ARMAX modelling of international tourism demand

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Abstract

Box–Jenkins (1970) models are often used to capture the autoregressive moving average of past observations of tourist arrivals from Japan to Taiwan and New Zealand. However, other explanatory variables, such as real income in the origin country, have also affected the demand for international travel. The purpose of this paper is to use the ARMAX model to investigate the dynamic relationship between tourism demand and real income of Japan, and to compare the findings with the single-equation model. Unit root tests and diagnostics are performed before estimating the income elasticity of travel demand by Japan for New Zealand and Taiwan based on seasonally unadjusted quarterly data for 1980(1) to 2004(2). The empirical results of the ARMAX model support the economic theory that the demand for international travel is positively related to income of the origin country.
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1. Introduction

Japan has long been a dominant economic power and a tourism superpower in the Asia-Pacific region. It has been the largest inbound market for many countries in the region, particularly in the 1980s and the 1990s. Fig. 1 shows the real GDP and outbound travel of Japan since 1980.

Japanese outbound travel rebounded strongly in 2004 and 2005, after 2 years of negative growth in 2001 and 2003 [14]. Fears of terrorism and diseases related to the events of 11 September 2001 in the USA, Severe Acute Respiratory Syndrome (SARS) and bird flu outbreaks in 2003, have caused negative growth of 9% and 20% in 2001 and 2003, respectively, in Japanese international travel demand (see Fig. 2).

After some discussion of tourism movements from Japan to New Zealand and Taiwan since 1980 and certain characteristics of the tourists in Section 2, the rest of the paper is organised as follows. The theoretical model and unit root tests for the tourism and income time series are discussed in Sections 3 and 4, respectively. In Section 5, the estimation of the single equation and ARMAX models is presented. Some concluding remarks are given in Section 6. The EViews 5 econometric software package [3] is used for the data analysis and empirical estimation.

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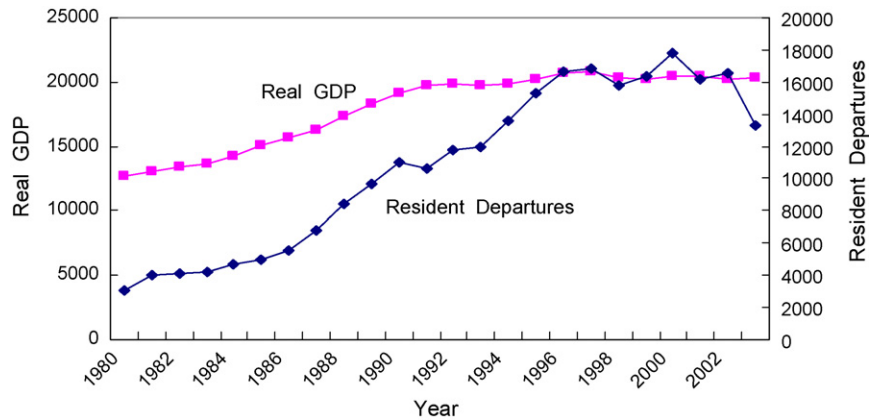*E-mail address:* clim@waikato.ac.nz (C. Lim).

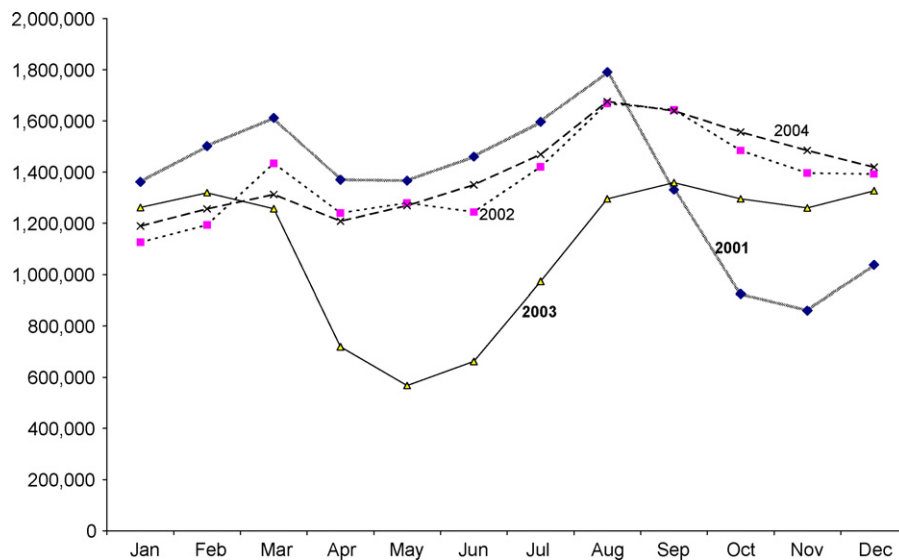Fig. 1. Real GDP (billion JYP) and resident departures ('000) of Japan, 1980–2003.

Fig. 2. Total short-term resident departures from Japan, 2001–2004.

2. Japanese tourism demand for New Zealand and Taiwan

Japan is New Zealand's largest Asian tourist source market. Tourist arrivals from Japan had been increasing by more than 14% per annum from 1980 to 1996, after which New Zealand started to experience a decline in the Japanese market (see Fig. 3). The 1997/1998 Asian economic and financial crises, continuing economic slowdown in the Japanese economy since the mid-1990s, SARS and the appreciation of the New Zealand dollar have all contributed significantly to the sharp decline in the Japanese market [9].

Most Japanese tourists regard New Zealand as a holiday destination, as shown in Fig. 4. As a long haul destination, it seems that New Zealand is a popular destination for older Japanese tourists, with 37% of all visitors aged 55 years and above. According to the international visitor surveys conducted in 2005, most Japanese visitors were package travellers, and very few were repeat tourists. Auckland (in the North Island), followed by Canterbury and Queenstown (in the South Island), were the most popular regions in New Zealand for Japanese tourists. Not surprisingly, hotels were the dominant type of accommodation used by these visitors.

Market surveys also indicated that shopping and eating out were the most popular activities engaged in by Japanese tourists [12]. Besides a decline in Japanese tourist arrivals, the increase in the strength of the New Zealand currency
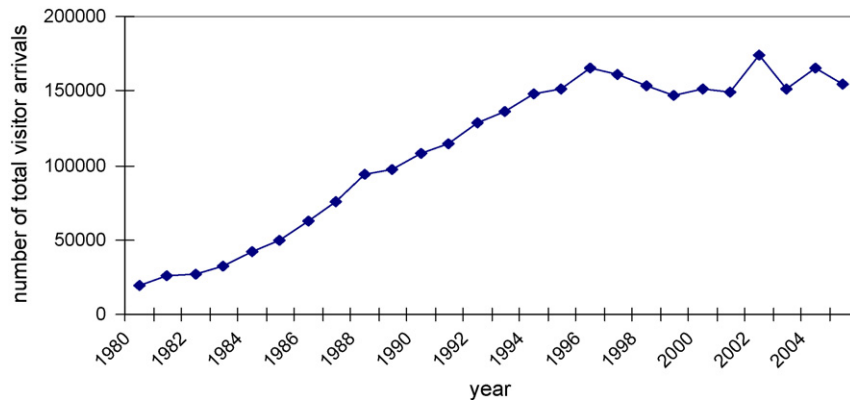
Fig. 3. International tourist arrivals from Japan to New Zealand, 1980–2005.

has also caused a decrease in tourist spending. Average Japanese tourist expenditures in New Zealand decreased by more than 13% from 2004 to 2005.

Historically, Taiwan was a colony of Japan from 1895 to 1945 prior to the Kuomintang (KMT) Party's flight to Taiwan (from China) to exercise its sovereignty. During that time, only the Japanese language and education were allowed to be spoken and learned by the island residents. Thus, Taiwan's lifestyle has been heavily influenced by the Japanese culture. For instance, Taiwanese and Japanese enjoy similar leisure activities, such as shopping, dining, and soaking in hot springs all year around [8].

Japan is a significant inbound tourism market for Taiwan in terms of tourist arrivals and tourist average daily expenditure. Japanese tourists, which accounted for over 30% of all international tourists in Taiwan, have been increasing by more than 4% between 1981 and 2005 [10]. Higher tourism or relative prices in Taiwan due to inflation in recent years have not slowed down the flows of tourists from Japan. In particular, the number of Japanese visitors to Taiwan has reached a new record of 1.1 million in 2005, a double-digit growth compared with 2004 (see Fig. 5). However, the SARS outbreak in 2003, which was the first pandemic of the 21st century declared by [13], had a far-reaching effect on Japanese inbound arrivals to Taiwan to such levels the country had not experienced since 1986.

Between 2000 and 2005, more than one-third of Japanese tourists to Taiwan were in the 50 and older age group. The share of Japanese male tourists outnumbered their female counterparts by the ratio of approximately 2:1. About 50% of Japanese travelled to Taiwan for pleasure, followed by business (30%), and visiting relatives and friends (3%), as shown in Fig. 6. According to a survey conducted by [11], *Taroko*, *Tienhsiang* (one of the national parks located on the eastern side of Taiwan) and the night markets were the major scenic spots for Japanese tourists. The study also found that cuisine and historical relics were the major attractions for most Japanese tourists. On average, their duration of stay was 5.02 nights, compared with 7.1 nights on average for all inbound visitors.
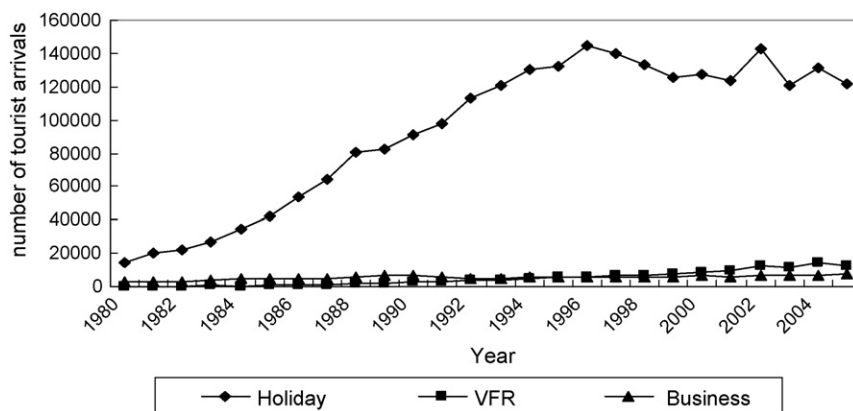

Fig. 4. Japanese tourists to New Zealand by trip purpose, 1980–2005.
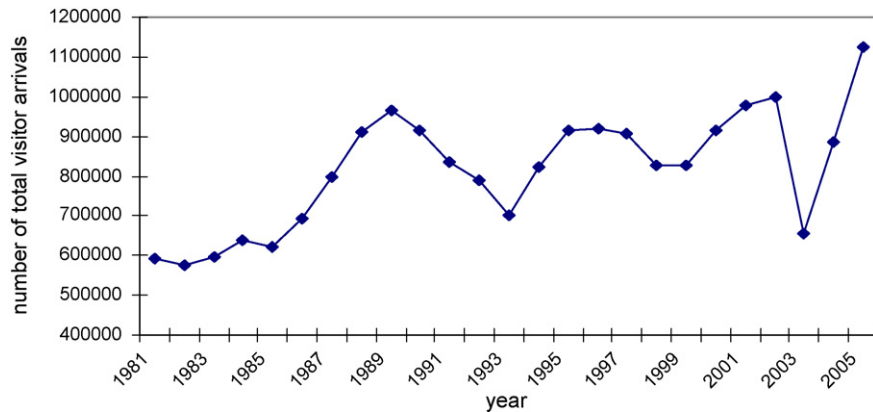
Fig. 5. International tourist arrivals from Japan to Taiwan, 1981–2005.
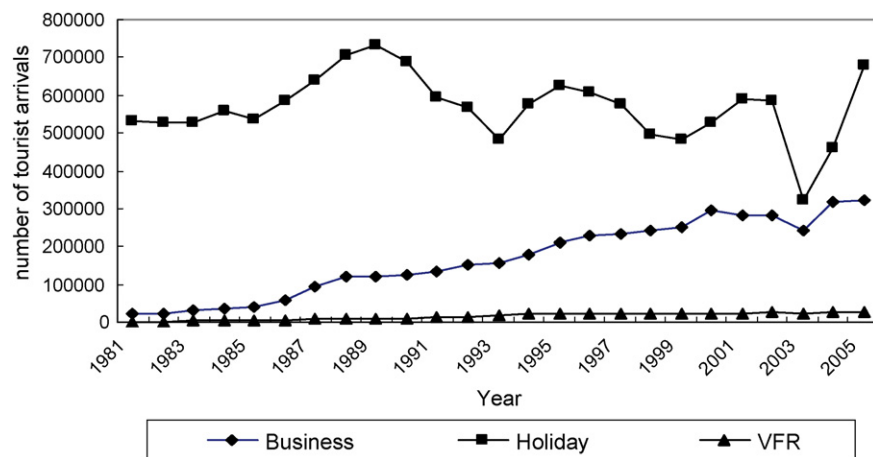
Fig. 6. Japanese tourists to Taiwan by trip purpose, 1981–2005.

The seasonal patterns of tourist arrivals from Japan to New Zealand and Taiwan are shown in Fig. 7. Using the multiplicative ratio-to-moving average technique to estimate the monthly seasonal indices, it is not surprising that there is less seasonal variation for a short-haul destination such as Taiwan. The seasonal range is 0.34 and 0.77 for Taiwan and New Zealand, respectively. Nonetheless, the peak tourism months for the two destinations are February (for New Zealand) and March (for Taiwan). The destinations have overlapping tourism seasons during the period 1979–2005,

Fig. 7. Estimated monthly seasonal indices for inbound tourist arrivals from Japan to New Zealand and Taiwan, 1980–2005.

that is, from November to March. While the intra-year movements of Japanese tourists to New Zealand may be related to the climatic conditions at the destination, the same argument would not seem to apply to Taiwan.

3. Theoretical model

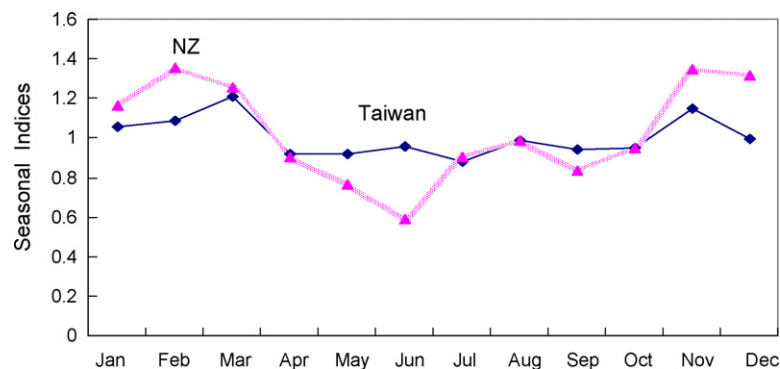One of the basic goals of tourism demand modelling is to estimate income and/or price elasticities, which can then be used in developing better informed public and private policies. The focus of econometric studies is to determine the extent to which the data support a particular theory. In reviews of empirical studies on international tourism demand and its determinants, Lim [6,7] argued that the most prominent and frequently used variable in these studies is income of tourist-generating countries, which affects the ability of consumers in these countries to pay for their overseas travel. More specifically, the demand for international travel is positively related to income in the origin market.

The focus of econometric studies is to determine the extent to which the data support a particular theory, namely the demand for international travel is positively related to income of the origin country. We propose to use time series econometric modelling of inbound tourism based on seasonally unadjusted quarterly data for 1980(1) to 2004(2) to obtain estimates of income elasticities of travel to New Zealand and Taiwan by Japanese residents.

We assume a linear model in the variables in which the data on $y_1, \ldots, y_t$ have been generated by $y_t = \alpha + \beta x_t + \varepsilon_t$, such that y_t depends linearly on α and β. The other key assumptions of the classical linear regression model include

(1) Expected value of disturbance term is 0: $E(\varepsilon_t) = 0$.
(2) Homoskedasticity, or constant variance of the disturbances: $\mathrm{Var}(\varepsilon_t) = \sigma_e^2$ for all t.
(3) No serial correlation of the disturbances across periods: $E(\varepsilon_t \varepsilon_s) = 0$ $(t \neq s)$.
(4) Explanatory variables are weakly exogenous, that is, there is zero covariance between ε_t and each explanatory variable: $E(x_t \varepsilon_t) = 0$ for all t.
(5) ε_t are normally distributed: $\varepsilon_t \sim N(0, \sigma_e^2)$ for all t.
(6) Parameter constancy: α, β and σ (>0) are fixed unknown numbers.

[1] models are often used to capture the autoregressive moving average of past observations of tourist arrivals from Japan to Taiwan and New Zealand. While it is possible to use the autoregressive (AR) and moving average (MA) processes to capture the current pattern of tourist arrivals from a particular market based on its own past arrivals and the random error from previous periods, other explanatory variables, such as real income in the origin country, have also affected the demand for international travel. The ARMAX model is an extension of the Box–Jenkins autoregressive-moving average (ARMA) model with explanatory exogenous variables (X).

Ordinary least squares (OLS) is used to estimate the influence of real income on tourism demand by Japan for New Zealand and Taiwan. Specifically, we will estimate single equation and ARMAX models to compare the estimates of the Japanese income elasticity of travel demand for the two destinations. The sensitivity of tourist arrivals from Japan to changes in real income will also be evaluated. As a guide to model selection, the Akaike information criterion (AIC) and Schwarz Bayesian criterion (SBC) are used to choose the model with the smallest AIC and SBC values. Before specifying the ARMAX model, tests and diagnostics are performed on the estimated Box–Jenkins models.

4. Unit root tests

A graphical analysis of the seasonally unadjusted quarterly data from 1980(1) to 2004(2) suggests that the logarithm of tourist arrivals from Japan to New Zealand and Taiwan are likely to be nonstationary (see Fig. 8). This result is supported by the correlogram, which displays the estimated autocorrelation and partial autocorrelation functions of the residuals.

A tourist arrival series is said to be stationary if the mean, variance and covariance of the series remain constant over time. The unit root test is a formal method of testing the stationarity of a series. Quarterly tourist arrivals (in logarithms) from Japan to New Zealand and Taiwan are tested for unit roots using the augmented Dickey–Fuller
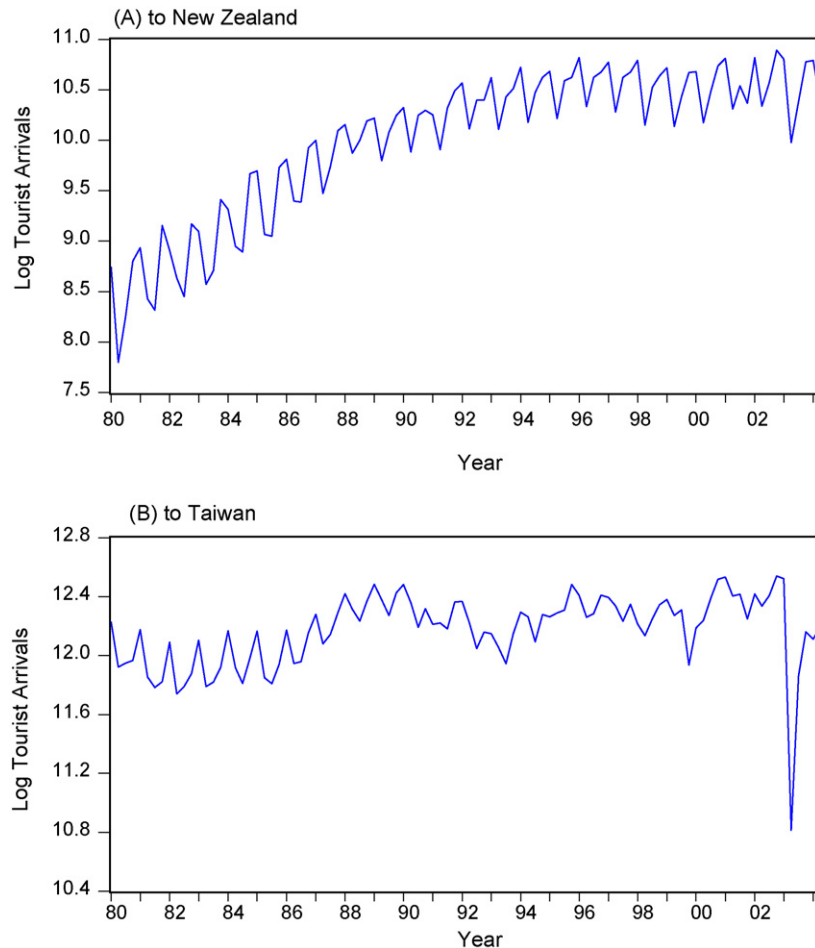
Fig. 8. Logarithm of short-term tourist arrivals from Japan, 1980–2004.

(ADF) test procedure, which is based on the following regression equation:

$$\Delta a_t = \alpha + \beta t + \delta a_{t-1} + \sum_{j=1}^{p} \psi_j \Delta a_{t-j} + \varepsilon_t$$

where α_t is the logarithm of tourist arrivals to New Zealand or Taiwan from Japan at time t, t is a deterministic trend, ε_t is a disturbance term of the regression which is independent and normally distributed with zero mean and constant variance. In order to test for unit roots, the hypothesis of interest is

$$H_0: \quad \delta = 0$$
$$H_1: \quad \delta < 0$$

The null hypothesis of a unit root is based on the t-statistic (which has a non-standard distribution) using simulated critical values. The deterministic time trend (t) is retained ($\beta \neq 0$) in the test regression because the ADF t-statistics with and without a trend are substantially different. As quarterly data are used, an initial lag length of 4 is used in the ADF regression to accommodate possible serial correlation in the disturbances. If the fourth lag is insignificant at the 5% level, the lag length is reduced sequentially until a significant lag length is obtained. The third lag is significant for both series.

The ADF test results indicate that the ADF statistics for the tourist arrival series from Japan to New Zealand and Taiwan (-1.36 and -2.67, respectively) are both greater (that is, are less negative) than the critical value of -3.46 at

Table 1
Log real GDP of Japan.

	ADF test statistic
Without trend	−2.13
With trend	−0.48

Table 2
Unit root tests.

	ADF lag length	ADF statistic	Critical value
Log real GDP of Japan	3	−0.32	−3.46
First difference log real GDP of Japan	2	−4.01	−2.89

the 5% significance level. Therefore, the null hypothesis of a unit root cannot be rejected, which implies that tourist arrivals from Japan to New Zealand and Taiwan are nonstationary.

Taking the first differences of the logarithm of the tourist arrivals and applying the ADF test procedure to the transformed series, a more negative test statistic (of −4.90 at a significant lag length of 4 for New Zealand and −10.2 at a lag length of 2 for Taiwan) than the critical value of −2.89 are obtained. This suggests that the first difference series are stationary. Individual ADF tests show that the logarithm of tourist arrivals is integrated of order 1, $I(1)$, whereas the first difference of the logarithm of the series follow an $I(0)$ process, or is integrated of order 0.

The ADF test procedures are applied to the real GDP of Japan (in logarithms) for the presence of unit roots. Since the reported ADF statistics, with and without a deterministic time trend, are substantially different from each other, the former is included in the auxiliary regression test for a unit root in log real GDP (see Table 1). The results of the ADF tests of real GDP presented in Table 2 show that the null hypothesis of a unit root cannot be rejected at the 5% level, which implies that real GDP series of Japan are nonstationary. However, the differenced series is stationary and follows an $I(0)$ process, or is integrated of order 0, whereas the logarithm of real GDP is integrated of order 1, $I(1)$. The first difference series for tourist arrivals and real GDP will be used in the empirical modelling in the next section.

5. Empirical modelling of Japanese tourist arrivals to New Zealand and Taiwan

Using a single-equation model, the influence of real income on tourism demand by Japan is given as follows:

$$a_t = \alpha + \beta y_t + \phi a_{t-1} + \varepsilon_t$$

where y_t is the log of Japanese real GDP at time t. With the inclusion of seasonal dummy variables, D_{2t}, D_{3t} and D_{4t} in the model as well as a SARS dummy variable for Taiwan, the following estimates are obtained by OLS (with absolute t-ratios in parentheses):

$$a_t = \underset{(6.00)}{0.03} + \underset{(1.35)}{2.39\hat{y}_t} - \underset{(4.08)}{0.03D_{2t}} - \underset{(12.0)}{0.08D_{3t}} - \underset{(1.31)}{0.01D_{4t}} \quad \text{(New Zealand)} \tag{1}$$

$$a_t = \underset{(2.35)}{0.01} - \underset{(0.27)}{0.39\hat{y}_t} - \underset{(0.38)}{0.002D_{2t}} - \underset{(4.92)}{0.03D_{3t}} - \underset{(2.15)}{0.01D_{4t}} + \underset{(5.43)}{0.09D_{\text{SARS}}} \quad \text{(Taiwan)} \tag{2}$$

Deletion of the insignificant seasonal dummy variable for New Zealand does not yield a significant income elasticity of travel demand. The same is also true for Taiwan with the deletion of the insignificant seasonal and SARS dummy variables.

The ARMAX model is used to investigate the dynamic relationship between tourism demand and real income of Japan, and to compare the findings with the single-equation model. Extensive discussion of ARMAX modelling and estimation can be found in [4,5]. A simple ARMAX(p, q) model can be expressed as

$$a_t = \alpha + \beta_1 a_{t-1} + \cdots + \beta_p a_{t-p} + \phi_0 y_t + \phi_1 y_{t-1} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \cdots - \theta_q \varepsilon_{t-q}$$

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Table 3
Pairwise Granger causality tests for Japanese tourist arrivals to New Zealand (method: least squares; sample (adjusted): 1980Q3 2004Q2; included observations: 96 after adjustments).

Variable	Coefficient	S.E.	*t*-Statistic	Probability
Dependent variable: tourist arrivals				
Constant	0.003674	0.004133	0.888968	0.3763
Lagged tourist arrivals	−0.220094	0.104389	−2.108399	0.0377
Lagged real GDP	−0.347553	3.023564	−0.114948	0.9087
Dependent variable: real GDP				
Constant	0.000604	0.000152	3.973787	0.0001
Lagged tourist arrivals	0.001894	0.003841	0.493021	0.6232
Lagged real GDP	0.024328	0.111245	0.218693	0.8274

Table 4
Pairwise Granger causality tests for Japanese tourist arrivals to Taiwan (method: least squares; sample (adjusted): 1980Q3 2004Q2; included observations: 96 after adjustments.).

Variable	Coefficient	S.E.	*t*-Statistic	Probability
Dependent variable: tourist arrivals				
Constant	−0.001615	0.002298	−0.702865	0.4839
Lagged tourist arrivals	−0.344570	0.097146	−3.546933	0.0006
Lagged real GDP	2.945668	1.580542	1.863707	0.0655
Dependent variable: real GDP				
Constant	0.000599	0.000152	3.953835	0.0001
Lagged tourist arrivals	0.002111	0.006407	0.329431	0.7426
Lagged real GDP	0.039771	0.104239	0.381535	0.7037

In this form, the model has lagged dependent and independent variables and a moving average disturbance. We assume that the errors are independently and identically distributed, with zero mean, constant variance and zero covariance. The Granger causality tests also suggest no feedback from α_t to y_t and vice versa (see Tables 3 and 4).

Additional independent variables, each with its own lag structure can be included in the model. An ARMAX(p, q) model with no additional regressors is equivalent to the ARMA(p, q) model:

$$a_t = \alpha + \beta_1 a_{t-1} + \cdots + \beta_p a_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \cdots - \theta_q \varepsilon_{t-q}$$

Another important special case is the ARX(p) model, which is an ARMAX(p, q) model with no significant disturbance terms:

$$a_t = \alpha + \beta_1 a_{t-1} + \cdots + \beta_p a_{t-p} + \phi_0 y_t + \phi_1 y_{t-1}$$

The unit root tests for different available price proxies show that the latter follows an $I(0)$ process, while the tourist arrival and real income series are integrated of order 1, $I(1)$.

Before the ARMAX model is used to estimate the relationship between income and travel demand by Japan, we need to identify a plausible set of ARMA models. Using the first difference of the log tourist arrivals from Japan, various ARIMA models have been estimated using ordinary least squares. By excluding insignificant AR and MA lags, the use of diagnostics and selection criteria would help to determine a more parsimonious model. The latter is subsequently used to undertake ARMAX modelling and estimation of the income elasticity of travel demand by Japan for New Zealand and Taiwan over the period 1980–2004.

Hence, the models selected yield significant t-statistics at the 5% level of significance for the AR and MA coefficients, with no serial correlation at the 5% level, using the Lagrange multiplier test for serial correlation. ARIMA(3, 1, 3) and ARIMA(2, 1, 4) have been identified for New Zealand, and ARIMA(4, 1, 4) for Taiwan as the optimal models. Inclusion of three seasonal dummy variables in these models and a SARS dummy for Taiwan, the final ARMAX

models are obtained as follows, with the lowest AIC and SBC values (with absolute *t*-ratios in parentheses):

$$a_t = \underset{(9.81)}{0.03} + \underset{(2.37)}{1.40}\hat{y}_t - \underset{(3.36)}{0.02}D_{2t} - \underset{(12.8)}{0.07}D_{3t} + \left(1 + \underset{(80.7)}{0.84}L - \underset{(77.2)}{0.49}L^4\right)\hat{\varepsilon}_t \quad \text{(New Zealand model 1)} \tag{3}$$

$$a_t = \underset{(6.23)}{0.02} + \underset{(4.14)}{2.53}\hat{y}_t - \underset{(10.2)}{0.81}\hat{a}_{t-1} - \underset{(7.78)}{0.66}\hat{a}_{t-2} - \underset{(8.66)}{0.65}\hat{a}_{t-3} - \underset{(6.10)}{0.07}D_{t-3} \quad \text{(New Zealand model 2)} \tag{4}$$

$$a_t = \underset{(5.07)}{0.01} + \underset{(4.76)}{1.00}\hat{y}_t - \underset{(16.9)}{0.88}\hat{a}_{t-1} - \underset{(13.0)}{0.78}\hat{a}_{t-2} - \underset{(14.6)}{0.84}\hat{a}_{t-3} - \underset{(5.55)}{0.02}D_{t-3} + \left(1 + \underset{(46.0)}{0.95}L^4\right)\hat{\varepsilon}_t \quad \text{(Taiwan)} \tag{5}$$

The Lagrange multiplier tests, LM(SC), show that the models do not have serial correlation at the 5% level.

6. Concluding remarks

In this paper we have estimated single-equation models to evaluate the effect of changes in income on Japanese travel demand for New Zealand and Taiwan over the period 1980–2004. By including an income variable with a finite lag structure, the ARMAX model is also used to estimate the income elasticity of tourism demand of Japan for the same period.

The tourist arrival and income variable have been tested and appropriately transformed to obtain stationarity of the data series. Additional variables, namely seasonal and SARS dummy variables, were also included in the estimation of the single equation and ARMAX models. Unlike the single-equation model, the ARMAX technique is more appropriate for investigating the dynamic relationship between tourism demand and real income of Japan. The model is developed in two stages, which initially requires that the Box–Jenkins ARIMA models be identified and selected.

The findings of the ARMAX model support the economic theory. In contrast to the single-equation models, all the ARMAX models show that the Japanese income elasticities of travel demand are positive and significant. According to the single-equation model for Taiwan, the effects of SARS in 2003 had a significant but positive effect on Japanese inbound travel. The latter is contrary to theory and reality. Only the seasonal effect in quarter 3 is negative and significant in both the single equation and ARMAX models for New Zealand and Taiwan.

Future research could include the Box–Jenkins intervention analysis, which is a useful technique to evaluate the effects of exogenous interventions which occurred at some identifiable points in time [2]. In this regard, intervention analysis may provide a useful stochastic modelling tool to enable an examination of the impact of the significant structural breaks on Japanese travel demand for different countries.

Acknowledgements

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