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Forecasting of Hong Kong airport's passenger throughput

Wai Hong Kan Tsui [a,*], Hatice Ozer Balli [b,c,1], Andrew Gilbey [a,2], Hamish Gow [a,3]

[a] Building SCT Room 2-16, Mawson Lakes Boulevard, Mawson Lakes, South Australia, Australia
[b] School of Economics and Finance, Massey University, Palmerston North, New Zealand
[c] Department of Economics, Suleyman Sah University, Istanbul, Turkey

HIGHLIGHTS

- The SARIMA and ARIMAX models were employed for forecasting air passenger throughput of Hong Kong until 2015.
- Future air passenger traffic of Hong Kong is projected to grow under different scenarios (an average of 0.5–0.8% per month).
- Both forecasting models are highly accurate with smaller forecasting errors.
- Future air passenger numbers travelling to Hong Kong from seven markets are likely to increase.
- Negative growth in air passenger numbers is predicted for Africa, Mainland China, and Taiwan.

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ABSTRACT

Hong Kong International Airport (HKIA) is one of the main gateways to Mainland China and the major aviation hub in Asia. An accurate airport traffic demand forecast allows for short and long-term planning and decision making regarding airport facilities and flight networks. This paper employs the Box–Jenkins Seasonal ARIMA (SARIMA) model and the ARIMAX model to forecast airport passenger traffic for Hong Kong, and projecting its future growth trend to 2015. Both models predict a steady growth in future airport passenger traffic at Hong Kong. In addition, scenario analysis suggests that Hong Kong airport's future passenger traffic will continue to grow in different magnitudes.

1. Introduction

Since the opening of the new Hong Kong International Airport (HKIA) at Chek Lap Kok in 1998, its airport traffic volumes (i.e. air passenger numbers and air cargo volume) have grown steadily, with the exception of during the aftermath of the September 11 terrorist attacks in the United States and the SARS outbreak (Grais, Ellis, & Glass, 2003; Kozak, Crotts, & Law, 2007; Lam, Zhong, & Tan, 2003; McKercher & Hui, 2004; Pine & McKercher, 2004; Siu & Wong, 2004). However, HKIA has experienced a tremendous challenge in the face of competition from nearby major international airports located in Southern China (i.e. the Pearl River Delta (PRD) region), Mainland China, and the neighbouring Asian nations (Wang et al., 2006; Yeung & Shen, 2008; Zhang, 2003). In terms of future air passenger demand at HKIA, it has been predicted that a decline in air passenger and cargo throughput will occur and its dominant role as the international hub and gateway to Mainland China will be subject to fierce competition from nearby international hub airports in the region (Hobson & Ko, 1994; Seabrooke, Hui, Lam, & Wong, 2003; Williams, 2006; Zhang, 2003). Furthermore, "neither the [Hong Kong's] gateway role nor the hub role should be taken for granted, and it will be risky to think that the hub role may be maintained forever and…high growth rates will persist for a long time" (Zhang, Hui, Leung, Cheung, & Hui, 2004, p. 95).

Tourist demand and the international air cargo hub status of HKIA has already been the subject of many prior studies (Cheng, 2011; Cho, 2003; Hiemstra & Wong, 2002; Wang & Cheng, 2010; Zhang, 2003; Zhang et al., 2004). However, few studies have attempted to forecast airport passenger demand for Hong Kong using empirical approaches (AAHK, 2011; Robinson, 2006; Williams, 2006). These significant shortfalls in prior research with respect to

* Corresponding author. Tel.: +61 8 8302 3360; fax: +61 8 8302 3384.
E-mail addresses: kan.tsui@unisa.edu.au, tsui_kan@windowslive.com (W.H.K. Tsui), H.Ozer-Balli@massey.ac.nz (H. Ozer Balli), A.P.Gilbey@massey.ac.nz (A. Gilbey), H.R.Gow@massey.ac.nz (H. Gow).
[1] Tel.: +64 6 356 9099x84044.
[2] Manawatu Campus, Social Science Tower 8.23, Massey University, Palmerston North, New Zealand. Tel.: +64 6 356 9099x4767.
[3] Manawatu Campus Room SST 4.05, Massey University, Palmerston North, New Zealand. Tel.: +64 6 350 5799x5514.

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HKIA are the main objective of this study; that is, to forecast and predict whether its future passenger throughput will continue to grow or decline. To achieve this, an accurate and reliable method of airport passenger demand forecasting is required, which will assist the short- and long-term planning and decision-making in number of areas (e.g. the planning of airport infrastructure and capacity from the government of Hong Kong and the airport authority, as well as flight network planning from home-based airlines). Furthermore, it aims to enhance the existing knowledge with respect to the development and application of suitable forecasting models to this specific type of international gateway hub airport.

This paper is believed to be the first empirical study to employ the Box–Jenkins ARIMA methodology to build and estimate the Seasonal ARIMA (SARIMA) model and ARIMAX model for forecasting HKIA's passenger throughput (using the data between 1993 and 2011) and project its future growth trend for the period of 2011–2015. This choice of methodology is supported by prior studies which have found that ARIMA-based models can accurately forecast airport traffic demand (Abdelghany & Guzhva, 2010; Andreoni & Postorino, 2006; Kawad & Prevedouros, 1995; Payne & Taylor, 2007). It is envisaged that the forecasting results will offer an insight with respect to the growth in HKIA's future passenger traffic and, perhaps more importantly, this projection will help to highlight the future challenges for policy makers, the airport authority, and airline management in order to meet the changing demand of air passenger traffic for Hong Kong.

The format of this paper is structured as follows: Section 2 will outline the Box–Jenkins ARIMA model and intervention model; Section 3 will describe the data period and the variables of interest used as well as detailing the ARIMA modelling approach; Section 4 will present the empirical results of the SARIMA and ARIMAX models for forecasting future passenger traffic for HKIA; and Section 5 will discuss and summarise what are believed to be the key findings.

2. Methodology

- The Box–Jenkins ARIMA model

This section outlines the Box–Jenkins ARIMA model and intervention model for forecasting HKIA's future passenger throughput. The acronym ARIMA is used to indicate the autoregressive, integrated, and moving average combined method. The non-seasonal ARIMA (p, d, q) model can be written as shown in Equation (1):

$$\Phi(p)\nabla^{d}Y_t = \alpha + \Theta(q)\varepsilon_t \tag{1}$$

Combining the non-seasonal stationary ARIMA (p, d, q) model and the seasonal stationary ARIMA (P, D, Q)s model, where s denotes the seasonal pattern presented in the time series, the model can be either written as the SARIMA (p, d, q) × (P, D, Q)s model or in the compact notation shown in Equation (2):

$$\Phi(p)\omega(P)\nabla^{d}\nabla_{s}^{D}Y_t = \alpha + \Theta(q)\Theta(Q)\varepsilon_t \tag{2}$$

- The intervention model

Where $\Phi(p)$ the polynomial non-seasonal AR (autoregressive) process of order p, ω(P) denotes the polynomial seasonal AR process of order P, $\Theta(q)$ denotes the polynomial non-seasonal MA process of order q, Θ(Q) denotes the polynomial seasonal MA (moving average) process of order Q, $\nabla^{d}\nabla_{s}^{D}$ denotes the level of differencing for non-seasonal and seasonal processes, respectively, Y_t denotes the dependent variable to be forecasted, ε_t denotes the error time, and α denotes the constant.

The intervention model incorporates the effects of interventions or exogenous shocks into the forecasting model. To examine their effects, deterministic dummies are incorporated into the model to develop an intervention model. Often, the SARIMA models are combined with the intervention analysis to include interventions into the forecasting models (Lim, McAleer, & Min, 2009; Williams, 2007); importantly, their effects can be considered as either permanent or temporary effects.

S_t is an indicator variable, which can have the permanent effect or step function:

$$S_t = \begin{cases} 1, & \text{if } t \geq T \text{(at and after the intervention)} \\ 0, & \text{if } t < T \text{(before the intervention)} \end{cases}$$

Or, P_t is an indicator variable, which can have the temporary effect or impulse function:

$$P_t = \begin{cases} 1, & \text{if } t = T \text{(at the intervention)} \\ 0, & \text{if } t \neq T \text{(not at the intervention)} \end{cases}$$

When the interventions are inserted into the SARIMA model in Equation (2), the intervention model can be written as shown in Equation (3):

$$\Phi(p)\omega(P)\nabla^{d}\nabla_{s}^{D}Y_t = \alpha + \Theta(q)\Theta(Q)\varepsilon_t + x_t \tag{3}$$

Where x_t denotes the response function (i.e. permanent function or temporary function), or sum of the response functions, to one or more interventions.

- Four steps of the Box–Jenkins ARIMA modelling procedures

We used four Box–Jenkins modelling steps to perform the SARIMA models: identification, model estimation, diagnostic checking, and forecasting as shown in Table 1 (Box & Jenkins, 1976; Gujarati & Porter, 2009; Pankratz, 1983).

3. Data description and the Box–Jenkins ARIMA modelling approaches

The monthly data for HKIA's passenger traffic between January 1993 and August 2011 were obtained from Airport Authority Hong Kong. Future passenger traffic for HKIA was modelled and forecasted using the SARIMA and ARIMAX models, and its future passenger throughput ahead to December 2015 was predicted.

The SARIMA model was used to model HKIA's passenger traffic between January 1993 and November 2010. The remaining period from December 2010 to August 2011 were used for evaluating the *ex-post* forecasting performance of the model. Furthermore, concerning the impact of different countries or regions upon air travel demand for Hong Kong, the total air passenger traffic travelling to HKIA was split and grouped into 11 principal origins, namely Africa, Australasia and Oceania, Continental Europe, Japan, Mainland China, North America, Other Asia, Southeast Asia, Taiwan, the Middle East, and the United Kingdom. Each origin was forecasted by the SARIMA model. These forecasting results are important for policy-making and future market segment analysis in Hong Kong's tourism industry.

An accurate and reliable airport-specific demand forecast is necessarily guided by its endogenous and exogenous forces for a local or non-local forecast (Graham, 1999; Strand, 1999). In addition, air passenger throughput of an airport will be largely affected by its ability and strategic role for transporting air passengers to and from the countries or regions, as well as the economic and operating environment in which the airport operates. Therefore the ARIMAX model (i.e. the multivariate ARIMA model) was