines to achieve market objectives and airlines' profits. The major 13 airlines which serve the cross-strait air services are China Airlines(CI), EVA Airways (BR),Mandarin Airlines(AE),Trans Asia Airways(GE),UNI Airways (B7), Air China(CA), China Southern Airline(CZ), China Eastern Airline(MU), Xiamen Airlines(MF), Hainan Airlines(HU), Shandong Airlines(SC), Shanghai Airlines(FM), and Shenzhen(ZH). Therefore, this study will present the cross-strait airlines of different routes as the study case to examine the airlines' competition and benchmarking.

There are 104 air routes of cross-strait aviation in 2010 February as shown in Figure 1,and Table 1. There are 13 routes served by AE, 15 routes by B7, 10 routes by BR, 10 routes by CI, 15 routes by GE, 10 routes by MU, and the rest routes by China airlines of 3U, CA, CX, FM, HGE, HU, KA, MF, NX, SC, TG, ZH, BR and CI airlines also are highest flight frequencies of cross-strait airlines. 3U, CZ, MF, CX and AE airlines are higher than 80% flight load factor of cross-strait airlines. Li (2010) shows passenger load factors of charter airlines are over 84% such GE airline's CCK-SHA (84.70%) route, CZ airline's TSA-CGO route (89.75%), and MF airline's TSA-FOC route (86.12%). Meanwhile, passenger load factors of scheduled airlines are over 80% such AE airline's TPE-HGH route (98.40%), and 3U airline's routes. The air route of CGO, HRB, KMG, and KWL are the higher passenger load factor air routes over 85%, there are not busy flights everyday. TPE-KMG route(95.30%), B7 airline's KHH-MFM route(89.70%), CZ airline's TPE -KWL route (88.70%),AE airline's TPE-CGO(86.20%), CZ airline's TPE-SH route (85.30%), ZH airline's TPE-CGO route(85.10%), SC airline's TPE-TAO route (84.60%), B7 airline's TPE-KMG route (83.20%) , CX airline's TPE-HKG route(82.00%), AE airline's KHH-HKG route(81.30%), MF airline's TSA-XMN route (80.05%).

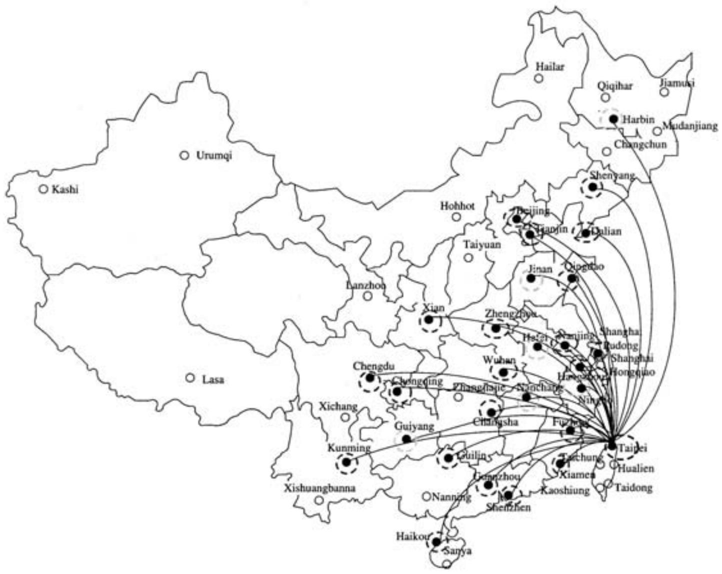

Figure 1   the direct flight distribution on cross-strait market

Table 1 The cross-strait market data on February 2010

Region	Route	Airline	Flight Frequency	Average Flight Time	Each hour Fuel	Passenger Number	Load-factor	Market-share
Central-South	7	25	591	130	3.84	82,151	63.79	0.1964
East	11	48	1,530	109	4.69	240,362	67.77	0.5746
North	3	9	264	187	6.03	50,520	70.05	0.1208
Northeast	4	8	118	184	2.98	16,827	78.22	0.0402
Northwest	1	2	32	218	5.21	4,464	76.45	0.0107
Southwest	5	12	198	189	2.92	23,949	74.03	0.0573
Total	31	104	2,733	138	4.17	418,273	68.70	1.0000

4.3 Demand Analysis of Airline's Routes

Tables 2 shows that the airline's fly time of TPE-CAN, TPE-HFE,TPE-NKG, TPE-SHA, TPE-SZX, TPE-VGB, TPE-XMN,TSA-FOC, TSA-HGH, TSA-KHH, TSA-SHA, TSA-XMN routes are shorter less than 2 hours to the destination, their market fares often depend on the cause of year festivals among airlines to modify fares. The fare of GE airline's TSA-TSN route, MU airline's TSA-SIA route, CZ airline's TPE-CSX route, MU airline's TPE-TAO route, MU airline's TPE-WUH route, CZ airline's TPE-HRB route, and BR airline's TPE-PEK route show that the demand route of point-to-point between cross-strait are higher than the fare of 3 hours trips. The ticket fare of average one hour for China airlines is cheaper than Taiwan airlines. Meanwhile, the ticket fare of average one hour and airline's number of routes are not apparently interactive influences and relations.

Table 2. The Minimum Fly Time and Ticket Fares of Each Route (NT dollars)

Route	Airlines	Fare	Fly time	Route	Airlines	Fare	Fly time	Route	Airlines	Fare	Fly time
KHH-HGH	AE	11,700	125	TPE-KWL	CZ	9,416	140	TPE-TSN	CA	11,716	185
TPE-CAN	BR	7,650	115	TPE-NKG	AE	11,810	115	TPE-TSN	FM	12,129	185
TPE-CAN	CI	7,007	115	TPE-NKG	FM	7,892	115	TPE-VGB	AE	7,769	95
TPE-CAN	CZ	6,726	115	TPE-NKG	MU	9,799	115	TPE-VGB	B7	8,632	100
TPE-CAN	HU	6,937	115	TPE-PEK	BR	14,000	185	TPE-VGB	HU	4,714	95
TPE-CGO	AE	11,583	155	TPE-PEK	CA	11,111	185	TPE-VGB	MU	11,641	95
TPE-CGO	CZ	10,486	155	TPE-PEK	CI	13,400	185	TPE-WUH	B7	11,810	165
TPE-CKG	CA	10,222	200	TPE-SHA	BR	13,600	105	TPE-WUH	CZ	13,161	165
TPE-CSX	AE	8,722	145	TPE-SHA	CA	9,480	105	TPE-WUH	MU	15,370	165
TPE-CSX	CZ	16,371	145	TPE-SHA	CI	12,341	105	TPE-XMN	AE	5,985	110
TPE-CSX	GE	13,982	145	TPE-SHA	CZ	8,739	105	TSA-CKG	3U	11,282	200
TPE-CSX	MF	8,632	145	TPE-SHA	MU	8,844	105	TSA-CTU	3U	11,282	205
TPE-CTU	CA	11,810	205	TPE-SHE	AE	11,583	230	TSA-CTU	GE	13,982	205
TPE-CTU	CI	13,966	205	TPE-SHE	CZ	13,696	230	TSA-FOC	GE	7,097	75
TPE-DLC	B7	10,751	195	TPE-SIA	CI	13,489	250	TSA-FOC	MF	4,819	75
TPE-DLC	CZ	10,539	195	TPE-SIA	MU	16,471	250	TSA-HGH	GE	10,275	120
TPE-DLC	HU	10,539	195	TPE-SZX	B7	8,200	110	TSA-KHH	MU	11,440	110
TPE-HFE	MU	11,440	120	TPE-SZX	CI	9,163	110	TSA-SHA	FM	13,717	105
TPE-HGH	BR	11,250	100	TPE-SZX	CZ	5,985	110	TSA-SHA	GE	12,923	105
TPE-HGH	CA	8,209	120	TPE-SZX	ZH	6,726	110	TSA-TSN	GE	17,160	185
TPE-HGH	MF	8,527	120	TPE-TAO	B7	10,751	150	TSA-WUH	GE	13,982	165
TPE-HRB	CZ	14,766	210	TPE-TAO	MU	15,465	150	TSA-XMN	B7	5,400	120
TPE-KMG	MU	12,446	190	TPE-TAO	SC	13,400	150	TSA-XMN	MF	4,714	120
TPE-KWE	CZ	13,161	170	TPE-TSN	BR	10,751	185				

4.4 Analysis of Aircraft Operation Cost on a Route

The aircraft B738 ,A321,A3210,A333, and MD90 are very busy and popular type by airlines, depend on statistics of flight fuel consumption , we estimate the fuel hours and flight operational costs of airlines. Airline BR,CI and AE pay munch more fuel consumption. From TABLE 3 show the airline's operation cost on the route, This always very related with fuel consumption and flight fly time. The relation coefficient between operation fuel and flight operation cost is very high 0.926. The relation coefficient between flight operation cost and fare revenue is also very high 0.959.

TABLE 3 Airline Market Data and Cost Data

Airline	Route	Flight frequency	Passenger	Market-share	Load-factor	Fuel(hour)	Total air network flight time	Fare Revenue	Flight Operation Cost	Fare Profit
CI	8	293	70,387	0.1683	71.4	7.57	1,190	77,274	14,033	63,241
BR	7	274	59,854	0.1431	69.8	9.13	955	73,423	13,216	60,207
MU	10	373	46,129	0.1103	64.2	3.31	1,385	49,614	6,059	43,555
CA	6	293	42,806	0.1023	69.1	3.66	1,040	42,466	7,411	35,055
AE	11	227	39,403	0.0942	75.0	5.24	1,365	35,556	5,358	30,198
CZ	12	266	34,941	0.0835	77.8	2.54	1,795	35,016	3,759	31,257
GE	13	220	25,894	0.0619	56.8	2.81	1,545	28,341	2,817	25,524
B7	14	195	25,735	0.0615	69.3	3.64	1,820	27,299	3,781	23,518
MF	4	146	20,024	0.0479	74.7	2.65	405	11,549	1,538	10,011
HU	5	114	13,111	0.0313	60.8	2.45	685	10,161	1,606	8,556
FM	3	90	11,751	0.0281	61.7	2.45	360	15,354	1,121	14,233
SC	4	88	11,236	0.0269	71.4	2.45	555	15,986	1,291	14,695
ZH	4	94	10,143	0.0242	68.0	2.49	630	8,913	1,181	7,731
3U	3	60	6,859	0.0164	72.3	2.81	595	8,040	1,335	6,704
Total	104	2773	418,273	1.0000	68.7	4.17	14,325	438,992	64,506	374,486

4.5 Model Result Analysis and Discussion

This study use Taiwan airline routes data and input parameters of ticket price, the flights eats, passengers load factor of each route, and the operation cost of flight frequency on each route, the current and optimal operational costs of Taiwan A airlines as Table 4. This study also run the optimal model, the outcome show the current operation cost of Taiwan A airline. We can see the optimal operation cost is less than the current costs, only spoiled cost larger than current spoiled costs. This study compares Table 5 and Table 6 with aircraft type, we can find the optimal and current operational aircraft is the same using A330-300, such as Table 5 and Table 6 the routes of TPE-HKG,TPE-CTU,TPE-DLC,TPE-KHN,TPE-TAO,TPE-WUH,TPE-XIY,TSA-SHA, KHH-PVG, and KHH-SZX. The optimal and current operational aircraft are the same using B747-400, such as TPE-CAN, TPE-PVG, and TPE-SZX.The optimal and current operational aircraft are different, such as KHH-HKG, KHH-PEK, which optimal solution using A321, but current operation using A330-300. Another routes of TPE-HAK, KHH-CKG optimal solution use A321, but current operation uses B737-800. TPE-PEK, optimal solution uses A330-300, but current operation uses B747-400. A330-300 allocates in ten routes are very popular aircraft type.

Table 4 The compare current and optimal operational costs

Objectives	Fuel consumption costs	Carbon costs	Spoiled costs	Total operational costs
Current operation	7,309,988	141,777	1,147,741	8,599,506
Optimal	5,751,540	111,551	1,279,729	7,142,820

Table 5 The current operational costs of Taiwan A airline in different routes

Routes	Aircraft	Fuel consumption costs	Carbon costs	Spoiled costs	Total operational costs
TPE-HKG	A330-300	219,548	4,258	0	223,806
TPE-CTU	A330-300	449,133	8,711	7	457,851
TPE-DLC	A330-300	386,405	7,494	280,280	674,179
TPE-KHN	A330-300	323,677	6,278	420,420	750,375
TPE-TAO	A330-300	303,604	5,888	0	309,492
TPE-WUH	A330-300	334,968	6,497	0	341,465
TPE-XIY	A330-300	470,461	9,125	0	479,586
TSA-SHA	A330-300	219,548	4,258	0	223,806
KHH-HKG	A330-300	188,184	3,650	0	191,834
KHH-PEK	A330-300	470,461	9,125	8,694	488,280
KHH-PVG	A330-300	898,607	17,429	0	916,036
KHH-SZX	A330-300	519,994	10,085	0	530,079
TPE-HAK	B37-800	147,788	2,866	174,110	324,764
TPE-SYX	B737-800	157,559	3,056	37,850	198,465
KHH-CKG	B737-800	183,208	3,553	226,380	413,141
TPE-CAN	B747-400	460,087	8,923	0	469,010
TPE-PEK	B747-400	738,056	14,315	0	752,371
TPE-PVG	B747-400	419,350	8,133	0	427,483
TPE-SZX	B747-400	419,350	8,133	0	427,483

Table 6 The optimal operational costs of Taiwan A airlines in different routes

Routes	Aircraft	Fuel consumption costs	Carbon costs	Spoiled costs	Total operational costs
TPE-HKG	A330-300	219,548	4,258	0	223,806
TPE-CTU	A330-300	449,133	8,711	0	457,844
TPE-DLC	A330-300	386,405	7,494	280,280	674,179
TPE-KHN	A330-300	323,677	6,278	420,420	750,375
TPE-TAO	A330-300	303,604	5,888	0	309,492
TPE-WUH	A330-300	334,968	6,497	0	341,465
TPE-XIY	A330-300	470,461	9,125	0	479,586
TSA-SHA	A330-300	219,548	4,258	0	223,806
KHH-HKG	A321	102,763	1,993	6,233	110,989
KHH-PEK	A321	256,906	4,983	113,022	374,911
KHH-PVG	A330-300	272,240	5,280	0	277,520
KHH-SZX	A330-300	198,221	3,845	0	202,066
TPE-HAK	A321	165,790	3,216	121,120	290,126
TPE-SYX	B737-800	157,559	3,056	37,850	198,465
KHH-CKG	A321	205,525	3,986	161,700	371,211
TPE-CAN	B747-400	460,087	8,923	0	469,010
TPE-PEK	A330-300	386,405	7,494	139,104	533,003
TPE-PVG	B747-400	419,350	8,133	0	427,483
TPE-SZX	B747-400	419,350	8,133	0	427,483

CONCLUSION

The airline's operating cost of route's aircraft allocation including the fuel costs will be implicated to discuss emission cost of air cross-strait market for the future. Therefore, this study measure fuel consumption cost, emission cost, and spoiled cost. The preliminary results and recommendations of this study are summarized as follows:

This study compares the current operational cost of aircraft type and optimal operational cost of aircraft type to find the popular aircraft types is A330-300 for Taiwan airline. In bigger load factor and no spoiled cost routes are allocate B747-400. These allocating principles of airline and passenger preference will suggest airlines' reference for management cross-strait air routs.

The spoiled costs and loader factors of frequency are very related, next steps will increase frequency distribution.

REFERENCE

Wen-Hsien Tsai,Kuen-Chang Lee. Jau-Yang Liu. Hsiu-Ling Lin.Yu-Wei Chou.Sin-Jin Lin,(2012). A mixed activity-based costing decision model for green airline fleet planning under the constraints of the Europwan Union Emissions Trading Scheme,Energy 39, pp 218-226

Sui-Ling, Li.(2009).An Efficiency Model of Taiwan International Air/Marine Cargo Transportation, The 8th Eastern Asia Society for Transportation Studies Conference, In Surabaya, Proceedings of the Eastern Asia Society for Transportation Studies, Vol.7

Sui-Ling, Li.(2011).The Forecast Analysis Air Cargo Revenue for Taiwan International Aviation Logistics Transportation, The 4th International Conference on Transportation and Logistics, Busan, Korea

Taiwan Civil Aeronautics Administration. (2010), Aviation Statistics Data of International flights for Statistics Data of Civil Aviation Administration.

China Civil Aeronautics Administration.(2010), Aviation Statistics of flight Fuel for Different aircraft.