Exploring the Impact of Introducing Scheduled Flights on Aviation Markets

Experience from Opening of China–Taiwan Nonstop Flights

Yi-Shih Chung and Jinn-Tsai Wong

The commencement of regular nonstop flights between mainland China and Taiwan in December 2008 was expected to increase the flow of traffic across the Taiwan Strait. Travelers would no longer have to stop to change aircraft; the flight between mainland China and Taiwan would be quicker, cheaper, and more convenient. Hong Kong and Macau, formerly the gateways connecting Taiwan to China, would now compete with point-to-point nonstop flights available to cross-strait travelers. The aim of this study was to examine the evolving supply and demand associated with the aviation market between China and Taiwan and to focus on the changes resulting from the introduction of scheduled nonstop flights. Data covering a 15-month period were collected and analyzed by using multilevel models. The results show that despite rapid growth in the nonstop cross-strait air travel market, growth rates are still restricted by limitations set by the Chinese and Taiwanese governments, particularly those routes connecting Taiwan with first-tier Chinese cities. For this reason, some travelers are forced to make a detour through Hong Kong or Macau on their way to China. However, city pairs connecting Taiwan with second- or third-tier Chinese cities have not performed as well as expected, and some markets have even demonstrated a negative trend over time, indicating a shrinking market. The market for cross-strait air travel exhibits clear heterogeneous characteristics in city pairs, which should be considered as governments take the next steps in opening up the market.

The commencement of scheduled nonstop flights between mainland China and Taiwan has changed the way that people travel across the Taiwan Strait and has had a significant influence on the aviation market in East Asia (*1*). This study focuses on the evolution of supply and demand in the China–Taiwan aviation market, particularly during the period following the introduction of nonstop flights.

BACKGROUND OF CROSS-STRAIT AVIATION MARKET

Before nonstop flights, travelers between mainland China and Taiwan had to make at least one stop to change aircraft, usually in Hong Kong or Macau, in China. Other stopover cities included Manila, in the Philippines; Tokyo; Bangkok, Thailand; and Seoul, South Korea, although these routes made up only a small portion of cross-strait traffic (*1*).

Mandatory indirect connections between mainland China and Taiwan were inconvenient and imposed a cost burden on travelers. According to Lin and Chu (*2*), compared with nonstop flights, indirect flights between Taiwan and northern, central, and southern areas of mainland China cost travelers an average of 170, 205, and 185 min in additional travel time, respectively. This cost is equivalent to 4.3 billion New Taiwan dollars or roughly $136 million U.S. annually, calculated from the volume of traffic and the value of the traveler's time. Indirect flights also caused higher operating costs for airlines resulting from an increase in the distance of flights as well as landing fees and air navigation charges.

To address the increased flow of traffic across the strait, the Taiwanese and Chinese governments launched nonstop flights in 2003. In the first 4 years, nonstop flights were offered only during the four major Chinese traditional festivals: the Spring Festival, Tomb-Sweeping Day, Dragon Boat Festival, and the Moon Festival. Initially, nonstop flights were available only to Taiwanese citizens. In response to the increasing demand for cross-strait travel, in November 2008 the Chinese and Taiwanese governments agreed to launch regular nonstop charter flights across the strait. These measures, which were no longer limited to Taiwan citizens, went into effect the following month. In the beginning, 17 Chinese cities were selected to share nonstop charter flights with four Taiwanese cities. These were first-tier Chinese cities including Shanghai and Beijing, and the four Taiwanese cities were Taipei, Taoyuan, Taichung, and Kaohsiung, shown as blue dots in Figure 1. Eventually, more Chinese airports gradually joined the cross-strait operations. To provide additional flights with better air routes available for belly-hold cargo services, nonstop charter flights became nonstop scheduled flights at the end of August 2009. In the meantime, 27 Chinese cities had signed up for nonstop scheduled flights. The newly added cities are represented as red dots in Figure 1 and include a number of second- and third-tier Chinese cities such as Harbin and Shenyang.

Indirect flights via Hong Kong or Macau are still available for cross-strait travelers. Traveling to China via Hong Kong is particularly convenient for those going to southern mainland China. Hong Kong remains an important hub in East Asia with a high frequency of flights, making it more convenient than a number of nonstop routes with lower frequency. In addition to air travel, ferries also offer the possibility of transport across the strait. Cross-strait travelers could take ferries between Kinmen and Matsu in Taiwan and Xiamen, Fuzhou, and Quanzhou in China. As shown in Figure 2, travelers could take flights from the main island of Taiwan to Kinmen or Matsu and then transfer to ferries bound for Xiamen, Fuzhou, or Quanzhou.

Y.-S. Chung, Department of Logistics and Shipping Management, Kainan University, No. 1 Kainan Road, Luzhu Shiang, Taoyuan 33857, Taiwan. J.-T. Wong, Institute of Traffic and Transportation, National Chiao Tung University, 4F, 114 Chung Hsiao Road West, Sector 1, Taipei 10044, Taiwan. Corresponding author: Y.-S. Chung, yishih.chung@gmail.com.

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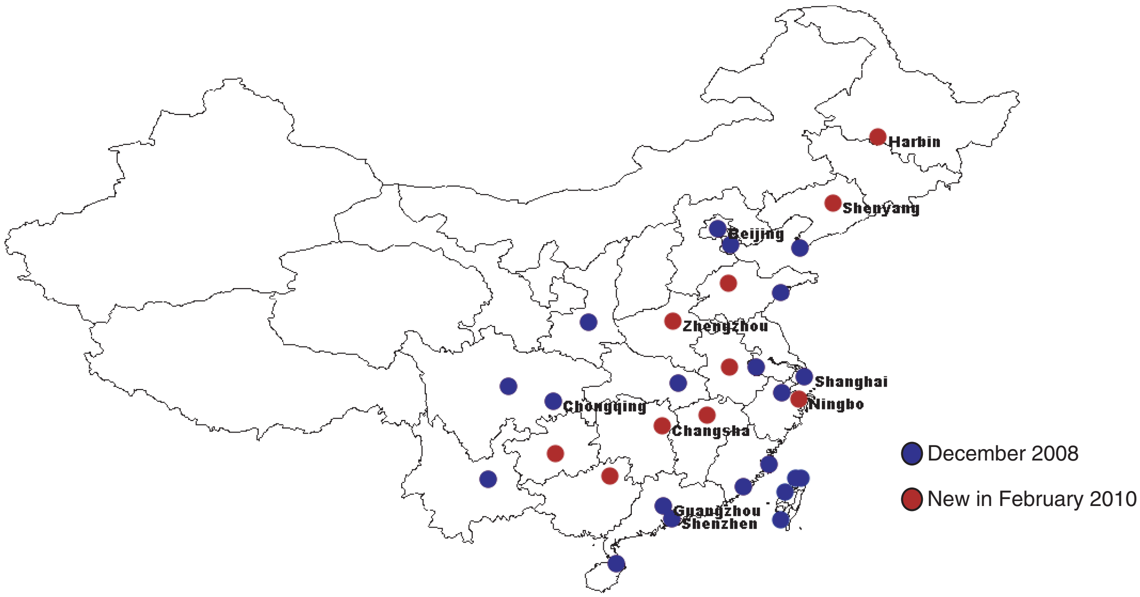

FIGURE 1 Location of cities offering nonstop flights.

CROSS-STRAIT PASSENGER TRAFFIC

Whereas for decades political factors prevented the establishment of official connections across the strait, unofficial traffic between mainland China and Taiwan has continued. Seeing the commercial potential, Taiwanese businessmen have been investing in mainland China since the 1980s, with investment rapidly increasing in the last 10 years. This business has led to an increase in the demand for travel options across the strait.

Figure 3 illustrates the volume of cross-strait travelers according to the location of departure. Although Taiwanese businessmen have been traveling to China for a long time, in the last 4 years (2006–2009), the number of travelers from Taiwan to mainland China (including Hong Kong and Macau) has flattened out with only a slight increase from 350,000 to 400,000 per month, as shown by the blue diamonds. Meanwhile, the number of travelers from mainland China to Taiwan (red squares) had been controlled by the governments and hence has remained constant since 2009. Since the commencement of scheduled nonstop flights, however, the number of travelers from mainland China to Taiwan has significantly risen. Because two-way passenger volume has increased, the total monthly flow has also increased, from 400,000 to 500,000.

Figure 4 shows the volume of passenger via the three primary approaches across the strait: nonstop flights, flights via Hong Kong or Macau, and ferries. As shown, these three approaches present three trends in passenger volume: the curve for flights to Hong Kong (dark blue diamonds) and to Macau (red squares) exhibits a downward trend, the curve for ferries is somewhat constant, and the nonstop-flight curve shows an upward trend.

The volume of passengers taking the Taiwan–Hong Kong (TWN–HK) route decreased by approximately one-seventh during this period, although the total passenger traffic through the Hong Kong airport has remained at approximately 4 million (*3*). Moreover, the discrepancy between TWN–HK (dark blue diamonds) and nonstop flights

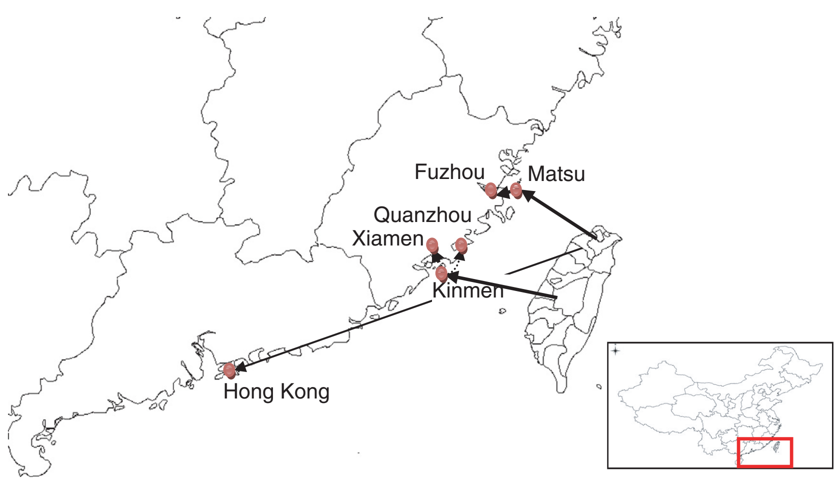

FIGURE 2 Two primary approaches to traveling across the strait besides nonstop flights: ferries and flights via Hong Kong.

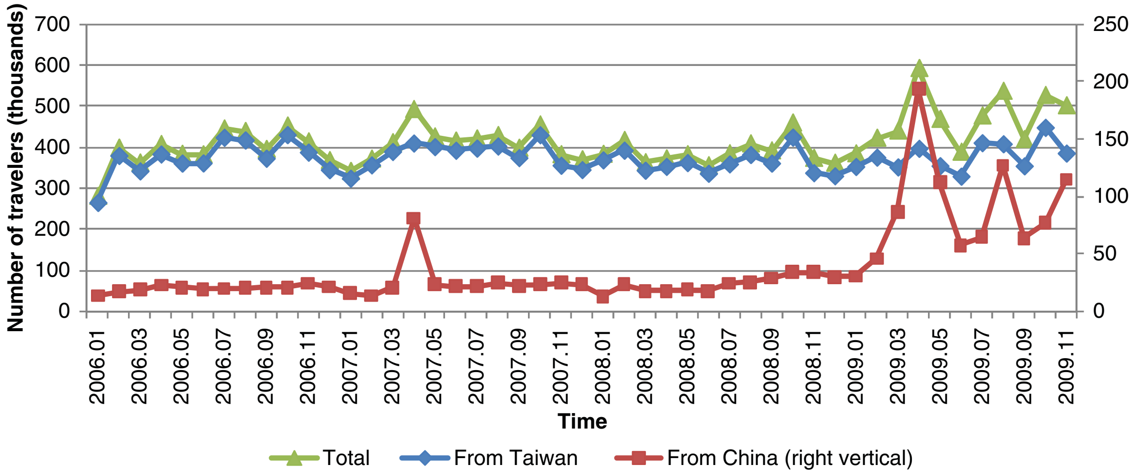

FIGURE 3 Monthly volume of cross-strait travelers based on location of departure.

(light blue crosses) has been shrinking. This finding implies that the decrease in traffic volume on the TWN–HK route is due partially to the commencement of nonstop flights.

However, the volume of passengers on the ferry routes accounts for approximately 5% of the total traffic and appears not to have been severely affected by the commencement of nonstop flights. Furthermore, according to a survey of travel patterns across the strait conducted in March 2009 (*4*), approximately 95% of passengers whose destination was Xiamen or Quanzhou traveled by ferry. This finding suggests a niche market for ferry routes.

AVIATION MARKET FOR NONSTOP-FLIGHT CITY PAIRS

Potential Markets

Figure 5 shows the characteristics of four nonstop routes between Taoyuan International Airport (TPE), Taipei International Airport (TSA), Kaohsiung International Airport (KHH), and Taichung International Airport (TXG); the first two airports are located in northern Taiwan and the last two are in southern and central Taiwan, respectively.

Figure 5 shows that TPE obviously dominates the nonstop-flight market, accounting for nearly 80% of passengers and capacity, 75% of flights, and 55% of routes. The three other Taiwanese airports carried the remaining passengers. Although TSA has been in second place in volume of passengers in the nonstop-flight market, its capacity, frequency of flights, and number of routes have all been decreasing. This situation may partially be the result of government policy and limitations caused by facilities. Most aircrafts operating out of TSA are medium-range and narrow-body craft such as the B757 and A321. Moreover, TSA is a city airport, located in the northern area of Taipei City, operating with only a limited number of permitted routes because of noise and considerations of capacity. Such restrictions have forced TSA to concentrate its nonstop-flight operations on a limited number of Chinese cities. In contrast, KHH and TXG have shown a steady increase in

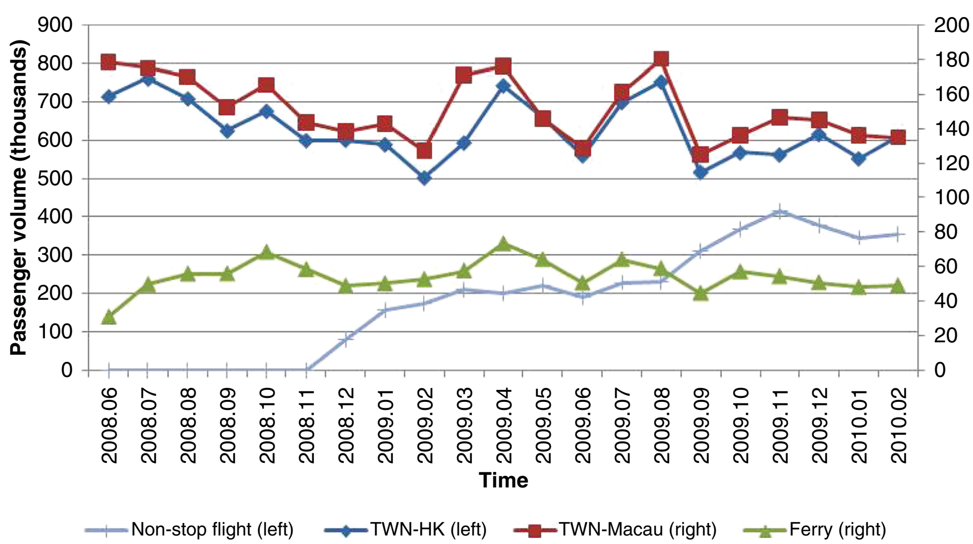

FIGURE 4 Monthly volume of passengers taking nonstop flights, flights between Taiwan and Hong Kong, flights between Taiwan and Macau, and ferries.

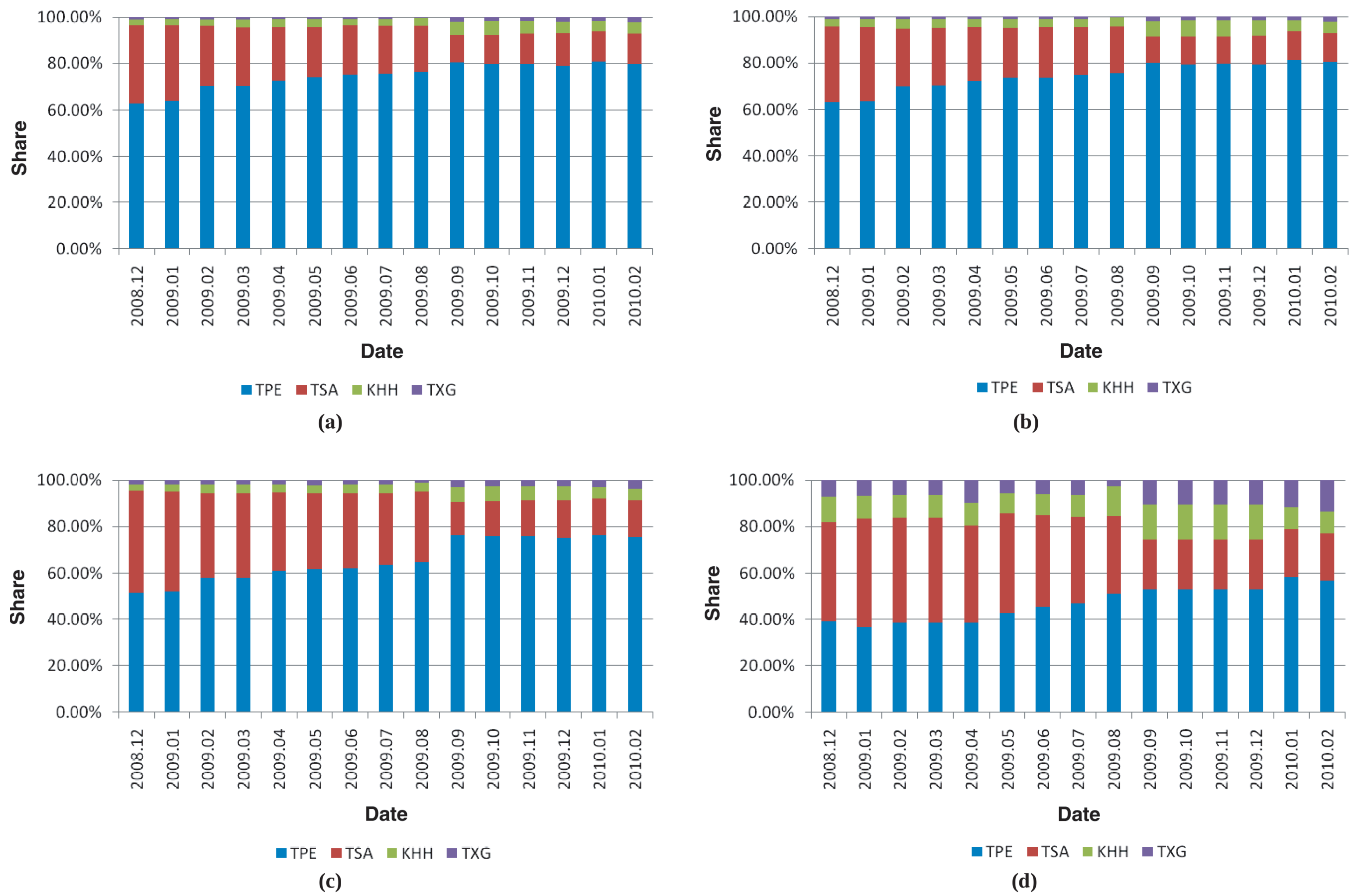

FIGURE 5 Market characteristics categorized by Taiwan airports: (*a*) monthly passenger share, (*b*) monthly capacity share, (*c*) monthly frequency share, and (*d*) monthly number-of-routes share.

passenger share in the nonstop-flight market, although the rate of change has been slight.

TPE is currently connected to 25 out of the 27 Chinese nonstop-flight cities, and all routes were still running in February 2010. In contrast, TSA, KHH, and TXG were connected with 20, seven, and seven Chinese airports at the beginning of nonstop flights, respectively; however, only nine, four, and five of them were still in operation in February 2010.

As shown in Figure 6, the Chinese cities connected with KHH (green circles) and TXG (yellow circles) are all east coast cities, including Hangzhou, Ningbo, Shanghai, Shenzhen, and Xiamen. TSA (pink circles) is connected to the aforementioned east coast airports as well as a number of cities in central mainland China including Wuhan, Nanchang, Chongqing, and Chengdu and one northern city, Tianjin. Finally, TPE is connected to 25 Chinese cities scattered across roughly the eastern half of mainland China.

Factors Affecting Market Potential

With increases in the flow of traffic across the strait, more city pairs are expected to join the nonstop-flight market. Therefore, it is important to examine the factors that influence demand in this market so that policy makers and carriers can make informed decisions and develop advantageous strategies.

Although passenger traffic is influenced by many factors, the focus here is on time, type of nonstop flight, supply, city location, and alternative connections.

Time

This study performs a longitudinal data analysis, making time an essential factor. Months are taken as the standard to represent time. This factor is considered a continuous variable and is recentered (i.e., the first month is coded as 0) for the convenience of interpretation in the modeling process.

Type of Nonstop Flight

As mentioned earlier, nonstop flights from December 2008 to August 2009 were charter flights, changing to scheduled flights in 2009. This factor is considered a time-varying dummy variable in the modeling process.

Supply

The factor of supply represents the availability of seats for cross-strait travelers. Before nonstop flights, most of these travelers made their way to China via Hong Kong, and a portion of them were expected to have switched to nonstop-flight routes. Thus, it is expected that a larger number (i.e., higher frequency or larger aircraft) of nonstop-flight routes would attract more passengers. This assumption remains uncertain, however, in consideration of the dynamic spatial evolution of Taiwanese businessmen in mainland China. Moreover,

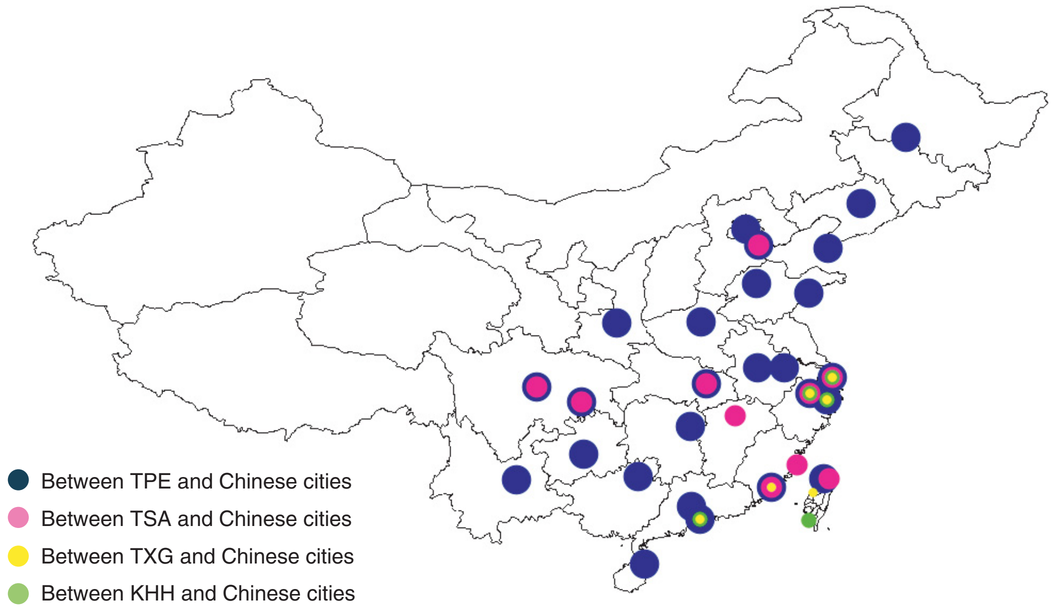

FIGURE 6 Spatial distribution of nonstop-flight city pairs in February 2010.

the impact of supply factors may differ between city pairs. These concerns are investigated by considering supply factors in the growth model.

City Location

The factor of location influences the volume of passengers taking nonstop flights because it implies flight and access time for routes. Furthermore, Chinese cities located in more southerly areas may face intense competition from TWN–HK routes or ferry routes. For these reasons, location was considered a factor, and the 27 Chinese cities connected by nonstop flights are categorized as north, central, south, and west areas in mainland China, as shown in Table 1.

Alternative Connections

As an alternative connection between mainland China and Taiwan and a major hub in southeastern Asia, Hong Kong airport provides frequent flights between Taiwan and Hong Kong and thus becomes a primary competitor to nonstop-flight city pairs, particularly for cities located in southern China. Although Macau offers another possible stopover between Taiwan and China, its share of the volume is relatively small. In addition, the volume of passengers via three small links (i.e., ships between Taiwan and Kinmen–Matsu and Fuzhou, Xiamen, and Quanzhou, in China) is even smaller. For the foregoing reasons, the market situation of the TWN–HK route was selected as the factor to represent the influence of alternative connections.

METHODOLOGY

Data

The data regarding demand for nonstop flights were obtained from the official statistics of the Civil Aeronautics Administration of Taiwan from December 2008, the first month of nonstop flights, to February 2010. Monthly volume data from a total of 15 months were collected for this study. The information provided by this data set is

TABLE 1 Variables

Factor	Variable	Type	Time-Varying	Value or Category
Time	TIME	Continuous	Yes	Month (recentered)
Type of nonstop flights	TYPE	Categorical	Yes	0: charter 1: scheduled
Supply	FREQ	Continuous	Yes	Monthly sum of flight frequencies of each city pair
	CAP	Continuous	Yes	Monthly sum of number of seats of each city pair
City location	LOC	Categorical	No	North: Zhengzhou, Dalian, Harbin, Shenyang, Xian, Beijing, Qingdao, Jinan, Tianjin Central: Changsha, Hefei, Hangzhou, Nanchang, Ningbo, Nanjing, Shanghai, Wuhan South: Guangzhou, Fuzhou, Haikou, Guilin, Shenzhen, Xiamen West: Chongqing, Chengdu, Kuming, Guiyang
Alternative connections	HK_FREQ	Continuous	Yes	Monthly sum of flight frequencies between Taiwan and Hong Kong
	HK_CAP	Continuous	Yes	Monthly sum of number of seats between Taiwan and Hong Kong

similar to that for U.S. Department of Transportation Form 41, Schedule T-100, including air carrier name, report date, origin–destination airports, aircraft types, available seats, and the number of passengers carried. Not all city pairs provided data for the entire 15 months. A number of nonstop routes started after December 2008 and did not remain in operation until February 2010. In addition, the data from five of the city pairs, totaling six data points, were excluded because these cities had fewer than three waves of data points, which threatened to negatively influence parameter estimation (*5*). In the end, 55 city pairs and 560 data points were adopted.

Multilevel Models

This research employed multilevel models (MLMs) to analyze systematic temporal changes regarding the data from the nonstop-flight market. The collected data were longitudinal and multiwave, which means that each city pair had one or more data points. Compared with traditional methods such as univariate analyses of variance, MLMs offer several advantages to analyzing data with a nested structure, including the ability to consider time-varying factors and evaluate the interactive effects of factors with time (*5*). A detailed discussion may be found elsewhere (*6*).

MLMs have been widely adopted in educational research for more than two decades (*7*); however, these models are still relatively new to researchers in air transportation. Abdelghany and Guzhva (*8*) discussed the advantages of using panel data over pure cross sections or pure time-series data in the analysis of air transportation, in which mixed-effect models (another name for MLMs) have to be considered. In their studies, statistical tests suggested the use of pooled ordinary least squares over mixed models. Nonetheless, in the next section, how the data adopted in this study indicate significant variance between city pairs will be examined, which led to the adoption of MLMs for this study rather than pooled or separate regression models.

In this research, the framework of linear growth curve models was adopted to examine passenger traffic trajectories of nonstop flights over the 15-month study period. In particular, a two-level framework was applied, and two initial models were estimated: an unconditional means model and an unconditional growth model.

The unconditional means model simply describes and partitions variation in the outcome, without predictors at every level:

Level 1:

$$Y_{ij} = \pi_{0i} + \epsilon_{ij}$$

Level 2:

$$\pi_{0i} = \gamma_{00} + \zeta_{0i}$$

$$\epsilon_{ij} \sim N\left(0, \sigma_{\epsilon}^2\right)$$

and

$$\zeta_{0i} \sim N\left(0, \sigma_0^2\right)$$

where

Y_{ij} = passenger volume for each city pair i on jth month,
π_{0i} = intercept in Level 1 representing initial passenger volume for each city pair i, and
ϵ_{ij} = error term in Level 1.

π_{0i} is further explained by Level 2 with intercept γ_{00} and a Level 2 error term ζ_{0i}. The two error terms, ϵ_{ij} and ζ_{0i}, both follow normal distributions with mean 0 and variance σ_{ϵ}^2 and σ_0^2, respectively. The unconditional means model stipulates that at Level 1, the true individual change trajectory for city pair i is completely flat.

The unconditional growth model introduces TIME into the Level 1 submodel:

Level 1:

$$Y_{ij} = \pi_{0i} + \pi_{1i}\text{TIME}_{ij} + \epsilon_{ij}$$

Level 2:

$$\pi_{0i} = \gamma_{00} + \zeta_{0i}$$

$$\pi_{1i} = \gamma_{10} + \zeta_{1i}$$

$$\epsilon_{ij} \sim N\left(0, \sigma_{\epsilon}^2\right)$$

and

$$\begin{bmatrix} \zeta_{0i} \\ \zeta_{1i} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_0^2 & \sigma_{01} \\ \sigma_{10} & \sigma_1^2 \end{bmatrix}\right)$$

where π_{1i} represents the slope of passenger traffic growth for each city pair i and σ_{01} and σ_{10} are the covariance between the two Level 2 variables, π_{0i} and π_{1i}. The Level 2 submodel has one additional equation to explain the value of π_{1i} with intercept γ_{10} and error term ζ_{1i}. Although the distribution of Level 1 error terms remains the same as in the unconditional means model, the distribution of the Level 2 error term becomes a bivariate normal distribution with a variance–covariance matrix as indicated earlier. An additional error term requires more than one parameter for estimation and thus quickly increases the complexity of computation.

On the basis of the unconditional means model and the unconditional growth model, the variables in Table 1 are introduced to investigate their relationship with the passenger traffic of nonstop flights. The analysis procedure follows the procedure suggested by Wallace and Green (*9*): (*a*) introduce variables with fixed effects only, (*b*) evaluate the random part of the model with the same fixed part based on the first step, (*c*) fine-tune the fixed part of the model, and (*d*) go through the previous three steps iteratively until a stable and interpretable model is obtained.

This research used software, R (*10*), with package "nlme" to develop MLMs. Full information maximum-likelihood estimation was adopted to estimate the parameters. Different variance–covariance structures were considered to reflect the autoregressive and heteroscedastic nature of longitudinal data and to scrutinize for better fits.

MODELING AND ANALYSIS

Is Multilevel Modeling Needed?

Before MLMs were estimated, it was necessary to evaluate whether MLMs were needed for the data of nonstop flights. The model of unconditional means was estimated and two indicators were computed: the intraclass correlation (ICC) and the design effect.

TABLE 2 Unconditional Means Model

Measure	Value
Fixed Effect	
INTERCEPT	5,450.99***
Standard error	1,386.64
Variance Components	
Level 1: within city pair	19,159,580.00
Level 2: in INTERCEPT	103,275,515.00
Goodness-of-Fit	
Deviance	11,195.73
AIC	11,201.73
BIC	11,214.71

NOTE: AIC = Akaike information criterion;
BIC = Bayesian information criterion.
$\sim p < .10$; $*p < .05$; $**p < .01$; $***p < .001$.

The ICC (ρ) represents the relative values of individual-level (within city pairs) and group-level (between city pairs) variances and is defined as follows:

$$\rho = \frac{\sigma_0^2}{\sigma_0^2 + \sigma_\epsilon^2}$$

The value ranges from 0 if the grouping conveys no information to 1 if all members of a group are identical. The results of the unconditional means model are shown in Table 2, with $\rho = 103{,}275{,}515.00/(103{,}275{,}515.00 + 19{,}159{,}580.00) \approx 0.844$. This value is far above the commonly seen ICC values in cross-sectional studies (between 0.05 and 0.20) (*11*), implying the need for MLMs.

To further confirm the need for MLMs, the effect of the design can be computed:

$$\text{design effect} = 1 + (n_c - 1)\text{ICC}$$

where n_c is the average number of monthly data points per city pair. Accordingly, the design effect for the nonstop-flight data was $1 + (10.182 - 1) * 0.844 = 8.749$, which is also far above the recommended threshold, 2.0 (*11*), indicating the need for MLMs.

Is a Linear Form Appropriate?

To decide whether a linear form would be appropriate for this multilevel modeling, the suggestions of Singer and Willett (*5*) were followed and linear growth models were used (i.e., TIME is the only predictor in the linear regression models) to analyze the passenger traffic of each city pair individually. Results showed that models for more than half the city pairs had *R*-square values higher than 0.5; therefore, a linear function form was considered acceptable for the estimation of MLMs to represent the data of nonstop flights.

RESULTS

The estimation results are shown in Table 3, where five types of models are presented: unconditional growth models, models with fixed effects only, models with interaction effects, models with random effects, and models considering autocorrelation or heteroscedasticity, or both, in their covariance structure. Only the best model for each type is presented.

Unconditional Growth Model

The unconditional growth model, Model A, introduces one predictor, TIME, into the Level 1 submodel. The results of Model A show that the average change in trajectory for passenger volume has a nonzero intercept of 2328.854 and a nonzero slope of 394.935. Compared with the unconditional means model (Table 2), the substantial reduction of Level 1 residual variance implies that the true change trajectory may be linear with TIME; approximately 68% of the within-city-pair variation in passenger volume was systematically associated with the linear variable TIME. The Level 2 variance components were used to quantify the amount of unpredicted variation in the intercepts and slopes. The correlation coefficient between the Level 2 residuals was 0.656, suggesting that routes carrying more passengers during the first month increased their share of the passenger volume more rapidly over time.

Models with Fixed Effects Only

Model B was the best model with individual fixed effects. As shown in Table 3, all of the coefficients were significant at a significance level of 0.10. Furthermore, both Level 1 and Level 2 variances were substantially reduced, indicating the effectiveness of the fixed effects.

The positive sign of the variable TIME indicated a positive rate of growth. This positive growth came from passengers diverting from the TWN–HK route as well as the newly introduced passengers because of the increasing flow of passengers between China and Taiwan, as shown in Figure 3. In particular, the Taiwanese government has gradually lifted the restrictions on Chinese tourists visiting Taiwan, which might contribute a great portion of the positive effect over TIME.

The positive coefficient of the variable FREQ was determined intuitively, because a higher frequency refers to better service for passengers, which could attract more passengers to use the nonstop-flight service. The positive sign also indicates that in the cross-strait aviation market, demand exceeds supply. Therefore, when more frequent flights are provided, passenger volume will increase.

The negative sign of the variable TYPE indicated that each city pair was expected to have more passenger traffic before September 2009 than after. This finding does not suggest that the operation of scheduled nonstop flights was less effective than the operation of charter flights. The unmet strong demand has gradually been absorbed by increasing supply (FREQ). Besides, the negative effect may have been the result of dilution of passenger traffic to the newly established neighboring airports following the expansion of flight networks. Fewer than 35 city pairs had nonstop flights before September 2009, but more than 45 city pairs had joined the nonstop-flight operations since that point.

Interestingly, the sign of the variable HK_VOL was positive. This finding shows that when more passenger traffic is observed on the TWN–HK route, more nonstop passenger traffic was expected. Three points can be made here. First, the TWN–HK route is an attractive alternative for nonstop-flight routes, particularly for those traveling between southern Chinese cities and Taiwan. Hong Kong is the primary gate to southern China, where Taiwanese businessmen have invested heavily. Second, the current supply of cross-strait flights is still restricted and far below demand, particularly for the city pairs

TABLE 3 Model Summaries

Measure	Model A Unconditional Growth	Model B Fixed Effects	Model C Interaction	Model D Random Effects	Model E Heteroscedasticity
Fixed Effects					
INTERCEPT	2,328.854* (1,024.589)	−2,185.478~ (962.059)	−3,486.239*** (864.518)	−3,138.186*** (819.290)	−2,610.546*** (702.037)
TIME	394.935*** (87.391)	113.799~ (48.802)	320.108*** (73.267)	169.701* (66.665)	207.391** (75.287)
TYPE		−2,429.120*** (454.104)	−1,151.489** (437.635)	−1,994.503*** (556.105)	−1,993.213*** (559.964)
HK_VOL		0.004* (0.002)	0.004** (0.001)	0.004** (0.001)	0.003** (0.001)
FREQ		182.493*** (5.518)	218.045*** (6.630)	208.947*** (6.054)	199.204*** (5.391)
FREQ × TIME			−7.549*** (0.676)	−2.645*** (0.586)	−2.744*** (0.561)
Variance Components					
Level 1: within-city-pair	6,102,318.7***	3,119,496.1***	2,499,415.3***	2,283,216.6***	1,009,904.2***
Level 2:					
In INTERCEPT	50,501,645.5***	7,763,128.2***	4,262,933.7***	3,321,953.3***	2,912,915.2***
In TIME	337,603.3***	19,083.1***	177,663.8***	142,897.4***	231,871.7***
In TYPE				6,524,450.4***	8,132,495.2***
Covariance					
Exponent					0.047
Goodness-of-Fit					
Deviance	10,672.93	10,179.21	10,128.18	10,057.72	10,029.59
AIC	10,684.93	10,197.21	10,148.18	10,083.72	10,057.59
BIC	10,710.89	10,236.17	10,191.46	10,139.98	10,118.18

NOTE: Numbers in parentheses refer to standard error.
~$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

connecting Taiwan to first-pier cities of China. A number of travelers are thereby forced to make a stopover in Hong Kong. Finally, more passenger traffic observed on the TWN–HK route implies that the overall aviation market in East Asia is improving, which also has a positive effect on nonstop flights. Therefore, the positive sign of HK_VOL only reflects the fact that the cross-strait nonstop market is part of the East Asian market benefiting from the economic development of the entire area.

Models with Interaction Effects

On the basis of Model B, the best model with interaction (fixed) effects is shown as Model C in Table 3, with the added interaction effect of FREQ by TIME. The significantly negative value suggests that the positive growth due to higher flight frequency could be offset with the elapse of time.

Models with Random Effects

From Model C, the best model with random effects is shown to be Model D in Table 3, where one random effect—TYPE—is included in the model. This result suggests that the effect of TYPE on passenger traffic, controlling for time, varies randomly across individual city pairs. Although all the coefficients of fixed effects remain significant and with identical signs as they do in Model C, the Level 1 variance and the variance for the intercept in the Level 2 submodel are substantially reduced. The goodness-of-fit statistics are also significantly better than those for the previous model based on an analysis of variance (ANOVA) test at a significance level of 0.01.

Models with Various Covariance Structures

Model D was further improved by considering various covariance structures. Because a longitudinal data set was analyzed, structures that could reflect autocorrelation and heteroscedasticity were tested. The best model was shown to be Model E in Table 3. Model E was significantly better than Model D on the basis of an ANOVA test at the significance level of 0.01. All of the coefficients of fixed effects remained significant with identical signs as they did in Model D, and the Level 1 variance and the variance for the intercept in the Level 2 submodel were further reduced compared with Model D.

DISCUSSION OF RESULTS

Nonstop flights between mainland China and Taiwan have been operating for more than a year, providing improvements in the connections across the strait in terms of shorter travel time. This study examines the evolving patterns of demand related to the city pairs associated with nonstop flights over the 15 months since the commencement of these flights. Analysis with MLMs showed that the cities selected for nonstop flights and the frequency of flights available were positively correlated with passenger traffic—the more flights air carriers provided between nonstop-flight city pairs, the more passenger traffic was observed. This result also implies insufficiency in the current supply of the cross-strait aviation market. Nevertheless, as indicated by the analysis results, the positive marginal effects provided by flight frequency have been fading with time, suggesting that the limits for passenger growth have been reached. In other words, nonstop flights have been sharing the cross-strait passenger market to a certain degree. At this stage of economic development, where passenger traffic across the strait has reached a relatively stable level, particularly for Taiwanese people traveling across the strait, air carriers should consider the limits to passenger growth when they devise their operational strategies. However, current economic connections between China and Taiwan are still developing. If more economic activity across the strait continues to develop, or the Taiwan government lifts its restrictions on incoming Chinese visitors, the total volume of traffic across the strait will increase.

Although all city pairs with nonstop routes have shown positive growth, the growth rates vary for each city pair. Moreover, the effects resulting from the change from charter flights to scheduled flights also vary between city pairs. These two heterogeneous characteristics of nonstop-flight city pairs are reflected in the significance of random effects in the time variable (TIME) and operation type variable (TYPE).

Although the fixed effect of the time variable was positive (indicating a positive rate of change), not all city pairs had such a positive effect after the random effects were considered. Eight city pairs were found that had negative time effects, indicating a shrinking aviation market associated with those city pairs. The three city pairs that were shrinking the most were Taoyuan–Tianjin, Taoyuan–Changsha, and Taipei–Dalian. In contrast, the three most rapidly growing city pairs were Taoyuan–Shanghai, Taoyuan–Beijing, and Taoyuan–Guangzhou.

The purpose of the operational change from charter to scheduled flights was to increase the frequency of flights and provide better air routes (i.e., shorter flight time) and belly-hold cargo services. Theoretically, this change should have increased the volume of traffic; however, the estimated effects, including fixed and random effects, were negative for every city pair after the effect of flight frequency was controlled for. In other words, after the benefits of increased flight frequency were removed, the change from charter to scheduled flights was negative with regard to passenger traffic growth in each city pair. This negative effect was particularly obvious in big city pairs, such as Taoyuan–Beijing, Taoyuan–Guangzhou, Taoyuan–Hangzhou, Taoyuan–Shanghai, and Taoyuan–Shenzhen. In short, it might be concluded that the biggest benefit provided by the change of operations from charter flights to scheduled flights was the increase in flight frequency. The inclusion of additional Chinese cities in the cross-strait aviation market after scheduled flight operations would increase competition among city pairs and lower the growth rates of the original city pairs, particularly for the large cities.

As the flow of traffic across the strait intensifies, the cross-strait aviation market is expected to open up, providing more flights and more carriers to join the market competing for passengers. Meanwhile, it will be necessary for the Hong Kong airport to consider how to respond to this trend. Currently, most nonstop routes are unable to compete with the frequency of TWN–HK routes, and the difference in ticket price between nonstop flights and flights via Hong Kong is not particularly obvious. However, the Hong Kong airport is going to face more severe competition from nonstop flights.

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