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FORECASTING AIR PASSENGER VOLUME IN SINGAPORE: DETERMINING THE EXPLANATORY VARIABLES FOR ECONOMETRIC MODELS

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Abstract

Nowadays aviation industry has become an important portion of Singapore economies progressively. It is essential to provide accurate prediction for aviation development. However, due to instability of economies, it is advisable to capture the impact of economy into forecasting. This paper explores several explanatory variables, such as Singapore GDP, China GDP, exchange rate and tourist numbers, to build econometric models to predict the air passenger movements and analyzes and compares the relative results from corresponding models. Before applying for model simulation, correlations among variables were checked. Various combinations of the variables were implemented to establish the models. Five econometric models were constructed for 18 years prediction from 1998 to 2015 in our study and the performance of these models were measured using MAPE, RMSE and degree of

divergence. By comparing the 5 models, the variables effectiveness is investigated. Moreover, the impact of the variables was also scrutinized. Finally, appropriate models for Singapore situation are to be recommended. Afterwards, forecasting for the next 18 years till 2033 is conducted and analyzed to have a better idea of the future development.

Keywords

Air passenger volume; Econometric models; Explanatory variables; Long-term forecasting; GDP

1. INTRODUCTION

The aviation industry becomes a large portion of Singapore economies progressively. Hence, it is primary to improve the service standard in order to increase the profitability of this industry. In addition, due to emerging low cost carriers, more demands occur, causing more congestion. Congestion and delay, which are costly, will degrade the airport service. Under such circumstances, an accurate forecast is necessary for keeping the service standard and implementing necessary facility construction plan.

The relationship between air passenger volume growth and economic activity (e.g. GDP) has been studied, indicating that GDP can influence air passenger transport development (Profillidis & Botzoris, 2015). International air passenger volume in Saudi Arabia was analyzed using several causal models, showing the explanatory variables are not affected by multicollinearity (Abed, Ba-Fail, & Jasimuddin, 2001). Total population and expenditures etc were employed in the model (Abed, Ba-Fail, & Jasimuddin, 2001). Maduranga and Anuja utilized GDP, Jet Fuel Price, Tourist Traffic Growth Index and Terrorist Activity as parameters of an econometric model (Priyadarshana & Shamini Fernando, 2015). In addition, real private consumption expenditure was utilized to forecast air passenger demands (Dennis, 2002). An ARIMAX econometric model has been employed to forecast Hong Kong air passenger demands (Tsui, Ozer Balli, Gilbey, & Gow, 2014). They also analyzed and proved the causality relationship between trade and travel volumes by using Engle-Granger vector autoregressive model (Tsui & Fung, 2016). The TVP (time varying parameter) model was shown to provide more accurate preceded forecasts than other

econometric models (Song & Witt, 2003). Analyses of explanatory variables affecting tourism demands were also conducted via structural equation modelling (Turner & Witt, 2001). TVP linear AIDS (Almost Ideal Demand System) was built to forecast tourism demands (Li, Song, & Witt, 2006). A TVP error correction model was also employed by Song and Witt for tourism demands forecasting (Li, Wong, Song, & Witt, 2006).

Forecasting air passenger demand means the introduction of forecasting models, statistical theories, assumptions, procedures and interpretation of results. In this paper, five econometric models were built. Different combinations of explanatory variables were implemented. Subsequently, the comparison of these five models was carried out.

2. Data Collection

The data of China GDP from 1998 to 2015 was gathered from the annual data of China GDP published by National Bureau of Statistics of China (Statistical Communiqué of the People's Republic of China, 2015). Likewise, the data of India GDP from 1998 to 2015 was extracted from Planning Commission of India (Planning Commission, Government of India, 2015). The data of Singapore GDP from 1998 to 2015 was collected from World Bank ("GDP at market prices (current US$) | Data", 2016). The exchange rates from Singapore dollars (SGD) to Chinese Yuan (CNY) and SGD to Indian Rupee (INR) during 1998 and 2015 were both collected from Foreign Currency Exchange Rates and Currency Converter Calculator website (fx-rate.net, 2016). The yearly average of exchange rate was used. In addition, Singapore tourists' volume data from 1998 to 2015, which was used as one of the explanatory variables, was collected from Singapore Tourism Board (Singapore Tourism Board, 2016).

3. Research Methodology

3.1 Explanatory variables discussion

An econometric model is a tool to forecast further developments considering various economic factors, such as inflation, GDPs and currency exchange rates. Nowadays the numbers of Chinese and India tourists are increasing and they have become the key market for recent years. Thus, in the models China and India GDPs are determined to be the explanatory variables. In addition, Consumer Price Index, Per Capita Income, Import of Goods and Services, Exchange Rate (Singapore/China), Exchange Rate (Singapore/INR), Consumer

Price Index and Population size were also taken into consideration. SPSS software was utilized for building representative models. GDP and GDP per capita are indicated to be correlated variables, showing no necessity to be variables simultaneously. Likewise, the relationships between other variables are also required to be examined (Abed, Ba-Fail, & Jasimuddin, 2001).

GDP was investigated initially. Figure 1 shows that Singapore GDP and India GDP behave similarly. China GDP and India GDP also follow the same trend. When one country GDP growths increase, the other two appear the same tendency. Therefore, only one country GDP was chosen for the model. Due to larger population from China comparing to Singapore, China GDP growth was assumed to have more impact on the passenger volume increase initially. Hence, China GDP was considered as one explanatory variable. Likewise, the exchange rate of SGD to INR is observed to be highly correlated to Singapore, China and India GDP. Hence, the exchange rate of SGD to INR was not used.

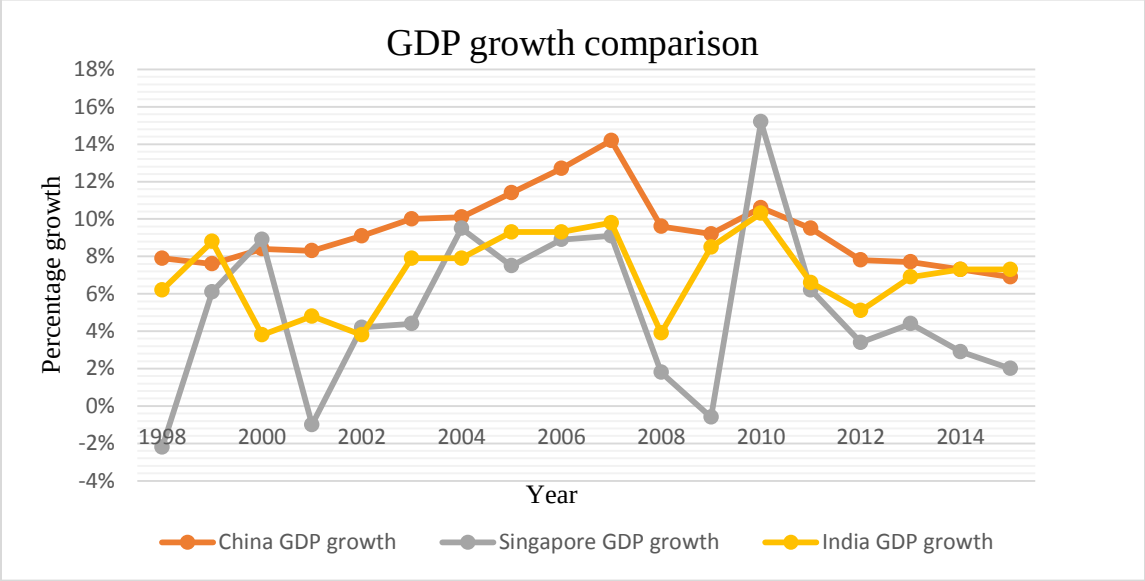

Figure 1: *Comparisons of China, Singapore and India GDP growths*

By observation from Figure 2, Singapore Consumer Price Index and China Consumer Price Index are highly correlated. India Consumer Price Index, however, behaves differently. Since Singapore is the study objective, Singapore Consumer Price Index and India Consumer Price Index are adopted as explanatory variables separately for model building. Subsequently they are compared to evaluate which one is feasible.

3.2 Model Construction

In this section, the econometric analysis is done by using SPSS software. Linear Regression was applied initially, whereas the result was found not satisfactory. The significant level of Singapore Consumer Index was observed to be 0.69 which was much larger than 0.1. The reason may be shopping is one of Singapore's attractions and Singapore is also a large transit place to go to other country. Under such condition, the variation of Singapore consumer index has no much influence on the tourist volume, hence no much effect on the air passenger volume growth. As such, Singapore consumer index was removed from independent variable set. In addition, since the growth rate of Singapore population was not significant, this factor was not considered due to little contribution to air passenger growth. In summary, China GDP, the exchange rate from SGD to CNY and the India Consumer Price Index were used as explanatory variables for Econometric model 1.

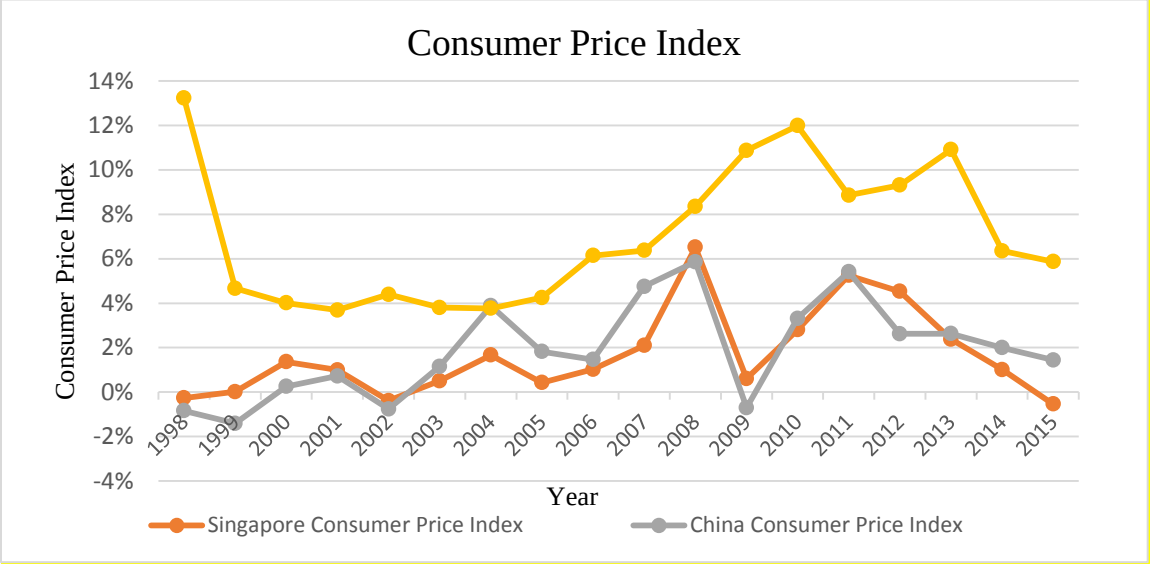

Figure 2: *Comparisons of Consumer Price Index*

Another group of explanatory variables is also chosen for modelling. The group is composed of China GDP, the exchange rate from SGD to CNY and Singapore tourist number for econometric model 2.

Although China provides large portion of tourists to Singapore, employing China GDP only provides a partial view of constitutes of Singapore air passenger volume. In light of the constraint, another set of explanatory variables, inclusive of Singapore GDP, Singapore

Consumer Index and Singapore tourists' number is used for air passenger prediction. Singapore import of goods and services were also considered. Hence two more models were built. One is with Singapore GDP, Singapore Consumer Index and Singapore tourists' number, which is marked as econometric model 3. The other is simulated with Singapore GDP, Singapore Consumer Index and Singapore import of goods and services, which is considered as econometric model 4. Moreover, in consideration of better comparison, econometric model 5 was built, using Singapore GDP, the exchange rate from SGD to CNY, and Singapore tourist numbers. The details are summarized in Table 3.2.1.

Table 1: *Summary of econometric models built*

Model Name	China G	The exchange from SGD to C	India C	Singapore GDP	Singapore C	Singapore touris number	Singapore Imports
Econometric Model 1	Yes	Yes	Yes	--	--	--	--
Econometric Model 2	Yes	Yes		--	--	Yes	--
Econometric Model 3	--	--	--	Yes	Yes	Yes	--
Econometric Model 4	--	--	--	Yes	Yes	--	Yes
Econometric Model 5	--	Yes	--	Yes	--	Yes	--

4. Result Analysis

In terms of econometric model 1, the coefficient of determination R^2 was calculated to be 0.979, which indicated a good match between the regression and actual data. The least-squares lines of the model is calculated to be

$$Y_t = -4772908.836 + 3.107X_1 + 6189088.8\,X_2 - 267948.44X_3$$

where X_1 stands for China GDP, X_2 stands for the exchange rate of SGD to CNY and X_3 stands for India consumer price index. If α=0.05 or 5% level, the two-tails critical t value is 2.110 for 17 degrees of freedom ("t Table", 2007). If α=0.01 or 1% level, the two-tails critical t value is 2.898 for 17 degrees of freedom. If α=0.1 or 10% level, the two-tails critical t value is 1.740 for 17 degrees of freedom.

According to Table 4.1, the t value of X_1 is much larger than the critical value at 1% level. Likewise, the t value of X_2 is larger than the critical value at 5% level. The t value of X_3, however, is smaller than the critical value at 10% level. The t-test significance of the coefficients was 0.000, 0.032 and 0.106, respectively. It can be observed that for the coefficients for China GDP and the exchange rate of SGD to CNY, 0.000 and 0.032 show that the coefficients fall into the 99.5% confident interval. Therefore, these two coefficients are statistically significant. The coefficient of China GDP is positive, which indicates a booster to Singapore air passenger movements. The coefficient of exchange rate of SGD to CNY, however, is positive shown above, which conflicts with the reality. The reason may be there is strong influence of China GDP on the exchange rate. In terms of the coefficient of India Consumer Price Index, 0.106 shows that the coefficient does not even fall into 90% confident interval. Hence, the coefficient for India Consumer Price Index is not statistically significant. Furthermore, the trend of the India and Singapore Consumer Price Index (CPI) is observed to be similar. Thus the change of India CPI may not have much influence on the growth of passenger movements. In conclusion, it shows that this model is not an appropriate model for Singapore passenger volume.

Table 2: *Coefficients analysis of econometric model 1 and model 2*

Model information						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t values	p value
1	(Constant)	−72126	132353			
	China GDP	42	1			
	SGD to CNY	66326	27920			
	India Consumer Price Index	−2690	1558			
2	(Constant)	161128	34337			
	China GDP					
	SGD to CNY	−17824	7960			
	Singapore Visitors					

In terms of econometric model 2, the adjusted coefficient of determination R^2 was calculated to be 0.998. The linear equation of the model is shown as Equation (2).

$$Y_t = 16112870.87 + 0.689X_1 - 1782446.58X_2 + 2.62X_4 \quad (2)$$

where X_4 stands for Singapore tourist volume.

Table 4.1 illustrates the absolute values of t of the coefficients for all the three explanatory variables are larger than the critical t value at 5% level. Hence, all the three explanatory variables are statistically significant.

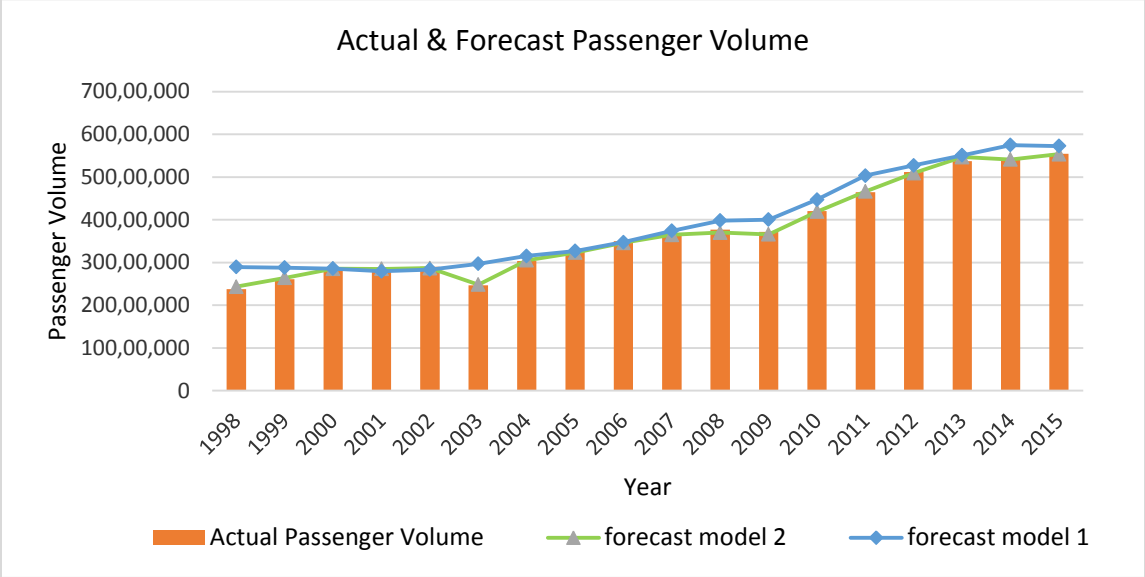

Figure 3: *Comparison of actual volume and forecasting demand for model 1 and model 2*

The forecasting passenger demands of econometric model 1 and model 2 are calculated out. Figure 3 shows the forecast of model 2 is quite accurate, but the forecast of model 1 is overestimated. The MAPE of model 2 is 0.906%, which is much lower than model 1, 5.89%. It is noteworthy that the MAPE of econometric model 1, 5.89%, is larger than that of the quadratic model, 4.26%. The general distribution of the degree of divergence is shown in Figure 4. The error distribution of econometric model 1 is around 0, however the error measurement of model 2 appears two outliers, and all the errors are far from zero.

After simulation of the third model, according to Table 4.2, the equation was calculated to be

$$Y_t = 5842034.759 + 30190350.07X_5 - 214467.136X_6 + 2.587X_7 \qquad (3)$$

X_5 stands for Singapore GDP (in millions), X_6 stands for Singapore Consumer Price Index and X_7 stands for Singapore tourists' numbers in Equation (3). The adjusted $R^2$was calculated to be 0.995.

Table 4.2 illustrates that the t values of these three coefficients are all larger than the critical t value for 5% level except the Singapore Consumer Price Index. Nevertheless, under the condition of 10% level, the coefficient of Singapore Consumer Price Index still falls within the confidence level, which is acceptable.

The fourth model was obtained as Equation (4):

$$Y_t = 8549946.017 + 132495485.873X_5 - 755985.629X_6 + 37192.607X_8 \quad (4)$$

where X_8 stands for Singapore Import of goods and services. The adjusted R^2 was 0.971. It is noticed in Table 4.2 that the coefficients of Singapore GDP (in millions) and Singapore Consumer Price Index are well fitted into the 95% confident level. The signs of the coefficients are in accordance with the real situation. If Singapore GDP grows and import increases, the air passenger movements will be boosted. But the coefficient of the Import of goods and services only falls in 70% confident level, which is not a good fit.

Table 3: *Coefficients analysis of econometric model 3 and model 4*

Model information						
Model		Unstandardized Coefficients		Standardized Coeffic	t values	p values
		B	Std. Error	Beta		
3	(Constant)	58420	11346			
	Singapore GDP(in millions)	30190	11284			
	Singapore Consumer Price Index	−2144	1052	-	-	
	Singapore Visitors					
4	(Constant)	85499	63559			
	Singapore GDP(in millions)	1324954	66924			
	Singapore Consumer Price Index	−7559	3287	-	-	
	Import	371	345			

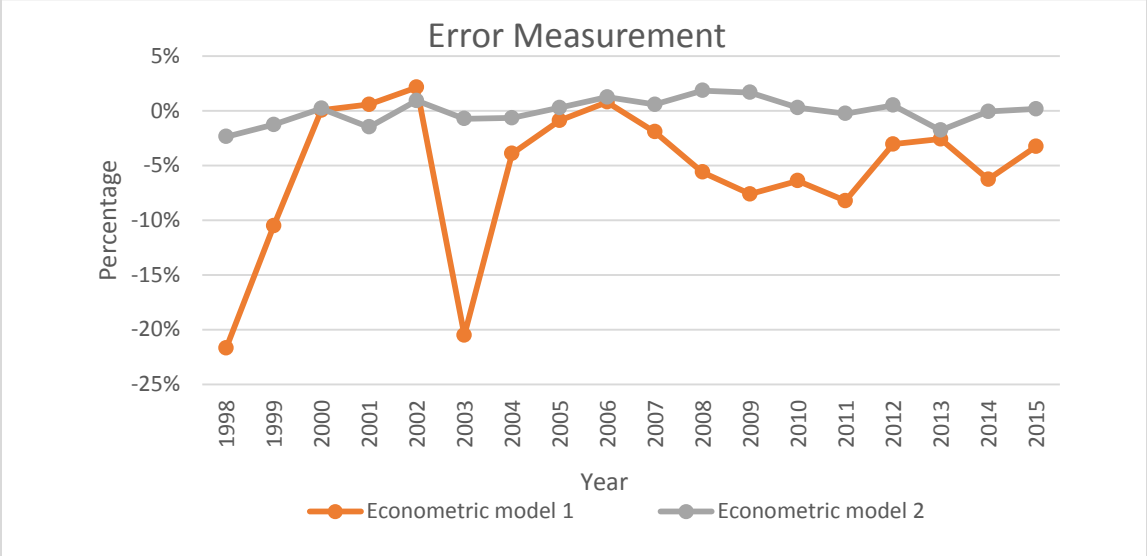

Figure 4: *Error Measurement of econometric model 1 and model 2*

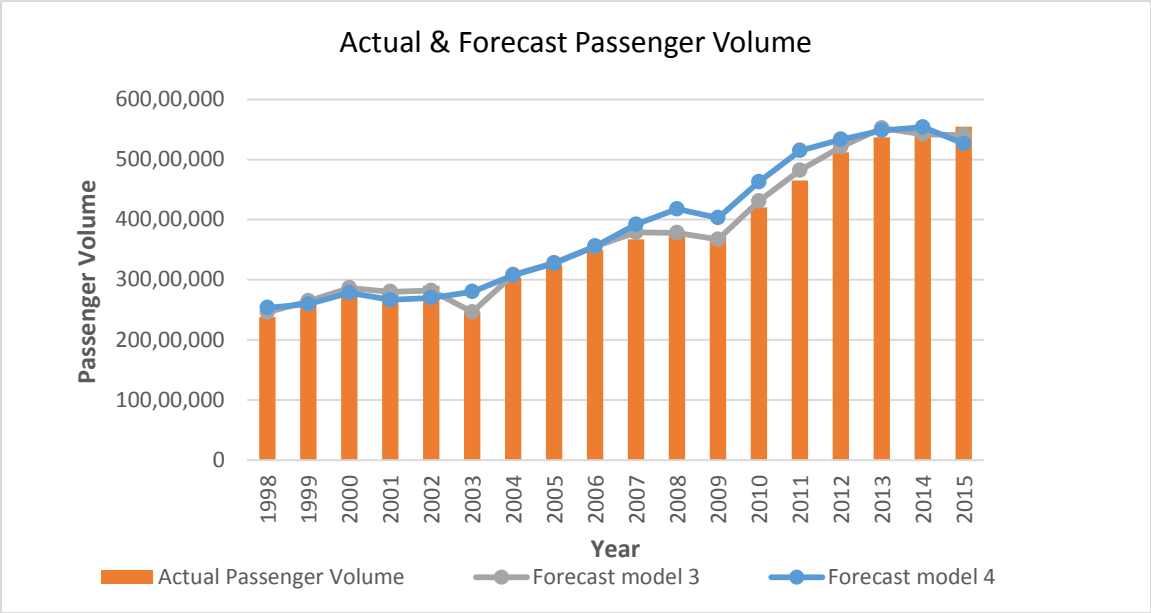

Figure 5: *Comparisons of actual volume and forecasting demand for model 3 and model 4*

In addition, Figure 5 shows that econometric model 3 outperforms econometric model 4. Although econometric model 4 also follows the actual trend tightly, the error was relatively large, causing overestimation and sometimes underestimation greatly. The D_{mean} of econometric model 3 was 1.69% while that of econometric model 4 was 5.54%. The largest degree of divergence for model 3 is -3.69% and for model 4 is -13.54%. The general distribution of the degree of divergence is shown in Figure 6. It is clearly indicated that the corresponding errors of model 3 were smaller compared to model 4. In addition, the degrees of divergence for model 3 all fall into the range of $\pm 5\%$, which indicates a good performance. The degrees of divergence for model 4, however, show significant outliers which can lead to accuracy reduction.

Table 4: *Coefficients analysis of econometric model 5*

Model information						
		Unstandardized Coefficients		Standardized Coeff		
Model		B	Std. Error	Beta	t value	p value
5	(Constant)	266027	32379			
	Singapore GDP (in millions)	310870	58975			
	Singapore Visitors					
	SGD to CNY	−43226	6417			

The equation of model 5 was obtained as follows:

$$Y_t = 26602722.17+31087002.85X_5 -4322612.246\times X_2 +2.564X_7 \quad (5)$$

The adjusted R^2 was calculated to be 0.999, which illustrates a highly match referring to Figure 7. The signs of coefficients all follow the real situation. According to Table 4.3, the p values of the coefficients are all close to 0. The t-values of the coefficients are all larger than the critical t value, 3.965, at 0.1% level for 17 degrees of freedom. Therefore, model 5 is claimed to be statistically significant.

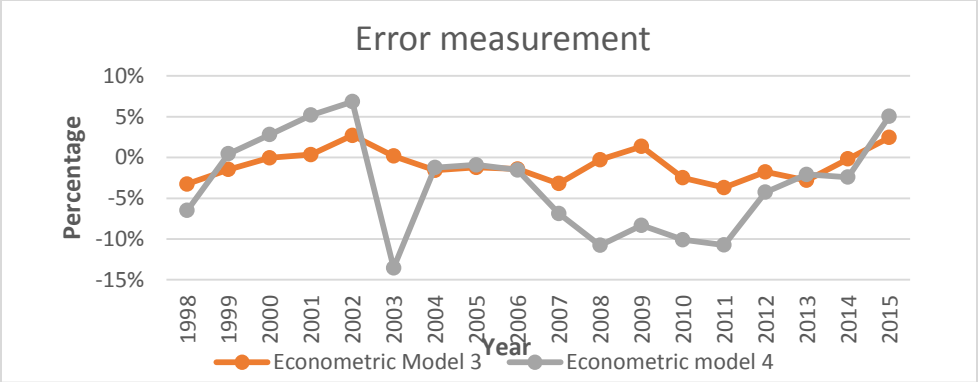

Figure 4: *Degrees of divergence of econometric model 3 and model 4*

Since econometric model 2 generates better result than econometric model 3, and for further in-depth comparison, econometric model 5 was taken into the picture. It was inferred that the exchange rate of SGD to CNY improved the model in comparison to Singapore Consumer Price Index. This one aspect demonstrates that along with rapid development of the world economy, air travel is becoming less of a luxury in people's life. Under such condition, the explanatory variable of Singapore Consumer Price Index has less influence on the change of air passenger volume as the living standard becomes higher. It also illustrates from another side that China tourists contribute much on the growth of Singapore air passenger movements. Econometric model 5 was built on such basis. Consequently, econometric model 5 outperforms other models. In addition, it can be observed that the coefficient of the exchange rate of SGD to CNY is negative, conforming to the real situation. When the exchange rate becomes higher, the passenger movements will decrease.

Table 4.4 shows the overall performance of the five models pertaining to error measurements. It can be observed that all the four error measurements of econometric model 5 have the smallest values while econometric model 1 has the largest. Figure 7 also illustrates that econometric models 2, 3 and 5 all fit the actual passenger volume quite well and reflect the overall trend. Whereas, econometric model 5 is the best-performed model, while econometric model 3 is the worst-performed model.

5. Forecasting of next 17 years air passenger demand

In view of the previous section, econometric model 5 was the best performed model. Consequently, 18 more years' passenger demands are forecasted. Firstly, the values of the explanatory variables are predicted for next 17 years. According to Ministry of Trade and Industry (MTI), the GDP growth forecast range is estimated to be 2-4 percent till 2020, while after 2020 the growth rate is assumed to follow normal trend that is 3-5 percent (Tay, 2015). Hence, in an optimistic scenario, Singapore GDP is forecasted with continuous growth. 3 percent was decided for the period till year 2020, and 4 percent from year 2021 to 2033. The exchange rate from SGD to CNY is set to be the average value of the 18 years, which is 4.8717. Moreover, as Singapore visitors' volume follows the trend of the air passenger volume, ARIMA (3, 2, 2) was employed to predict Singapore visitors demand from year 2017 to 2033 (GUO & ZHONG, 2016).

Table 5: *Error measurements of 13 models*

Models	MAPE	RMSE	Largest Degree of divergenc (Absolute value)	D_{bal}
Econometric model 1	5.89%	2534130	21.67%	5.49%
Econometric model 2	0.91%	400459	2.36%	0.05%
Econometric model 3	1.69%	839354	3.69%	0.91%
Econometric model 4	5.54%	2492358	13.54%	3.27%
Econometric model 5	0.67%	355495	2.18%	0.02%

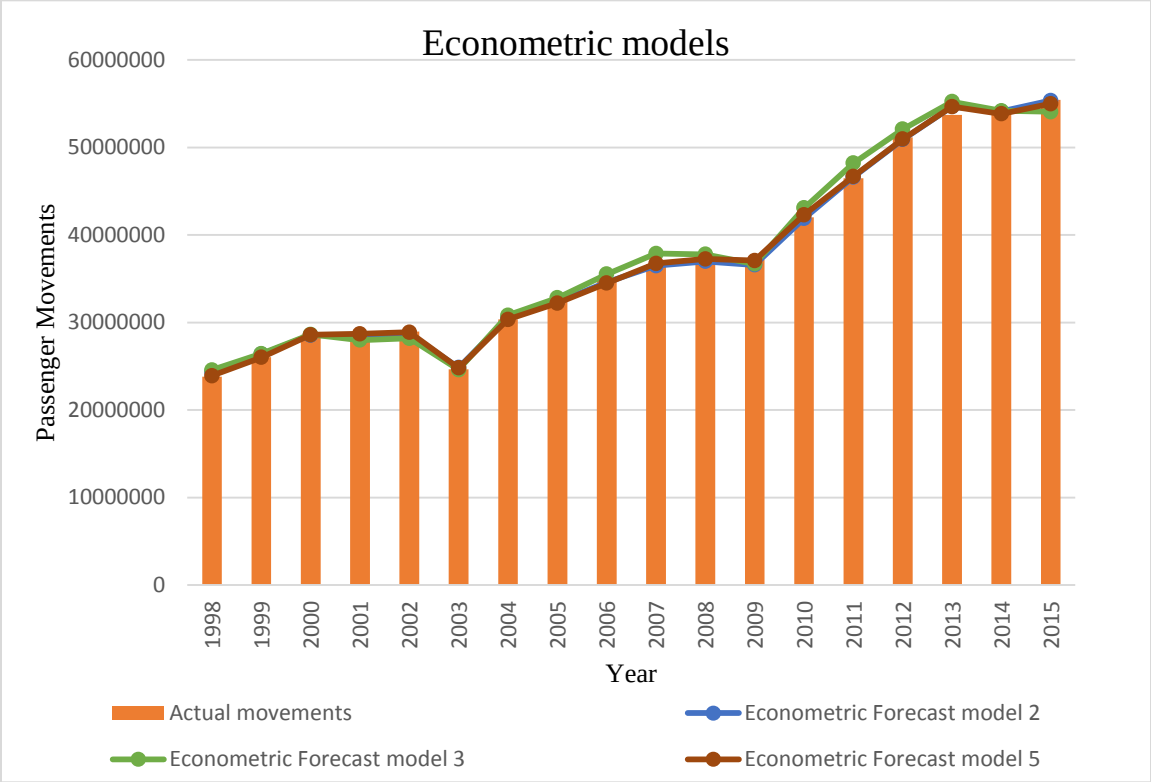

Figure 7: *Forecasting results comparisons between econometric models*

The pessimistic scenario was also considered. In accordance with the historical GDP data from 1998 to 2015, it is speculated that every 6 years there would be economic crisis, which means GDP in year 2021, 2027 and 2033 would decrease. The decrease rate is set as the average of decrease rate extracted from historical data, which is −3.89%. The predicted growth rate was set to be the same as the optimistic scenario.

Afterwards, Equation 5 for econometric model 5 was used. Figure 8 shows the forecasting results. In the optimistic scenario, it shows that in 2033 the air passenger volume may rise to 103,847,242, double of the current passenger volume. In the pessimistic scenario, 100,144,762 was obtained, 1.8 times of the current passenger volume. It is understood that the current handling capacity is 66 million passengers. The forthcoming terminal four can handle 16 million passengers, bringing Changi Airport's total capacity to 82 million passengers (Changiairport.com, 2016). Thus, there is necessity of the concept plan of Terminal 5 to be implemented (Changiairport.com, 2016). As Terminal 5 can increase the total capacity to 135 million passengers, referring to our forecasting results, by 2033 Changi airport can continue to operate appropriately.

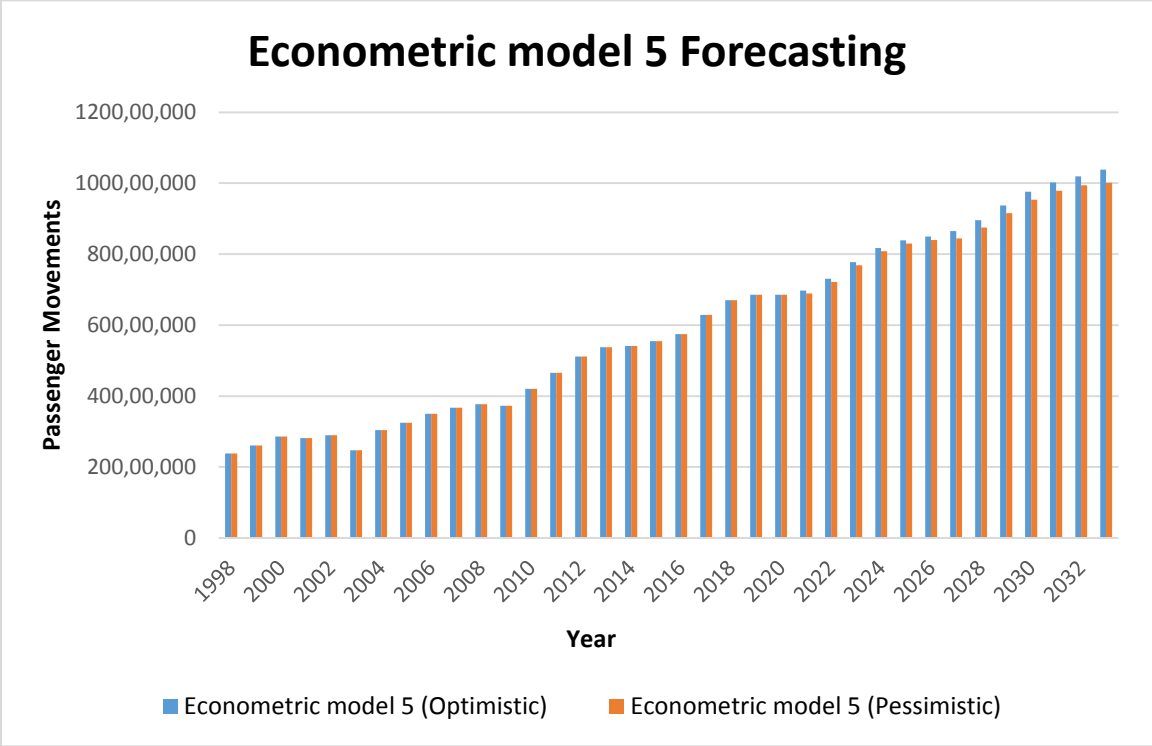

Figure 8: *Forecasting passenger volumes from year 2017 to 2033*

6. Conclusion and Future Works

This study examined the forecasting ability of several econometric models for air passenger movements in Singapore. Seven explanatory variables are explored: China GDP, the exchange rate from SGD to CNY, India CPI, Singapore GDP, Singapore CPI, Singapore tourists' number and Singapore Imports. Four performance measure metrics are used to conduct the analysis of all the models: MAPE (Mean Absolute Percentage Error), RMSE (Root Mean Squared Error), absolute value of largest degree of divergence and balance of degree of divergence. The results in this study show that all the models provide quite accurate prediction, in which econometric model 5 is the best.

While building econometric models, more factors should be adopted. For instance, events should be considered. The market share of low cost carriers should also be investigated about the influence. In addition, Design of Experiment (DOE) can be used to select the explanatory variables. Since the ARIMA model were the best model among time series models (Guo & Zhong, 2016), combination of ARIMA and econometric models can be studied to improve the accuracy.

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