The Impact of the Great East Japan Earthquake on Inbound Tourism Demand in Japan

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The Great East Japan Earthquake struck Tohoku, Japan seriously, and caused deadly tsunami wide-sparing the whole east Japan coast. Soon after this earthquake, the inbound tourist arrivals to Japan went down dramatically. The purpose of this study is to examine how severe the impact of the disaster on inbound tourism demand and estimate whether tourist arrivals have recovered to normal up to November 2012 by applying auto-regression integrated moving average (ARIMA) models incorporating one-off events to estimate inbound tourist arrivals after the disaster and, then compare the predicted data with actual ones. This work will be useful for understanding the impact and tourism recovery process after the earthquake. It is also applicable and shed light on the estimation of tourism recovery level for other disasters.

Keywords: the Great East Japan Earthquake, inbound tourism demand in Japan, ARIMA analysis, disaster recovery

1. Introduction

The Japanese government has positioned ‘tourism’ as a strategic industry to revitalize Japan’s economy and enhance inter-regional communication, and has been making efforts to promote Japan as a ‘Tourism-based Country’ ¹. According to the 2010 survey report ² by Ministry of Land, Infrastructure, Transport and Tourism (MLIT), tourism industry made a great contribution to Japan’s economy: tourism expenditure was 23.8 trillion Yen; the spread effect of tourism industry was 49.4 trillion Yen, which accounted for 5.5% of the production in national economic counting; the induction effect in employment was 424 thousand people.

The 2011 earthquake off the Pacific coast of Tohoku that occurred on March 11, 2011 at 05:46 (UTC) offshore of the east coast of Honshu, Japan, had a magnitude of 9.0 on the Richer Scale and triggered a devastating tsunami resulting in serious nuclear disaster. The earthquake is also known as the Great East Japan Earthquake, 2011 Tohoku Earthquake or 3.11 Earthquake. The huge earthquake accompanying with tsunami and the accident of the nuclear plant in Fukushima caused considerable loss of casualties: 18,131 dead, 2,829 missing and 6,194 injured ³.

The earthquake has also impacted inbound tourism demand in Japan severely. The report ⁴ released by Japan National Tourism Organization (JNTO) suggests that soon after the huge earthquake during the period between 12 March and 31 March, the international visitor arrivals to Japan fell off sharply by 72.7% as compared with the same period in 2010. The visitor arrivals from abroad for the whole year (2011) decreased by 27.8 %, compared with that in the previous year (2010), which is the highest reduction in Japan’s recorded history.

MLIT has been taking aggressive tourism promotion measures ⁵,⁶ aiming at recovering and stimulating international travel demand, for example, by promoting MICE (Meetings, Incentives, Conferences, Exhibitions) in the affected areas, further reinforcing the framework for accommodating visitors from overseas and implementing new visa policies for Chinese, etc.

The number of international tourist arrivals has a direct impact on tourism industry and government agency investment. Therefore, policymakers either in tourism industry or in administrative organizations need to have a clear understanding of how disasters on inbound tourism demand. Though tourism has been regarded as a strategic industry and Japan has experienced many kinds of natural disasters, especially earthquake due to its geological location, little research on Japan’s inbound tourism demand has been taken to understand the impact of disasters on inbound tourism demand to Japan. The purpose of this study is to make a better understanding of the changes and trends in the inbound tourism demand by examining how severe the impact of one of the deadliest earthquakes, the Great East Japan Earthquake, on inbound tourism demand and estimate whether tourist arrivals have returned to normal up to November 2012.

In this study we apply ARIMA analysis introduced by Box and Jenkins ⁷ to explore the impact of the disaster on the demand for inbound tourism and estimate the recovery level of inbound tourism demand from the devastating earthquake.

2. Disaster and tourism demand

The literature on the impact of disaster on tourism can be divided into two correlative aspects: the impact on tourism demand (e.g. domestic visitors, international visitors including inbound visitors and outbound visitors) and the impact on tourism supply (e.g. tourism destination as a whole, tourism authorities, tourism enterprises such as hotels, travel agencies). This study examines the impact of the disaster on inbound tourism demand in Japan by investigating the volatility of the number of inbound tourists. According to the historical
statistics of visitors to Japan from overseas released by JNTO, visitors from abroad consists of four types by purpose of visit to Japan: tourist, business, others and short excursion. Here we focus on inbound tourist arrivals.

Several methods are available in assessing the impact of disasters on tourism flows, such as Chow test (Chow 8), intervention or interrupted time series analysis (Box and Tiao 9; McCain and McCleary 10), forecasting methods based on models (e.g. Mazzocchi and Montini 11; Huang and Min 12; Mendoza et al. 13), Chow test is widely used in time series analysis to test for the presence of a structural break but cannot identify the pattern of structure change. Intervention analysis mainly focuses on estimating change pattern by observing the variation in parameters.

Previous studies relevant to the field commonly applied forecasting method to examine the impact of disasters on tourism demand by investigating difference between estimated and actual values. The method mentioned above mainly consists of two kinds: one is based on regression analysis (e.g. Wang 14) and the other is on account of time series forecasting (e.g. Huang and Min 12). Time series forecasting uses a model to predict future values based on previously observed data. Regression analysis often applies models to test the relationship between a dependent variable and one or more independent variable changes. It is suggested that time series analysis often generates acceptable forecasts at low cost with reasonable benefits in testing the accuracy of different forecasting models for tourist arrivals (Chu 15). So we will employ time series model to examine the impact of the Great East Japan Earthquake on inbound tourism demand in Japan.

There are a number of literatures relating to the impact of disasters on tourism demand by applying time series analysis. Mazzocchi and Montini 11 evaluated the statistical relevance of the earthquake that stroke the Umbria region in central Italy on September 26, 1997, using the data of monthly time series of tourist arrivals and stays. Huang and Min 12 built up seasonal ARIMA model based on the data of monthly inbound visitor arrivals before the 921 earthquake (M7.3) to forecast the inbound visitor arrivals after it (September 1999 to July 2000), then compared the volume forecast and actual values, and got the conclusion that up to the 11th month after the earthquake, the inbound tourism demand had not rebounded completely. Mendoza et al. 13 also focused on monthly visitor arrivals to measure the impact of the earthquakes in Chile (the earthquake in the north on 21 April 2007 with magnitude of 6.2; the earthquake in the south on 14 November with a magnitude of 7.7 and the earthquake in the center of Chile on February 2010 with a magnitude of 8.8) by seasonal ARIMA analysis and the results inferred that the impacts depended on the magnitude of the earthquake and the perception of safety. Kuo et al. 16 estimated the impacts of Avian Flu and severe acute respiratory syndrome (SARS) on international tourist arrivals in Asia countries by using the autoregressive moving average model with exogenous variables (ARMAX) model. McAleer et al. 17 also evaluated the impact of SARS and Avian Flu on international tourist arrivals to Asia, utilizing static line fixed effect and difference transformation dynamic models.

This study will apply time series forecasting analysis to assess the impact the huge earthquake by comparing the out-of-sample forecast arrivals with actual ones. There are numerous of time-series methods for forecast available, such as smoothing methods, exponential smoothing and ARIMA. As ARIMA analysis requires time series data to be tested for stationarity in identification step before undertaking estimation, diagnosis and forecasting. If a time series is nonstationary, the time series must be transformed to a stationary series by differencing before the ARIMA modeling process can proceed. The forecasts by using a model that has been transformed to apply in stationary series are expected to be more accurate and reliable forecasts than using a model with nonstationary series. ARIMA also considers tests for unit roots before estimation, diagnosis and forecasting exercise. Therefore, ARIMA analysis has been diffusely applied and usually outperforms other forecasting approaches in forecasting tourism demand (Lin et al. 18; Lim and McAleer 19; Gonzalez and Moral 20). Furthermore, in order to improve forecast accuracy, one-off events will be taken into ARIMA through the use of dummy variables. We would establish a Box-Jenkins ARIMA model incorporating dummy variables for Japan’s inbound tourism demand based on the data before the devastating earthquake to

![Fig.1. Inbound tourist arrivals to Japan from January 1996 to November 2012. (Source: JNTO)](image-url)
estimate the inbound tourist arrivals after the disaster.

3. Data and methodology

The data used in this study is monthly international tourist arrivals to Japan between January 1996 and November 2012 collected by JNTO (see figure 1). Here international tourists mean the people who come to Japan for the purpose of tourism rather than business or others.

The ARIMA time series analysis uses lags and shifts in the historical data to uncover patterns (e.g., moving averages, seasonality) and predict the future values. The ARIMA model was first developed in the late 60s but it was systemized by Box and Jenkins. ARIMA processes provide a wide range of models for univariate time serials modeling and forecasting and have been successfully applied in economic, social issues and also in forecasting tourism demand (e.g. González and Moral, Lim and McAleer; Kulendran and Shan).

One-off events such as global financial crisis and deadliest disasters may distort the estimation and diagnosis, and then impact the accuracy of forecast. In order to account for the impact of one-off events, the method by using dummy variables to represent one-off events is often applied in tourism research (e.g. Witt et al; Lim and McAleer; Kulendran and Shan). Therefore, in this study the impact of the exogenous shocks will be incorporated in ARIMA models by using deterministic dummy variables in order to improve forecasting accuracy.

To examine the impact of the Great East Japan Earthquake on inbound tourism demand to Japan, we employ ARIMA model with deterministic dummy variables to forecast the inbound tourist arrivals and investigate the difference of predicted and actual values. Figure 2 shows the framework of the methodology in this study.

ARIMA model is described as follows:

\[ Y_t = c + \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + \cdots + \theta_p Y_{t-p} + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + \cdots + \theta_q \epsilon_{t-q} + \epsilon_t \]

where \( Y_t \) is the actual value at time of \( t \); \( \theta_i \) (\( i=1,2,\ldots,p \)) and \( \theta_j \) (\( j=1,2,\ldots,q \)) are parameters; \( \epsilon_t \) is random error at time of \( t \) and is assumed to be independently. Equation 1 can also be presented shortly in the following form

\[ \varnothing(L)Y_t = C + \Theta(L)\epsilon_t \]

where

\[ \varnothing(L) = 1 - \varnothing_1 L - \varnothing_2 L^2 - \cdots - \varnothing_p L^p \]

\( \varnothing \) is a polynomial of the lag operator representing the auto-regression (AR) model that calculates the present value from past values; and

\[ \Theta(L) = 1 + \Theta_1 L + \Theta_2 L^2 + \cdots + \Theta_q L^q \]

\( \Theta \) represents the moving average (MA) model that calculates the present value from past error terms.

The stationarity of the time series can be tested by the figures of autocorrelation function (ACF) and partial autocorrelation function (PACF), and unit root test such as Dickey-Fuller test (Dickey and Fuller). Differencing (regularly or/and seasonally) is often applied to the time series to remove the trend and stabilize the variance before an ARIMA model is identified. Usually the differentiated ARIMA model can be presented as follows:

\[ \varnothing(L)\Delta^d Y_t = \Theta(L)\epsilon_t \]

where \( \Delta \) is a degree of difference. As this study uses an ARIMA model with dummy variables to account for the impact of one-off events, the ARIMA model incorporating dummy variables is presented as follows:

\[ \varnothing(L)\Delta^d Y_t = \Theta(L)\epsilon_t + \sum_{i=1}^{M} \beta_i D_i \]

where \( D_i \) is a dummy variable and \( \beta_i \) is a parameter of the dummy variable. \( M \) is the number of the dummy variables.

Based on the above procedure we can identify a likely ARIMA \((p,d,q)\) model or ARIMA\((p,d,q);(P,D,Q)s\) model if seasonality is indicated, with dummy variables.

In diagnosis procedure, Ljung-Box test (Ljung and Box) is used to test if the residuals of the fitted ARIMA model are white noise. The Ljung-Box Q test can be defined as follows:

Hypothesis: \( H_0 \): The data are independently distributed; \( H_1 \): The data are not independently distributed.

\[ Q = n(n+2) \sum_{k=1}^{h} \frac{\rho_k^2}{n-k} \]

where \( n \) is the sample size, \( \rho_k \) is the sample autocorrelation at lag \( k \), and \( h \) is the number of lags being tested. At significance level \( \alpha \), the critical region for rejection of the hypothesis of randomness is
\[ Q > \chi^2_{1-\alpha, h} \] [6]

where \( \chi^2_{1-\alpha, h} \) is the \( \alpha \)-quantile of the chi-squared distribution with \( h \) degrees of freedom.

If the fitted model is adequate, it can be used to estimate the inbound tourism arrivals after the disaster. Then the impact level of the earthquake on inbound tourism demand is available from the difference between the estimated and the actual values.

4. Empirical results

(1) Identification

Figure 1 suggests that international tourist arrivals went down sharply after the Great East Japan Earthquake. As the time series has an upward trend as a whole (see figure 1), we take logarithm to deal with this issue (see figure 3). The ACF in figure 3 shows there are spikes at several lags, so the new time series is nonstationary. So regularly first-time difference is necessary and the result is shown in figure 4.

From the ACF in figure 4, there is a spike at lag 12. So seasonally first-time difference is taken (see figure 5) and ACF suggests the time series seems stationary. We use a unit root test (Dickey and Fuller [31]) as a diagnostic tool to test whether the time series is stationary.

<table>
<thead>
<tr>
<th>Augmented Dickey-Fuller test statistic</th>
<th>t-Statistic</th>
<th>Prob. *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test critical values:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% level</td>
<td>-3.472256</td>
<td>0.0010</td>
</tr>
<tr>
<td>5% level</td>
<td>-2.979846</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-2.576510</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 6. ADF test result.

(2) Estimation

During the period from January 1996 to February 2011, Japan mainly experienced the SARS global health crisis in 2003, Lehman shock of 2008, the movement of the Lunar year and the H1N1 Flu epidemic. Therefore, the ARIMA model incorporating dummy variables in this study can be presented as follows:

\[ \Theta(L) \Delta^d \text{LOG} Y_t = \Theta(L) \epsilon_t + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 \] [7]

where \( D_1 \) is a dummy variable with a value 1 for the SARS epidemic from April 2003 to June 2003 and is 0 otherwise [33]. \( D_2 \) is a dummy variable with a value 1 for Lehman shock of 2008 in the period between September 2008 and October 2009, and is 0 otherwise. \( D_3 \) is a dummy variable with a value 1 for the movement of the Lunar year in February 2009, and is 0 for the otherwise. \( D_4 \) is a value 1 for the H1N1 Flu epidemic from May 2009 to June 2009. [34]
The ACF and PACF in figure 5 show that there are spikes at some lags. The dummy variables were incorporated into the ARIMA specifications and ARIMA (2, 1, 3) (1, 1, 1)_{12} model seems appropriate by investigating the spikes at several lags. The tentative model (without a constant) based on the data before the disaster is presented as follows:

\[
(1 - \theta_1 L - \theta_2 L^2)(1 - \rho_1 L^{12})(1 - L)(1 - L^{12}) \log Y_t = (1 + \theta_1 L + \theta_2 L^2 + \theta_3 L^3)(1 + \theta_4 L^{12}) \varepsilon_t + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4
\]

In this study, we apply Eviews 6.0 statistics software to estimate the parameters of the tentative model by using Ordinary Least Square (OLS), which is a method for estimating the unknown parameters in a linear regression model. The t-statistics of all parameters are significant at 5% level. The dummy variables, D1, D2, D3, are not significant at the level, therefore they are not included in this model. The estimation result is as follows (with absolute t-ratios in parentheses)

\[
\begin{align*}
(1 + 0.48L + 0.22L^2)(1 + 0.22L^{12})(1 - L) &\quad (-5.91) \quad (-2.44) \quad (-2.78) \\
\times (1 - L^{12}) \log Y_t &\quad = (1 - 0.19L^3)(1 - 0.94L^{12}) \varepsilon_t \\
&\quad (-2.09) \quad (-44.40)
\end{align*}
\]

\[-0.12D_4 \quad (-2.17)\]

The results suggest that the earthquake did impact inbound tourism demand severely (in the first three months after the earthquake dropped by 63.62%, 82.42%, and 64.66% respectively). Up to November 2012, the percentage of difference between the estimated and actual values hovered near the normal level. The largest difference (-510243) came in the following month of the catastrophe occurring and the smallest difference (-2978) was in June 2012.

Figure 5 and figure 8 provide graphical presentations of empirical findings. According to table 1 and figure 8, the differences between the predicted and actual numbers of tourist arrivals for the 21 months have decreased significantly on the whole. Though tourist arrivals are bouncing back from the devastating earthquake, the figures for March 2011, April 2011, February 2012, June 2012, and October 2012 need further discussion. As the Great East Japan Earthquake occurred in mid-March 2011, the total number of tourist arrivals in March was not lowest. The largest difference in the forecast period falls in April 2011 with the data of 510243. The difference in this month demonstrates the volume of decreased tourist arrivals caused by the earthquake. For the entire forecast period, the smallest difference falls in June 2012 with the data of 2978, during which actual arrivals are very close to the estimated ones. Figure 9 illustrates the trend of convergence between actual and estimated arrivals following the earthquake. It should be noted that February is usually shoulder season for the inbound tourism, however, the actual number of tourist arrivals decreased as Chinese Spring festival, during which Chinese tourists to Japan are usually numerous, moved to January in 2012. \[35\] It should also be noted that the actual number of tourist arrivals in October, usually boom season for the inbound tourism market, increases, though the difference is still large as the actual tourist arrivals has been impacted by nuclear pollution problem, the problem of the Senkaku Islands between China and Japan and so on. \[36\]

According to the recovery process (see figure 8, 9), the entire forecast period from March 2011 to November 2012 can be divided into two stages and January 2012 is the cut-off point of recovery process. Before the month, inbound tourist arrivals recovered quickly, but after the point, the difference percentage fluctuated and was close to the normal level. Figure 8 also indicates that the forecast model follows the overall trend in inbound tourism demand.

If compared with the case of September 21 Earthquake in Taiwan (Huang and Min \[12\], 2002), the convergence is much faster in the case of Japan. In the case of Taiwan with the magnitude of 7.3, which is lower than that of 9.0 in the case of Japan, after 11 months there was still a 5% decrease in international tourist arrivals. The recovery process of Japan reached 0.7% decrease after 11 months.
Table 1 Actual and forecasting values of inbound tourist arrivals after the Great East Japan Earthquake

<table>
<thead>
<tr>
<th>Year/Month</th>
<th>Actual value</th>
<th>Estimated value</th>
<th>Difference (Act-Est)</th>
<th>% Diff (Diff/Est*100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011/03</td>
<td>190730</td>
<td>524337</td>
<td>-333607</td>
<td>-63.62%</td>
</tr>
<tr>
<td>2011/04</td>
<td>108820</td>
<td>619063</td>
<td>-510243</td>
<td>-82.42%</td>
</tr>
<tr>
<td>2011/05</td>
<td>183799</td>
<td>520107</td>
<td>-336308</td>
<td>-64.66%</td>
</tr>
<tr>
<td>2011/06</td>
<td>282118</td>
<td>494469</td>
<td>-212351</td>
<td>-42.95%</td>
</tr>
<tr>
<td>2011/07</td>
<td>396559</td>
<td>674542</td>
<td>-277983</td>
<td>-41.21%</td>
</tr>
<tr>
<td>2011/08</td>
<td>373195</td>
<td>615213</td>
<td>-242018</td>
<td>-39.34%</td>
</tr>
<tr>
<td>2011/09</td>
<td>323947</td>
<td>452787</td>
<td>-128840</td>
<td>-28.45%</td>
</tr>
<tr>
<td>2011/10</td>
<td>404377</td>
<td>562356</td>
<td>-157979</td>
<td>-28.09%</td>
</tr>
<tr>
<td>2011/11</td>
<td>358056</td>
<td>456797</td>
<td>-98741</td>
<td>-21.62%</td>
</tr>
<tr>
<td>2011/12</td>
<td>423650</td>
<td>508098</td>
<td>-84448</td>
<td>-16.62%</td>
</tr>
<tr>
<td>2012/01</td>
<td>485860</td>
<td>489081</td>
<td>-3221</td>
<td>-0.66%</td>
</tr>
<tr>
<td>2012/02</td>
<td>364537</td>
<td>485069</td>
<td>-120532</td>
<td>-24.85%</td>
</tr>
<tr>
<td>2012/03</td>
<td>452568</td>
<td>511008</td>
<td>-58440</td>
<td>-11.44%</td>
</tr>
<tr>
<td>2012/04</td>
<td>582511</td>
<td>609030</td>
<td>-26519</td>
<td>-4.35%</td>
</tr>
<tr>
<td>2012/05</td>
<td>473662</td>
<td>520959</td>
<td>-47297</td>
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</tr>
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<td>514461</td>
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<tr>
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<td>666623</td>
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<td>459122</td>
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<tr>
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<td>546065</td>
<td>-65811</td>
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<tr>
<td>2012/11</td>
<td>455665</td>
<td>458829</td>
<td>-3164</td>
<td>-0.69%</td>
</tr>
</tbody>
</table>

Fig. 8. Actual and estimated values of inbound tourist arrivals.
5. Conclusion and discussion

The number of inbound tourist arrivals directly impacts the tourism industry and the investments of government agencies therein. Therefore, policymakers need to make a better understanding of how natural disasters affect inbound tourism demand. This study finds that the devastating earthquake affected inbound tourism demand in Japan most negatively, and the inbound tourism demand in Japan has not yet fully recovered from sharply decreased inbound tourist arrivals due to the earthquake after 21 months. It is also found that the number of inbound tourist arrivals recovers rapidly in the early part of the recovery process; however, the difference percentage fluctuates and is close to the normal level later.

Faced with the fierce competition on tourism market, having a high market share is critical for the economic prospects of destination countries. It is suggested that the policymakers in Japan keep a close watch on the recovery level of inbound visitors, including the segments of the market such as tourist market and business travel market, in order to adopt appropriate incentives in timely manner. According to the message from the Director General, Japan tourism agency, inbound visitor arrivals has recovered to the normal level up to July 2012, however, it does not mention the recovery level of inbound tourist arrivals. It may lead the tourism industry and policymakers to launching the strategies with the aim of keeping or developing inbound tourism demand rather than recovery strategies.

In regards to time-series analysis, this study finds that exogenous variables may have significant impact on forecast. Unlike the other time-series models that just take time series data into consideration, in order to improve forecast accuracy, our study incorporates actual known periods of one-off shock events in ARIMA model through the use of dummy variables. During the observation time period, Japan mainly experienced the shocks of SARS, the Lehman shock, and the Lunar year movement and the H1N1 Flu epidemic occurring in the period of Lehman shock. The results find that the H1N1 Flu epidemic in the period of the Lehman shock has negatively impacted inbound tourism, as the estimation parameter is negative 0.12 and the other dummies had no significant impact on tourism demand as they are significant at the 5% level. This study presents contributions to the research regarding the effective use of forecasting models to estimate the recovery status of tourism demand from disasters.

This study is limited to investigating the recovery status of inbound tourism demand. It does not explore the impact of the disaster on domestic tourism demand, as the statistics of domestic tourist in Japan is limited. It would be interesting to compare the recovery status of domestic and inbound tourism demand after disasters. This study only focuses on inbound tourist arrivals. It does not attempt to uncover the inbound tourists’ travel motivations, and furthermore, examine the factors that affect the travel demand in Japan.

Hayashi 38 indicates that the recovery from recent disaster is a long term recovery process which is a time consuming and complicated process. This study finds that the recovery process is complex rather than simple linear recovery. As it is estimated that there will be Large-scale earthquakes such as Tokyo inland earthquake and Nankai Trough earthquake in the near future in Japan (Cabinet Office, Government of Japan 39), hence, this study suggests that to improve the resilience of tourism industry, the Japanese government and tourism industry put crisis management in tourism on agendas. Though the researchers such as Faulkner 40 and Ritchie 41 provide tourism disaster management frameworks for all tourism industries, international tourists are not homogeneous and the conditions of destination countries are also diverse, so a common crisis management framework will not achieve the expected outcome. It will be especially interesting to study and develop tourism crisis management framework for Japan in the future.

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