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# Assessing impact of Natural Disasters on Tourist Arrivals: The Case of Xitou Nature Education Area (XNEA), Taiwan

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**ABSTRACT:** Tourist arrivals represent popularity of a recreation site. However it could be changed due to accessibility, weather, and natural disaster. These factors are complex and their effects on tourist arrival are mixed. This study applies switching regression approach to assess impact of natural disasters on tourist arrivals in the popular forest recreation and education site, Xitou Nature Education Area (XNEA), Taiwan. Natural disaster in a tourist destination cause environmental changes which impact short- and long-term changes on tourist arrivals. Precisely estimating the impacts on tourist arrivals could therefore provide an insight to management. The results show that (1) Typhoon Herb reduced tourist arrivals by an estimated 530 thousand over three years; (2) the Chichi earthquake caused a 2.59 million loss in tourist arrivals over seven years; (3) Typhoons Toraji and Nari resulted in a 360 thousand reduction in tourist arrivals over three years; and (4) Typhoon Mindulle reduced tourist arrivals by 80 thousand over a one-year period.

**Keywords:** Natural disaster; Typhoon; Switching regression; Tourist arrivals

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# Introduction

Tourist arrivals indicate the popularity of a recreation area and reflect the effectiveness of recreation area management. The number also shows the environmental impact of human activities, particularly on rural or mountain forest recreation areas. It is therefore important to understand changes in tourist arrivals, and their implications for managers of recreation areas.

Numerous studies have shown that many factors can affect tourist arrivals, including transportation accessibility, weather, economic environments, and travel duration (Albalate and Bel, 2010; Cho, 2003; Taylor and Ortiz, 2009; van der Merwe and Saayman, 2008). The research methods used in such studies can be divided into two basic types: trend analysis and multivariate analysis. Trend analysis uses time series approach to evaluate changes in tourist arrivals, while multivariate analysis is applied to understand the different aims and backgrounds of groups and their interrelations (Amberger and Haider, 2007; Chan, 1993; Chu, 2009; Gil-Alana, 2005; Goh and Law, 2002; Lim and McAleer, 2002; Song and Li, 2008). Typically tourist arrivals' analysis studies both long-term trends and short-term changes. The long-term trend refers to ongoing changes in tourist arrivals, while short-term changes consider unexpected events that impact tourist arrivals, such as natural disasters (i.e. earthquakes, typhoons, or mud slides) and major epidemics. Compared to periods of a decade or more, short-term changes may last several days, weeks, months, or longer. Unexpected natural disasters frequently have severe environmental consequences, representing short-term environmental changes that may influence tourist arrivals immediately and perhaps last from months to years in a tourist destination. Estimating influences of natural disasters in a tourist destination is critical because tourism practitioners may need the information to make recovering plans and budget.

# Literature Reviews

Tourist arrivals usually serves as an ultimate (dependent) variable in tourism demand study and factors influencing tourist arrivals are often considered as explanatory variables. Typically, the root of this type research could be found in both economic and socio-psychological theories (Goh, 2012). Economic framework represents a main stream in studying tourism demand.

Tourism economists study tourism demand in order to understand the effects of various determinants and forecast of the future demand for tourism. The explanatory variables include such as income, travel costs and one-off events (Song, Witt, and Li, 2009). Origin country income is a key explanatory variable and enters the tourism demand function in per capital form, particularly for holidaymaking or visits to friends and relatives (VFR) types of tourism demand (Kulendran and Witt, 2001; Song et al., 2000; Syriopoulos, 1995). In addition to income factor in a tourism demand model, travel cost is included in tourism demand studies. Tourism demand model usually takes account of travel costs, for example: airfares between the origin and destination or gasoline costs for surface travel (Dritsakis, 2004; Lim and McAleer, 2002; Kulendran and Witt, 2001; Witt and Witt, 1995). In practice, the effects of one-off event could be captured by using dummy variables in a tourism demand model such as the two oil crises in the 1970s with worldwide effects on tourism demand (Witt et al., 2003; Han et al., 2006). This approach could apply to some regional and country-specific events for example, the financial crisis in 1997, SARS in 2003, and the terrorist attack in the USA on September 11, 2001 (Ming, 2005; Lim, 2004; Wong et al., 2007). These events have caused significant loss on tourist arrivals in the affected countries and regions. The selected factors above demonstrate their potential influences on tourist arrivals. As mentioned earlier, the major purpose of this study is to assess impacts of natural disasters on tourist arrivals. From econometrics perspective, these natural disasters can be considered as "one-off events" and could be captured their impacts by using dummy variables. Therefore dummy variable and switching regression model are incorporated to analyze structural breaks in terms of tourist flow.

## *Overview of Study Site*

The Xitou Nature Education Area (XNEA) is located in a valley alongside Feng-Huang Mountain in central Taiwan. It is a concave geographic feature surrounded by mountains on three sides (east, west, and south). The total area of the XNEA is around 2,200 hectares with an elevation range of 800-2,000 meters. Frequent rainfall results in high humidity and cool climate. Average monthly temperature ranges from 11.0-28.0°C, average annual temperature is 16.6°C, and average annual rainfall is 2,635.18 mm. These conditions frequently bring clouds and fog and create a unique climatic landscape that results in XNEA having rich biological resources, including approximately 300 species of woody plants and 1,300 species of herbaceous plants, 96 species of birds, and 20 species of reptiles. With an abundant in nature resources, XNEA has attractive environmental conditions for tourists and has become a key forest recreational area in Taiwan. XNEA also has a well-designed scenic area, recreational facilities, and a trail system that provides tourists with sufficient resources and services for a range of recreational activities.

## *Tourism in XNEA*

XNEA is the first forest recreation area established in Taiwan, and tourist arrivals have been grown since it opened in 1971. XNEA has maintained its strong popularity and now attracts over one million tourists annually (Taiwan Tourism Bureau, 2011) (see Figure 1).

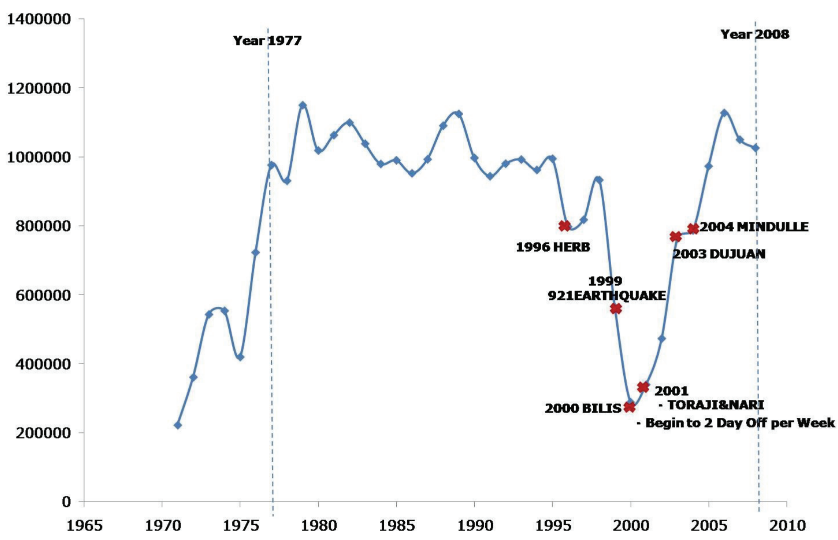



**Figure 1.** Tourist arrivals at XNEA from 1977 to 2008
*(Source: Taiwan Tourism Bureau Statistics 2011)*

As Figure 1 shows, the trend in tourist arrivals at XNEA comprises three periods: growth, stability, and disaster. The growth period runs from 1971 to 1976, a period of rapid growth in tourist numbers. This period was followed by two stable periods: (1) 1977 to 1995 and (2) 2005 to 2008. Although Taiwan experienced high economic growth during both periods, tourist arrivals remained between 950 thousand and 1.1 million. The disaster period from 1996 to 2005, there were several severe typhoons and the Chichi earthquake strike central Taiwan (see Table 1). These disasters dramatically decreased tourist arrivals at XNEA.

**Table 1.** Major natural disasters in the XNEA from 1996 to 2005

| Year | Natural Disaster | Duration | Intensity |
|---|---|---|---|
| 1996 | Typhoon HERB | 07/29/1996 – 08/01/1996 | Severe |
| 1999 | Chichi Earthquake | 09/21/1999 | 7.3ML |
| 2000 | Typhoon BILIS | 08/21/2000 – 08/23/2000 | Severe |
| 2001 | Typhoon TORAJI | 07/28/2001 – 07/31/2001 | Moderate |
| 2001 | Typhoon NARI | 09/13/2001 – 09/19/2001 | Moderate |
| 2003 | Typhoon DUJUAN | 08/31/2003 – 09/02/2003 | Moderate |
| 2004 | Typhoon MINDULLE | 06/28/2004 – 07/03/2004 | Moderate |

During the disaster period, Typhoon Herb in 1996 seriously damaged central Taiwan, and the number of tourists in XNEA dropped below 0.8 million for the first time in 20 years. Although tourist arrivals subsequently exhibited gradual growth, the Chichi earthquake struck central Taiwan in 1999, forcing XNEA to close for the first time. Total visitors reached less than 300,000 in 2000, recording a historic low. Since 2000, the number of visitors has gradually recovered in central Taiwan due to reconstruction projects. But in 2001 Typhoon Toraji damaged the XNEA, forcing it to close for three months. Although numerous typhoons occurred after 2001, their impacts on the XNEA were limited. Annual tourist arrivals subsequently increased and returned to one million in 2006. This trend continued until 2008. Thus from 1996 to 2005, natural disasters significantly affected XNEA.

## Method

This study integrates natural disaster and tourist arrivals data to analyze the effects of natural disasters on tourist arrivals in XNEA. This study applies switching regression of the intervention model. Figure 2 shows the analysis flow used in this study:

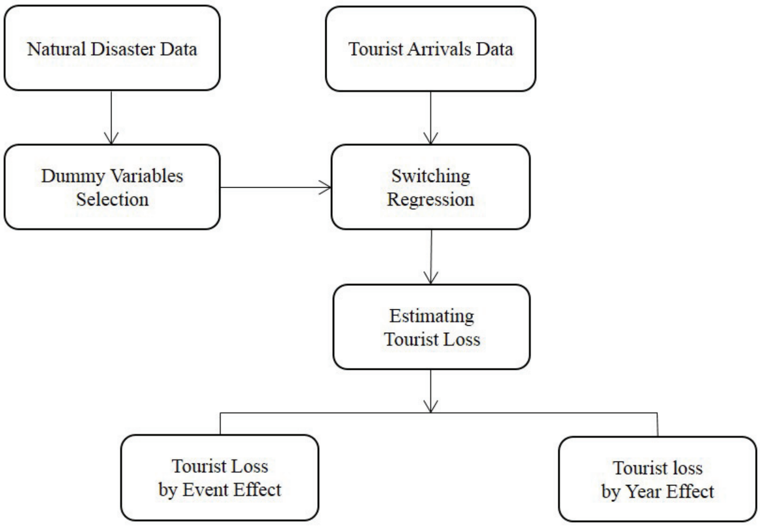



**Figure 2.** Analysis flow

The tourist arrivals of XNEA is gathered on a daily basis and categorized based on admission fees (standard, discount, free). Since this study analyzes the effects of natural disasters on annual tourist arrivals, daily tourist data are totaled to yield yearly data. As the period from 1971 to 1976 comprises the growth period for tourism in the XNEA and exhibits a different trend from the following stable and disaster periods, this study applies tourist data from 1977 to 2008. To assess the impacts of individual disasters on tourism, this study also uses monthly tourist data. Based on long-term trends in XNEA tourist arrivals, the number of tourists is stable at between 1.2 and 0.9 million. That is, in the absence of natural disasters, annual visitor numbers are approximately 1 million. This provides a baseline for estimating the loss in tourism caused by natural disasters.

As tourist arrivals is collected for different time points or time periods, and the events or data are arranged chronologically, this kind of data can be seen as time series data. Since time series data have serial correlation, non-stationary, and seasonal effect problems, the common parametric or nonparametric statistical models are not suitable in this investigation. This study thus applies the intervention model to overcome these problems, which can shed light on relationships between the intervention and tourist arrivals. The intervention model, which combines ARIMA (autoregressive integrated moving average) and transfer function models, can examine whether exogenous factors significantly impact the time series data (Kulendran and Wong, 2009; Morley, 2009; Smeral and Wuger, 2008; Yuksel, 2007). Many studies of the tourism industry have applied the intervention model to identify various "interventions," such as policy implementation, marketing, advertising, and natural disasters (Goh and Law, 2002). The following briefly addresses statistical approaches applied and study data.

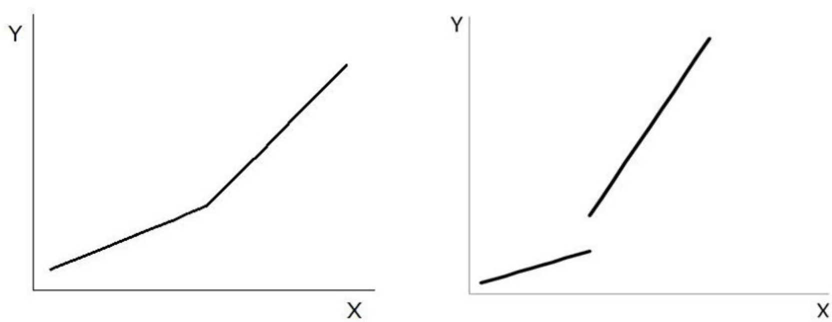
## *Intervention Model*

The intervention model was introduced by Box and Tiao (1975) to study time series data in the context of environmental and economic problems. The study presents two applications of intervention models: (a) the reduction in the permitted proportion of reactive hydrocarbons in locally sold gasoline and its effect on oxidant pollution levels in Los Angeles following the opening of the Golden State Freeway; (b) the possible effects of United States government actions to control inflation on the consumer price index (CPI) in the country. The intervention model uses dummy variables to represent exogenous time series whose influence must be considered. Before constructing an intervention model, it is necessary to know the starting time points and patterns of exogenous variables. The effects and time range of interventions can thus be observed based on the constructed model. The dummy variable generally takes the values 0 and 1 to denote the nonoccurrence and occurrence of intervention. In this study, the dummy variable is set to 0 to indicate nonoccurrence and 1 to indicate occurrence, and other dummy variables are set to represent the period of recovery from damage, wherein the dummy variable is set to 1 as well.

## *Switching Regression*

Nonlinear models have three major forms: polynomial, exponential, and piecewise regression/switching. In some cases, events can be divided into different stages, each within a linear relationship with dependent and independent variables. For example, education expenditure differs from elementary school to high school stages as a result of simple variation. Such relationships can be divided into two categories. In the first category, the two periods have a structural break but remain continuous, as shown in Figure 3(a), represented by piecewise regression. The other category is switching regression, which is characterized by structural breaks between period data that make them non-continuous, as shown in Figure 3(b).

In this study, a natural disaster is considered an intervention on the number of tourists that causes a structural break. Gallet and Braun (2001) indicated that certain exogenous factors affect visitor preferences that may be reflected in the revenue of a recreation area or park. The gradual switching model is able to estimate the possibility of preference change. This model has two advantages: it allows for a structural break, and it can determine the time path of coefficients adjustment (Gallet and Braun, 2001). By accounting for a structural break in the model, the results indicate that the gradual switching model procedure is a powerful approach that can explain neglected aspects of tourism demand.




(a). A continuous structural break (b). A discontinuous structural break

**Figure 3.** Continuous and discontinuous structural breaks

## *Data and Dummy Variable Setting*

This study applies switching regression model to estimate changes in tourist arrivals resulting from natural disasters affecting XNEA between 1996 and 2005. This study thus sets natural disasters as dummy variables to evaluate the impacts of their consequences, and separately investigates the effects and recovery periods for each disaster. The monthly number of tourists is used for the model presented in this study (see Figure 4).

Monthly data on average tourist arrivals from 1977 to 2008 (excluding the disaster period from 1996 to 2005) demonstrates that the number of tourists to XNEA generally peaks in July and August, with an average of 114,389 and 101,060, respectively. The number of tourists during these two months is approximately 20 percent of the total annual number. This investigation thus uses the average number of tourists in July and August, 107,724 (Figure 4), as a criterion for a dummy variable to observe any recovery in the number of tourists after disasters.

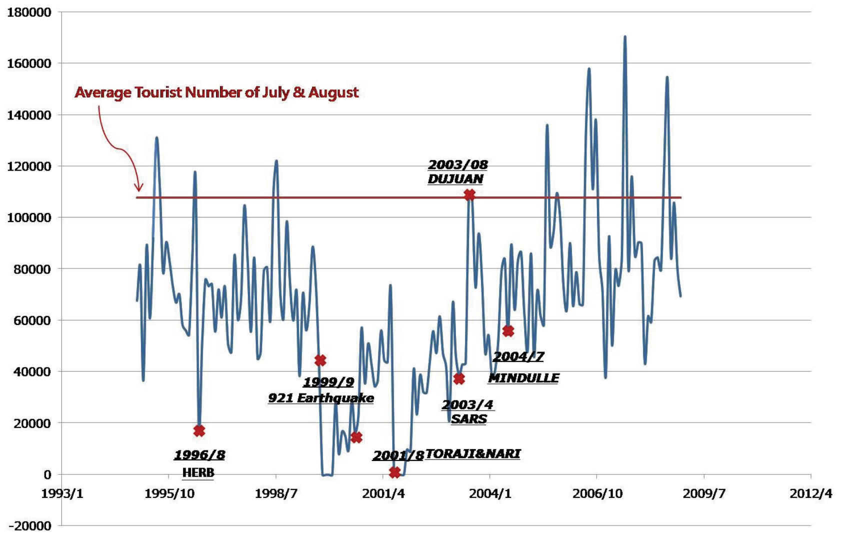



**Figure 4.** Monthly tourist arrivals during 1995 to 2006 in XNEA

**Table 2.** Codes for dummy variables and periods

| Dummy Variable | Effect (Code/Year) | Recovery (Code/Year) |
|---|---|---|
| 1996: Herb | E1996/3 | R1996/1 |
| 1999: Chichi Earthquake | E1999/7 | R1999/5 |
| 2001: Toraji and Nari | E2001/3 | R2001/1 |
| 2004: Mindulle | E2004/1 | — |

Figure 4 further illustrates the monthly change in tourist arrivals and the time of natural disasters. The disaster period contains four major events, including Typhoon Herb in August 1996, the Chichi earthquake in September 1999, Typhoons Toraji and Nari in August 2001, and Typhoon Mindulle in July 2004. The study uses the above events as a basis for setting dummy variables in the model (Table 2). Moreover, each natural disaster that occurs comprises two stages, both effect and recovery periods. The former reflects the immediate reduction of tourist arrivals following natural disasters, while the later involves the gradual recovery in tourist arrivals. In this situation, dummy variables should be set to represent both effect and recovery periods. The length of each effect of the recovery period should be determined simultaneously (Table 2).

**Table 3.** Weights for dummy variables in the switching regression model

| Year | E1996 | R1996 | E1999 | R1999 | E2001 | R2001 | E2004 |
|---|---|---|---|---|---|---|---|
| 1996 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1997 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1998 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 1999 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 2000 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 2002 | 0 | 0 | 1 | 2 | 1 | 0 | 0 |
| 2003 | 0 | 0 | 1 | 3 | 1 | 1 | 0 |
| 2004 | 0 | 0 | 1 | 4 | 0 | 0 | 1 |
| 2005 | 0 | 0 | 1 | 5 | 0 | 0 | 0 |
| Accumulated | 3 | 1 | 7 | 15 | 3 | 1 | 1 |

A disaster may significantly damage an area and have an impact lasting for years, as in the case of the Chichi earthquake. A new disaster may then strike before the area completely recovers from the previous disaster. It is therefore important to separate the effects of individual disasters to estimate the loss to tourist numbers, even though the effects of a disaster may continue for years. Typhoon Herb in 1996 reduced tourist arrivals, and these did not recover until 1998. The dummy variables for this effect period are thus set from 1996 to 1998, totaling three years; the dummy variable for the recovery period is set to 1998 (Table 3). With regard to the impacts of the Chichi earthquake in 1999, this event seriously damaged central Taiwan, where XNEA closed for three months from late 1999 to 2000. It also took a long time to recover the level of tourist arrivals found in 2005. The dummy variables for the effect period of the Chichi earthquake are calculated from 1999 to 2005, totaling seven years. Regarding the recovery period, since the data demonstrates that the number of tourists started to recover from 2001 and finally normalized in 2005, the dummy variables for the recovery period are set from 2001 to 2005, totaling five years. As the recovery in tourist numbers is accumulated by years, the dummy variables for the recovery period are set to 1 in 2001, 2 in 2002, 3 in 2003, 4 in 2004 and 5 in 2005 (Table 3). The accumulated recovery number is similar to an arithmetic series, which over the five years totals 15 times (see

Table 3).

Typhoons Toraji and Nari struck XNEA in 2001, and tourist arrivals did not recover until 2003. As for the results, the dummy variables for the effect period are set to 1 from 2001 to 2003, a period of three years. As the number of tourists recovered in 2003, the dummy variable for the recovery period is set to 1 in 2003. The effect period of Typhoons Toraji and Nari lasted for three years, and is thus accumulated three times. As the recovery occurs in the third year, it is only accumulated once. The final event is Typhoon Mindulle in 2004, after which the number of tourists declined dramatically. The period of effect of Typhoon Midulle lasted for about one year, so the recovery period is negligible. The dummy variable for the effect period is thus set to 1 in 2004, and this study does not set the dummy variable for the recovery period for this event. In the switching regression model, the weights set for the dummy variables are as listed in Table 3.

## Results

This section presents and interprets the model results including the estimated loss in the number of tourists due to natural disasters in Taiwan.

### *Estimated Loss in Tourist Numbers*

Given the setting of the dummy variables, Table 4 shows the results of the switching regression model. The F value is 31.23, and the p-value is less than 0.01. The adjusted R2 is 0.89 that represents the model is statistically significant. Most variables are statistically significant, with the exception of Year, R1996, and E2004. The sign of each variable is as expected, with the dummy variables for the effect periods negatively impacting tourist numbers and the dummy variables for the recovery periods positively impacting tourist numbers (Table 4).

Based on the earlier results and the frequency of the impact of each natural disaster, the study estimates the annual effect and the loss in tourist arrivals for individual disasters (Table 5).

As shown in Table 6, the estimated total loss of tourist arrivals at XNEA is approximately 3.56 million from 1996 to 2005. Regarding the reduction in total tourist numbers because of Typhoon Herb, the effect lasted three years (1996 to 1998). The reduction of tourists totals approximately 220 thousand in each of the first two years and approximately 95 thousand in the third year. The number of tourists recovered in 1998 to about 0.12 million. The total reduction is thus approximately 0.53 million and the reduction is about 0.44 million.

**Table 4.** The results of the switching regression model

| Variable | Coefficient | SE | T Stat. | P-value |
|---|---|---|---|---|
| Intercept | 1022946.95 | 15460.14 | 66.17 | 0.00 |
| E1996 | -172288.29 | 44629.58 | -3.86 | 0.00 |
| E1999 | -601710.51 | 52974.79 | -11.36 | 0.00 |
| R1999 | 103534.47 | 15730.60 | 6.58 | 0.00 |
| E2001 | -168882.65 | 63898.00 | -2.64 | 0.01 |
| R2001 | 201390.79 | 91892.82 | 2.19 | 0.04 |

**Table 5.** Annual effect and loss in tourist arrivals of individual disasters

| | E1996 | R1996 | E1999 | R1999 | E2001 | R2001 | E2004 | Year Total |
|---|---|---|---|---|---|---|---|---|
| Coefficient | -219,462 | 123,998 | -604,249 | 109,239 | -183,972 | 191,758 | -78,906 | |
| Year | | | | | | | | |
| 1996 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | -219,462 |
| 1997 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | -219,462 |
| 1998 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | -95,464 |
| 1999 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | -604,249 |
| 2000 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | -604,249 |
| 2001 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | -678,982 |
| 2002 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | -569,744 |
| 2003 | 0 | 0 | 1 | 3 | 1 | 1 | 0 | -268,747 |
| 2004 | 0 | 0 | 1 | 4 | 0 | 0 | 1 | -246,200 |
| 2005 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | -58,055 |
| Accumulated | 3 | 1 | 7 | 15 | 3 | 1 | 1 | |
| | -658,386 | 123,998 | -4,229,743 | 163,8581 | -551,916 | 191,758 | -78,906 | -3,564,614 |
| Event Total | -534,388 | | -2,591162 | | -360,158 | | -78,906 | |

As for the decrease in tourist arrivals as a result of the Chichi earthquake, the effects lasted seven years (1999 to 2005). Meanwhile, the reduction in tourist numbers was about 0.6 million annually. The total reduction of tourist arrivals is 4.22 million over the seven years. The number of tourists in XNEA gradually recovered at a rate of 110 thousand tourists per year from 2001 to 2005. The total recovery thus totals approximately 1.64 million tourists. Consequently, the net reduction in the number of tourists is approximately 2.59

million.

With regard to the reduction in the number of tourists resulting from Typhoons Toraji and Nari, the annual reduction from 2001 to 2003 is about 0.18 million, so the total reduction is approximately 0.55 million. Meanwhile, the recovery during the following year is approximately 0.19 million. The net reduction is thus 0.36 million. Similarly, since the effect of typhoon le Mindulle only lasted for a year, the decrease is about 80 thousand.

**Table 6.** Estimation of annual loss in tourist arrivals

| Year | Variable | Loss in tourist numbers by considering variables | Loss in tourist numbers by not considering variables* | Differential of the number of tourists |
|---|---|---|---|---|
| 1996 | E1996 | 219,462 | 228,916 | -9,454 |
| 1997 | E1996 | 219,462 | 210,008 | 9,454 |
| 1998 | E1996 + R1996 | 95,464 | 95,464 | 0 |
| 1999 | E1999 | 604,249 | 464,982 | 139,267 |
| 2000 | E1999 | 604,249 | 741,159 | -136,910 |
| 2001 | E1999 + R1999 + E2001 | 678,982 | 690,770 | -11,788 |
| 2002 | E1999 + 2×R1999 + E2001 | 569,744 | 557,955 | 11,788 |
| 2003 | E1999 + 3×R1999 + E2001 + R2001 | 268,747 | 268,747 | 0 |
| 2004 | E1999 + 4×R1999 + E2004 | 246,200 | 246,200 | 0 |
| 2005 | E1999 + 5×R1999 | 58,055 | 60,413 | -2,358 |

*Note: It is investigated by subtracting the actual number of tourists from the estimation without using dummy variables in the model.*

The annual loss in tourist arrivals can be estimated by adding up all the effect and recovery variables for the relevant year in the simulated model (Table 6). The year with greatest loss in tourist arrivals of the model is 2001. It could be postulated that the number of tourists affected by the Chichi earthquake, Typhoons Toraji and Nari. The total reduction in the number of tourists is estimated around 0.68 million during 2001. But if the study estimates the numbers excluding the effects of natural disasters, the greatest loss in tourist numbers occurred in 2000 (around 0.74 million), followed by 2001 (0.69 million). In the case of the Chichi earthquake in 1999, the loss of the number of tourists in the model considering dummy variables is estimated to be about 0.60 million, compared to a loss of about 0.46 million for the situation without considering dummy variables. Comparing the results obtained by the two models, the prediction results of the switching regression model may sometimes overestimate or underestimate the loss in the number of tourists, particularly in 1999 and 2000. Notably, an overestimation of 139,000 exists in 1999, and an underestimation of 136,000 exists in 2000 (see Table 6).

Additionally, Figure 5 compares the actual number of tourists, the estimated number of tourists considering seven dummy variables (E_No.), and the estimated number of tourists without considering the dummy variables (NE_No.). The estimated number of tourists without considering the dummy variables is approximately 10.31 million from 1996 to 2005. Compared to the estimated loss of the number of tourists (3.56 million in the E_No model), the loss is about 35 percent of the total loss over this ten-year period. Natural disasters thus have a dramatic impact on tourist numbers (Figure 5).

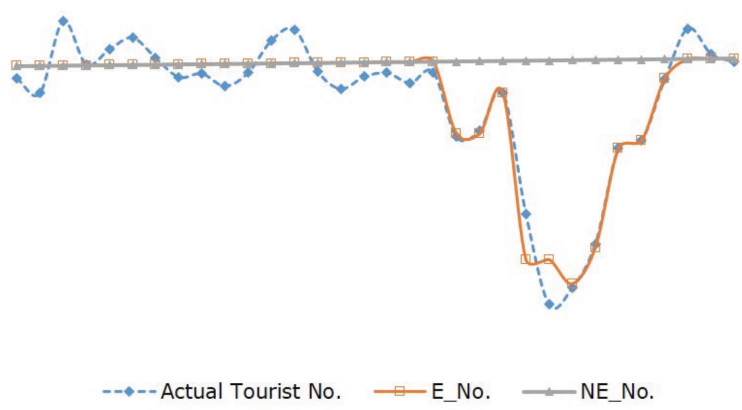



**Figure 5.** Tourist numbers in different approaches

*Note: Actual tourist numbers (No.), the estimated number of tourists considering seven dummy variables (namely E_No.), and the estimated number of tourists without considering the dummy variables (namely NE_No.) during1997-2008 in XNEA.*

Figure 5 shows that the estimated number of tourists in the E_No model is generally close to the actual number of tourists during the ten-year study period. The trend would have been stable had no natural disasters occurred (the line shown by NE_No. in Figure 5). The differences between the estimated and actual numbers of tourists show that the model contains some overestimation and underestimation in 1999. This difference occurs because of the Chichi earthquake that struck central Taiwan in September 1999. Before the earthquake, the annual number of tourists visiting XNEA was 560,000. Although the number of tourists dropped to zero immediately following the earthquake, the number of tourists in 1999 already accumulated a certain number of tourists. Consequently, the number of tourists during 1999 does not actually reflect the reduction in tourist numbers resulting from the earthquake, causing an over estimation of the loss number. In contrast, the number of tourists in 2000 reflects the exact loss for the previous year.

## Discussion

In conclusion, this study applies switching regression to estimate the reduction in tourist arrivals in XNEA following natural disasters. The model sets seven dummy variables to deal with the effect and recovery periods for each major natural disaster. The results demonstrate that switching model can efficiently estimate the impacts of natural disasters on the reduction in tourist arrivals, and the impacts of individual disasters in XNEA. The results show that: (1) Typhoon Herb reduced tourist arrivals by an estimated 530 thousand over three years; (2) the Chichi earthquake caused a 2.59 million loss in tourist numbers over seven years; (3) Typhoons Toraji and Nari resulted in a 360 thousand reduction in tourist arrivals over three years; and (4) Typhoon Mindulle reduced tourist arrivals by 80 thousand over a one-year period. During the disaster period from 1996 to 2005, all natural disasters resulted in a total reduction of 3.56 million in the number of tourists visiting XNEA. Based on the model's estimation, the XNEA could have approximately 10 million tourists during this disaster period. Natural disasters accounted for approximately 35 percent of the reduction in tourist arrivals in XNEA. The loss of tourism revenues in XNEA could therefore be estimated. From the information above, tourism practitioners could understand that recovery for tourist arrivals takes longer than expected and the recovering plans should be made accordingly. The major contribution of this study lies in distinguishing and estimating the impacts of natural disasters on tourist arrivals in XNEA. It can serve as a reference to the other countries with similar circumstances.

Few limitation of this research should be addressed. The study time frame (from 1996 to 2005) is selected because major natural disasters are occurred during this period in XNEA. It should be noted that it's a relatively small sample size for switching regression test. The data interpretation should be cautionary and explained within local context. Additionally, there are some "one-off" events during the study period such as '97-'98 Asian financial crisis, the terrorist attacks of Sep. 11, 2001 in the U.S., and the outbreak of SARS on 2003. These events have shown a significant and negative effect influence on international tourist arrivals (Ming, 2005; Lim, 2004; Wong et al., 2007). The events above may have great potential to influence over inbound tourists in Taiwanese tourism market. However, XNEA is a domestic tourism destination and domestic tourists are major flow in the tourist arrivals in XNEA. In this sense, authors consider the effects of the events are relatively minor comparing to the effects of natural disasters in XNEA and tend to analyze the major events.

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