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Analysis of the economic impact of meteorological disasters on tourism: the case of typhoon Morakot's impact on the Maolin National Scenic Area in Taiwan

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This study explores the cost of extreme weather disasters to the tourism industry, taking the Taiwan Maolin National Scenic Area as an example. The paper evaluates the economic damage caused by typhoon Morakot. The author uses long-term tourist trend lines as the basis for calculating disaster losses and adopts an error correction model as a measurement method for the estimation. The study finds that the entire park lost over 700,000 visitors in the year and a half after the disaster, representing a loss of NT$1.39 billion in tourism business – a value three times the infrastructure loss. Any delays in reconstruction will increase the losses to the tourism industry. However, several tourist spots were gradually losing their attractiveness even before the disaster, and hastening to rebuild such sites is not conducive to the recovery of tourism. Rather, efforts should first be made to understand the reasons why these tourist spots were becoming less attractive and to gauge tourist demand for them before their reconstruction.

Keywords: weather disaster economic costs; climate change; tourism demand analysis; disaster recovery; error correction model; Taiwan

Tourism is deeply influenced by climatic conditions (Gómez-Martín, 2005; Amelung *et al*, 2007; Scott *et al*, 2007; Conrady and Bakan, 2008; Taylor and Ortiz, 2009; Scott, 2011), and so scholars have actively studied the impact of climate change on tourism. These studies have explored the influence of the

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amount of rainfall, temperature and other meteorological conditions on tourist numbers and then combined these factors with climate models to predict the impact of climate change on future tourism markets. The relationship between climate change and tourist numbers has yielded clear results on the national, regional and global scales (Hamilton and Tol, 2007; Eugenio-Martin and Campos-Soria, 2010; Rosselló-Nadal *et al*, 2011). Many studies have specifically evaluated the impact of long-term temperature increase on the tourism market. For example, a severe coral bleaching of Australia's Great Barrier Reef caused by sustained high temperatures could decrease tourist visits by 35% (Prideaux, 2006). Rising temperatures, which can result in the disappearance of glacial landscapes (Brugman *et al*, 1997; Hall and Fagre, 2003), changes in vegetation cover, habitat reduction and even the extinction of organisms (Halpin, 1994; Cumming and Burton, 1996; Scott *et al*, 2002; Hall and Fagre, 2003), are projected to decrease the number of visitors by 19% and 31%, respectively, at Glacier-Waterton International Peace Park and Banff National Park (UNWTO-UNEP-WMO, 2008).

The aforementioned studies used long-term meteorological data to assess the impact of long-term temperature increases caused by climate change on tourism. However, the impact of another characteristic of climate change – extreme weather conditions – is rarely discussed. In recent years, the global frequency of extreme weather events has increased substantially, including some of the worst flooding in half a century in Thailand in 2011 and Australia in 2012 and a serious drought in China during the same period. Climate disasters have caused serious damage to the tourism industry, and some tourist spots have even been destroyed; for example, a 2010 flood destroyed Inca ruins in Machu Picchu, Peru. However, previous analysis of the impact of such extreme meteorological disasters on tourist visitation is inadequate. Analysis of the damage caused by extreme meteorological disasters is crucial for planning climate change strategies in the tourism industry. Such analysis should include an estimation of the scale of natural disasters, an assessment of the opportunity cost of reconstruction and a provision of standards for comparison in a recovery. To compensate for the inadequate prior research on the impact of extreme meteorological disasters on tourism, this study investigates the impact of typhoon Morakot on the Maolin National Scenic Area in Taiwan, estimates the damage caused by this disaster (also called the 88 typhoon disaster in Taiwan) and the opportunity cost of reconstruction, and assesses the priorities for allocating reconstruction resources.

Typhoon Morakot hit Taiwan on 7 August 2009, resulting in 673 deaths, 26 missing people and NT$27.94 billion in property damage, of which NT$2.18 billion was damage to tourist facilities (Morakot Post-Disaster Reconstruction Council, Executive Yuan, 2010). Among the major scenic attractions, Maolin National Scenic Area had the most serious damage. The Maolin National Scenic Area was established on 2 October 2001 as one of the tourist spots with the most potential in southern Taiwan. The Purple Butterfly Valley in this area is one of the two world's largest wintering butterfly valleys, with high ecological importance and tourism value. The heavy rain brought by typhoon Morakot disrupted the vast majority of local traffic in the Maolin National Scenic Area. The management headquarters and Liugui Visitor Center collapsed. Landslides destroyed most hotels, hot springs and scenic spots. Property losses totaled

NT$4.6 billion (Morakot Post-Disaster Reconstruction Council, Executive Yuan, 2010).

However, the impact on tourism is not limited solely to tangible facilities. The invisible decline of tourist activity was another outcome of this disaster.[1] Decreased tourist numbers can be used to estimate reduced tourism activity. The tourist numbers projected for the case in which the disaster did not occur constitute the benefit that could have been generated (the opportunity cost). This cost must be counted as one of the losses from the typhoon disaster. Currently, only project costs are listed in Taiwan's official typhoon disaster losses. To correctly account for typhoon Morakot's impact on the Maolin National Scenic Area, both the scale and the economic value of tourist activity loss due to the typhoon disaster should be carefully estimated.

The assessment of tourist visits or tourist demand is the basis of damage analysis. Tourism demand forecast can provide information on the past status and future trends of tourism and serve as the basis for decision making during reconstruction. Thus, to reconstruct effectively the Maolin National Scenic Area, the Taiwanese government should recognize the status of tourists' activities and tourism demand in this region, and then define the priorities in each reconstruction phase.

Tourism demand analysis is rarely used to assess disaster damage. Bonham *et al* (2006) and Gut and Jarrell (2007) studied the impact of the September 11 terrorist attack on the tourism industry. Kuo *et al* (2008) and Huang and Min (2002) assessed the impact of SARS and avian flu and the 921 earthquake on the Taiwanese tourism industry. Other tourism disaster assessments include those for the global financial crisis (Song and Lin, 2010). Bonham *et al* adopted an error correction model (ECM) to assess the tourist demand function. This ECM can be combined with overall economic data to predict changes in tourist numbers. This model is suitable for the estimation of the opportunity cost of post-disaster reconstruction and meets the requirements of this study. Therefore, we followed the method of Bonham *et al* to estimate tourism demand and predict tourist trends for the Maolin National Scenic Area. Based on the results, we calculated the output loss in tourism caused by the damage brought by typhoon Morakot. Our research targets four major tourist spots in the Maolin National Scenic Area: the Maolin Scenic Area, the Taiwan Aboriginal Culture Park, the Wutai Recreation Area and the Baolai and Pu-lao Hot Springs.

The data analysed in this study can be divided into two parts: tourist numbers and other general economic variables. Tourist numbers were acquired from the Tourism Bureau (2010) in the form of monthly tourist numbers at major domestic tourist spots. Maolin National Scenic Area Administration is officially responsible for determining the tourist numbers and uses a variety of methods to estimate the number of tourists visiting the park. These methods include mandatory visitor registrations in the Wutai Recreation Area, an entrance ticket requirement to the Taiwan Aboriginal Culture Park, and visitor contacts at visitor stations in Maolin Scenic Area and Boalai and Pu-lao Hot Springs. The visitor station of Maolin Scenic Area is located at the only entrance of the scenic area and the park staff count visitors passing the visitor station. Visitor counts from each site have to be reported within two weeks of the end of each month. Other general economic variables were sourced from the national income and economic growth database at the DGBAS (Directorate General of

Budget, Accounting and Statistics) (2010). All data are reported on a monthly basis, covering the period from January 2001 to December 2010. In addition, per capita tourist spending data were taken from the 2010 National Tourist Survey Report (Tourism Bureau, 2011).

The introduction of this paper summarizes the purpose of this study and research methods. The second section describes the significance of the long-term tourist trend line and its policy implications. We discovered that using the tourist trend as a basis can help us to understand the impacts of disasters on tourism activity and to evaluate the adequacy of reconstruction efforts and their priorities. The third section uses the error correction model to predict long-term tourist trend lines at the major sightseeing sites in the Maolin National Scenic Area and estimate the influence of the typhoon disaster on tourism activity changes. Such changes can be represented as numbers of tourists or alternatively represented by currency after monetization for comparison with other losses from the typhoon disaster. Our research conclusions are presented in the final section.

The economic view of the impact on tourist numbers

It is generally believed that when tourist numbers are restored to pre-disaster levels, the tourism industry[2] is considered to have recovered from a disaster. However, this view does not consider the influence of overall economic changes during the reconstruction period and thus misjudges the damage to the tourism industry from environmental disasters. This error becomes exacerbated as the reconstruction schedule is extended. To correctly measure typhoon Morakot's impact on Maolin tourism, we must consider both the length of the reconstruction schedule and the original tourism activity without the disaster.

Tourist numbers at the Maolin National Scenic Area are influenced by the overall environment including population and economic growth. By only examining the total number of tourists at each time point without carefully studying each variable's influence on the tourist numbers, we would find that the number of tourists demonstrates a certain trend, as illustrated by the trend line in Figure 1. If the number of tourists before the typhoon is represented by point A following the impact of the typhoon disaster the number of tourists would drastically fall to point B; subsequently, the number of tourists may rise to point C, recovering to the pre-disaster level. If reaching point C is considered the full recovery of tourism activities, then the impact on the tourism industry is represented by ΔABC. This view assumes that the external environment remains unchanged or that the external environment is irrelevant to the number of tourists visiting the scenic area. Such assumptions are clearly inconsistent with the characteristics of the tourism industry.

The inadequacy of using pre-disaster tourist numbers as the benchmark for recovery can be easily demonstrated by an example at time T. Suppose the disaster did not happen; under normal circumstances, the number of tourists is D at time T. Owing to the typhoon disaster, the actual number of tourists at time T is E. Therefore, DE is the number of tourists lost due to the disaster, indicating the impact on tourism (the total impact of the disaster is ΔABG, a far greater impact than ΔABC). However, if A is used as the basis point,

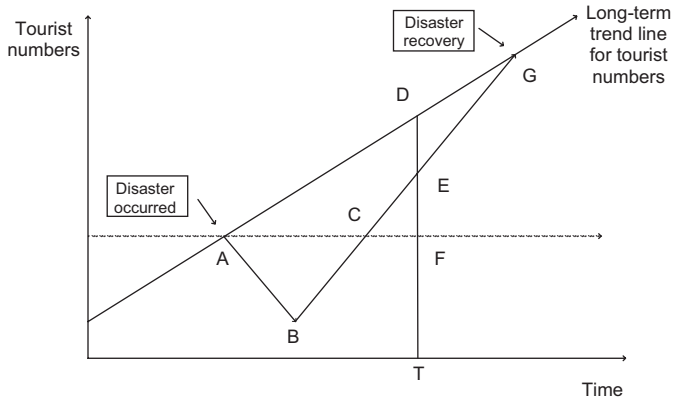

Figure 1. Change in the number of tourists after the disaster.

because the number of tourists at time T is already higher than point A, it could be considered that the tourism industry has already recovered and experienced growth EF.

Using a time trend as the basis can demonstrate the overall influence of the external environment on tourism activity during the reconstruction period and thus reflect the opportunity cost of the disaster. Using a pre-disaster value as the basis, however, ignores the original features of the scenic area during the reconstruction period. Comparing the two approaches, we find that the latter would misjudge the impact of the disaster. Therefore, a time trend should be used as the basis for typhoon disaster assessment.

The impact of typhoon Morakot on the tourist numbers at the Maolin National Scenic Area is illustrated in Figure 2. The line of asterisks represents the time trend before the typhoon disaster, representing the monthly numbers of tourists from January 2001 to June 2009. The thin solid line represents the time trend after the disaster as the monthly number of tourists after the disaster until December 2010. July 2009 is excluded because of possible errors in that month's data. July 2009 was one month before typhoon Morakot, when tourism activity had not yet been affected by the typhoon. However, the visitor statistics of July 2009 were incomplete because of the disaster. Tourist numbers should be consistent with the time trend, but the recorded number is much smaller than it should be, approaching zero. This anomaly likely represents an error in the statistics rather than a sharp decline in tourist numbers. To avoid propagating this error, data from July 2009 were removed from our study.

According to the historical data on tourist statistics, the numbers of visitors at the four major attractions at the Maolin National Scenic Area display a high degree of inconsistency. In terms of the total numbers of visitors, the Baolai and Pu-lao Hot Springs are the most popular, followed by the Taiwan Aboriginal Culture Park. The average number of total monthly visitors at these four attractions can reach as high as 200,000 but can also be near zero. These data show not only that tourism activity at the Maolin National Scenic Area is influenced by seasonality but that the popularity of the different attractions also varies. From the perspective of time trends, only the tourist numbers at

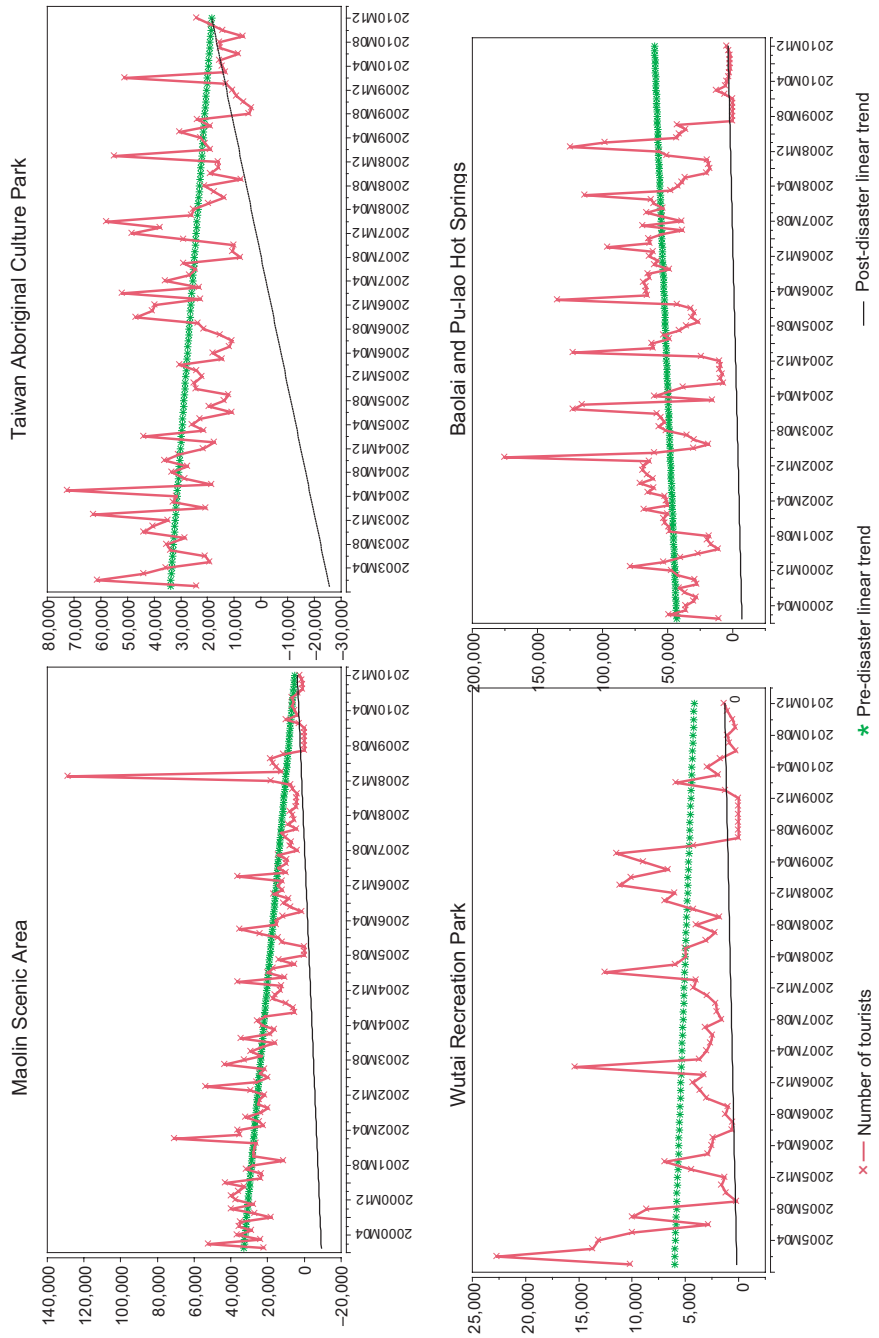

Figure 2. Comparison of the pre-disaster and post-disaster tourist numbers at the Maolin National Scenic Area.

the Baolai and Pu-lao Hot Springs show positive growth, whereas the tourist numbers at the other three parks are gradually decreasing, especially that of the Maolin Scenic Area.

The effects of the disaster on the four attractions were also inconsistent. The Baolai and Pu-lao Hot Springs were the most popular attractions before the typhoon disaster and were thus influenced the most. After examining the post-disaster tourist numbers, we found that the post-disaster tourist trend was still far from an upward trend line before the disaster, showing that tourism activities at Baolai and Pu-lao Hot Springs have not recovered yet. Although the post-disaster tourist numbers at the Wutai Recreation Area are gradually trending towards pre-disaster numbers, this increase is likely not because the post-disaster trend is upward but rather because pre-disaster tourist numbers were already decreasing. Tourism activities recovered quickly at the Taiwan Aboriginal Culture Park, almost keeping up with the pre-disaster trend. Tourist numbers at the Maolin Scenic Area are also recovering gradually.

Comparing the tourist trends before and after the disaster, we discovered that in rebuilding tourism activity at the Maolin National Scenic Area, the primary focus should be placed on the reconstruction of the Baolai and Pu-lao Hot Springs. The Baolai and Pu-lao Hot Springs were the most important attractions before the disaster and have failed to show any signs of recovery, suggesting the necessity of reinforcing reconstruction activities at these sites. The Maolin Scenic Area and the Taiwan Aboriginal Culture Park show more positive responses to reconstruction. Although tourism activity at both sites was decreasing before the disaster, they have recovered quickly after the disaster. Tourist numbers at Wutai Recreation Area were sparse before the disaster and have remained limited after the disaster.

Studying historical data for tourist statistics can help us to understand the adequacy of post-disaster reconstruction efforts. Despite some increases, the tourist numbers at Baolai and Pu-lao Hot Springs remain far from what they should be, suggesting inadequate reconstruction efforts in the area. Although the attractiveness of the Maolin Scenic Area and the Taiwan Aboriginal Culture Park was declining before the disaster, it recovered quickly after the disaster. Therefore, by leveraging post-Morakot reconstruction, it is possible to resurrect the Maolin Scenic Area and Aboriginal Culture Park as domestic tourist hotspots. The recovery strategies for these two areas should not be limited to considering the recovery of their original tourist numbers but should instead first focus on understanding the reasons for the decline of their attractiveness to tourists and identifying these two areas' positions in the domestic tourism industry in the future before undertaking infrastructure reconstruction. The Wutai Recreation Area was a popular recreational area (with monthly numbers of visitors exceeding 20,000), but its number of visitors had been gradually decreasing. The downward trend continued after the disaster. Therefore, rebuilding Wutai Recreation Area should be a lower priority in the reconstruction planning at the Maolin National Scenic Area.

In the previous discussion, we discovered that using a tourist trend is helpful for understanding the impact of a disaster on tourism activity. It also helps to compare the trends before and after the disaster in each area and evaluate the adequacy of reconstruction tactics and priorities. However, a graphical analysis can only grasp general conditions and does not take full advantage of the

information available in statistics. To fully capture the impact and evaluate the effects of typhoon Morakot on tourism activity in the Maolin National Scenic Area, we used an econometric tourism model to estimate the long-term tourist trend lines at each of the major sightseeing sites. Based on the trend lines, we calculated the loss of tourism output at Maolin.

Quantitative analysis of the number of visitors

In this study, we used an econometric tourism model to evaluate the major factors that influence the long-term tourist trend lines at each major tourist site in the Maolin National Scenic Area. The results were then used as bases for calculating tourism output loss. Because autocorrelation and unit roots (Song *et al*, 2008) can exist in time series data in the tourism industry and affect the statistical nature of linear regression estimates, we must first determine the variables and then choose a suitable econometric model according to the statistical characteristics of the data.

The existence of a unit root reflects that the data reflect stationary time series variables. Traditional quantitative analysis methods assume that all variables are stationary time series. Regression analysis using non-stationary time series data may produce spurious regression phenomena (Granger and Newbold, 1974; Engle and Granger, 1987; Granger, 2007). In this situation, least squares estimates will not be consistent, and the variance of the residual will approach infinity as time increases. In addition, external shocks (such as a typhoon disaster) occurring in a time series only produce temporary influences on stationary time series but have permanent influence on non-stationary time series. Therefore, econometric models cannot be applied directly to non-stationary time series. Differential calculations must be applied to non-stationary time series data to convert them into stationary time series. If a non-stationary time series becomes stationary after a time difference operation d, such a time series is called integrated in order d, denoted as Xt~I(*d*).

We applied the augmented Dickey–Fuller (ADF) test (Engle and Granger, 1987) to tourist numbers for the major tourist spots at Maolin National Scenic Area to examine unit roots and found that unit roots exist in the data of all four parks. Therefore, a regression analysis (Table 1) cannot be directly applied. Because first-order differential operations removed all the unit roots, all of the sequences at the Maolin National Scenic Area are therefore I(*1*) sequences.

Table 1. Unit root tests for tourist numbers.

	Original values of of tourist numbers	First-order differences in tourist numbers
Maolin Scenic Area	–4.45	–18.90***
Taiwan Aboriginal Culture Park	–2.83	–17.24***
Wutai Recreation Area	–3.08	–12.91***
Baolai and Pu-lao Hot Springs	–3.07	–15.60***

Note: ***$p < 0.01$.

Traditional econometric model cannot be used for the analysis of non-stationary time series data in the tourism industry. To address this problem, Song, Witt and Li (2008) proposed an error correction model, following models first proposed in the 1960s. According to Engle and Granger (1987), if a co-integration relationship exists between two variables, the relationship can be represented by an error correction model. This concept explains short-term changes in relationships among sequences and the process of adjusting from a short-term imbalance to a long-term equilibrium using the imbalance in the long-term co-integration relationship to adjust and fix short-term dynamics. Therefore, changes in the current variables are influenced by factors including previous error correction items, previously changed auto-correlated items, and previous changes in other variables. In summary, error correction consists of corrections and adjustments in the current time cycle to compensate for the deviation of residuals from the previous time cycle.

The advantages of the error correction model compared with other econometric models include the following. (a) The error correction model simultaneously demonstrates short-term and long-term equilibriums. (b) The error correction model avoids false correlation issues among variables (such as spurious regressions). Because the majority of time series data in tourism are non-stationary data, this method can solve false correlation issues. (c) The error correction model can reduce regression collinearity problems. (d) The error correction model avoids the controversy of data mining. (e) The error correction model does not presume relationships among parameters but is rather a generalized model (Song *et al*, 2008).

The error correction model can be expressed as follows:

$$\Delta y_t = \beta_0 \Delta x_t - (1 - \phi_i)[y_{t-1} - k_0 - k_1 x_{t-1}] + \varepsilon_t.$$

The Engle–Granger two-stage estimation method is often used for such estimations. However, this method does not yield long-term equilibrium estimates and produces errors in the analysis of small samples. Another estimation technique is the Wickens–Breusch one-step estimation method (WB1S), expressed as follows:

$$\Delta y_t = \alpha + \beta_0 \Delta x_t + \phi_i \Delta y_{t-1} + \lambda_1 y_{t-1} + \lambda_2 x_{t-1} + u_t. \quad (1)$$

The parameters determined using the WB1S method are consistent, valid and unbiased, regardless of whether long-term or short-term relationships are analysed. Therefore, in this study, we used WB1S method to estimate the model parameters.

The dependent variable in the tourist demand model (the tourism long-term trend line) is the number of tourists (T). There are many possible options for the independent variables. Based on the results of recent comparative analyses of tourist needs (Crouch, 1995; Song and Li, 2008), we chose Taiwan's total population (POP), per capita national income (GDP) and consumer price index (PI) as the independent variables for the model. To estimate the parameters, we first require the differentials of each variable (DPOP, DGDP, DPI and DLT) and one-step-backwards values for each variable (LPOP, LGDP, LPI and LT). Then, plugging the results into Equation (1), we obtain the values listed in Table 2.

Table 2. ECM estimation results (based on the Wickens–Breusch one-step approach).

	Intercept	DPOP	DGDP	DPI	LPOP	LGDP	LPI	DLT	LT
Maolin	–312.79	1045.57*	–3.18	–0.10	21.94	–3.70**	–0.08**	0.01	–0.83***
	(299.63)	(573.12)	2.25	0.07	18.74	(1.70)	(0.04)	0.12	(0.15)
Culture Park	–326.91	672.08	0.23	–0.10	19.77	0.46	–0.07	–0.18	–0.64***
	(420.78)	(499.46)	(2.06)	(0.08)	(25.46)	(1.34)	(0.05)	(0.13)	(0.17)
Wutai	–1291.83	214.76	–1.93	–0.03	78.34*	–1.97	–0.07	–0.06	–0.57***
	(799.65)	(972.50)	(4.61)	(0.15)	(48.24)	(3.45)	(0.08)	(0.18)	(0.19)
Baolai	–261.02	505.92	–2.00	–0.04	15.85	–0.06	–0.03	0.00	–0.36***
	244.36	462.43	1.75	0.06	515.14	1.25	0.03	0.10	(0.08)

Note: $^{*}p < 0.1$; $^{**}p < 0.5$; $^{***}p < 0.01$.

Table 3. Differences between actual and estimated tourist numbers (units: visits).

	Maolin Scenic Area	Aboriginal Culture Park	Wutai Recreation Area	Baolai, Pu-lao Hot Springs
2009Q3	–17,197	–14,564	–16,001	–98,468
2009Q4	–12,634	–25,078	–14,481	–103,206
2010Q1	2,007	22,730	–8,836	–86,974
2010Q2	3,252	–13,922	–13,158	–98,925
2009Q3	–251	–13,628	–13,016	–98,521
2009Q4	–5,801	8,058	–11,368	–91,399

As shown in Table 2, by inputting the total population, per capita national income and consumer price index into the model, we estimated the expected numbers of tourists per month if the typhoon had not occurred. After subtracting the actual monthly tourist numbers from the estimated numbers of tourists, the residual numbers represent the impact of typhoon Morakot on tourism. The quarterly aggregated differences in the numbers of visitors are listed in Table 3. Taking the Maolin Scenic Area as an example, the actual number of tourists in the third quarter of 2009 is 17,000 below the expected number. This difference is due to the typhoon and can therefore be considered the impact of the disaster on tourism. From immediately after the disaster until the end of 2010, the total number of tourists in the entire Maolin National Scenic Area was reduced by 721,381 visitors, suggesting that the Maolin National Scenic Area not only suffered serious property damage to buildings, roads and tourist sites but also suffered a significant loss in the number of tourist visits.

In addition to the number of tourist visits, the invisible tourism damage can also be measured by the output of the tourism market. To monetize such a loss, we must estimate the value of each tourist visitor or the average value of all visitors. Because the tourism database estimates only national average spending on tourism based on an annual tourism survey and does not include tourists' spending at each tourist spot, we can estimate only the output loss as the

Table 4. Tourism output fluctuations due to changes in tourist numbers (units: thousand NT$).

	Maolin Scenic Area	Aboriginal Culture Park	Wutai Recreation Area	Baolai, Pu-lao Hot Springs
2009Q3	–33,035	–27,978	–30,737	–189,156
2009Q4	–24,270	–48,175	–27,818	–198,259
2010Q1	3,856	43,664	–16,974	–167,077
2010Q2	6,246	–26,744	–25,277	–190,035
2009Q3	–482	–26,180	–25,004	–189,258
2009Q4	–11,144	15,480	–21,838	–175,577

spending per person per trip from the survey report. According to the national tourism survey report in 2010, the annual tourist spending per person per trip is NT$1,921. Using this spending level and the changes in tourist visits listed in Table 3, we can calculate the change in tourism output at the Maolin National Scenic Area; the results are shown in Table 4. As of December 2010, total tourism output was reduced by NT$1.39 billion after the typhoon disaster. This loss is three times the loss from property damage, showing that considering only facility damage seriously underestimates the impact of the typhoon disaster.

Conclusion

This study estimated the impact of typhoon Morakot on tourism activity in the Maolin National Scenic Area. The estimation was measured in tourist numbers and New Taiwan dollars. This study marks the first report of the use of long-term tourist trend lines supplemented with an error correction model as a basis for measuring disaster losses in Taiwan. Tourism losses from the typhoon disaster, long-term tourist trend lines and error correction models are rarely discussed in the tourism industry literature. However, only by combining these three methods can we correctly assess the losses caused by this disaster. Although a series of natural disasters occurred, the nation is still actively promoting tourism. A correct tourism damage assessment method is urgently needed to assist in formulating tourism-related policies. This study fills this research gap in the tourism industry.

The use of long-term tourist trend lines as bases can facilitate a more in-depth understanding of disaster impacts on tourism activities and help us grasp the priorities of post-disaster reconstruction by comparing trends before and after a disaster. The Maolin Scenic Area and the Taiwan Aboriginal Culture Park have recovered considerably. The Baolai and Pu-lao Hot Springs are currently the most popular tourist attractions but suffered the most serious impacts. There remains a considerable distance to full recovery, and more resources should be invested in the reconstruction of these areas. The number of tourists who were there was sparse before the typhoon disaster and remained sparse after the disaster. Therefore, the priority for the Wutai Recreation Area can be reduced in reconstruction planning for the Maolin National Scenic Area.

The reconstruction of the Maolin Scenic Area and the Taiwan Aboriginal Culture Park has yielded considerable results. However, reconstruction should not be performed hastily, particularly just restoring the area to its original state. The long-term tourist trend line shows that the attractiveness of the two regions to tourists was decreasing before the disaster. Simply restoring damaged facilities may not reverse the declining trend in tourist numbers even after significant reconstruction, which would drastically reduce the effectiveness of the allocated reconstruction funds. In contrast, if we first investigate the reasons for the decline in tourist attractiveness before the disaster and consider the positions of these two regions in the future domestic tourism market and employ suitable tactics, we may be able to restore the attractiveness of the Maolin Scenic Area and the Taiwan Aboriginal Culture Park and generate the benefits of increased national tourism.

A unit root test revealed that tourist numbers are I(*1*) sequences, so this error correction model was used to estimate long-term tourist trend lines for the four major parks in the Maolin National Scenic Area. Based on these trend lines, we calculated the damage to tourism caused by typhoon Morakot. The entire park lost 700,000 tourist visits during the 18-month period after the disaster, equivalent to at least NT$1.39 billion in tourism output, a value three times that of the loss of tourist facilities. This loss will increase as the schedule of the reconstruction period is extended.

In the past, estimates of typhoon disaster loss included only the costs of buildings, facilities, roads and environmental remediation but not the scale of decreased tourist activity. This study found that this decrease is rather significant. The exclusion of the opportunity cost of tourism activities seriously underestimates the disaster's impact on tourist spots, preventing them from acquiring adequate disaster prevention resources. Delays in reconstruction will aggravate the loss of tourism. However, our study also found that several tourist spots were already losing attractiveness before the disaster. The reconstruction of these tourist spots should be suspended and restarted only after proper long-term planning to avoid the consumption of resources that could be used for the reconstruction of other spots and prevent the reconstruction of facilities that may not meet the needs of the tourism market. The most urgent task for the authorities is to find a solution that shortens the reconstruction schedule and thus reduces tourism losses while taking into account the long-term needs of tourist activities. The results of this study can be used as a reference for the allocation of post-Morakot reconstruction resources.

Endnotes

1. Because the public infrastructure, particularly the roads, bridges, water supplies, power facilities and telecommunication were severely damaged, even residents living within the park area had to be rehoused elsewhere for months. Tourism also totally ceased for a couple of months.
2. Accommodation, food and beverage services, passenger rail and bus transport, passenger air transport, vehicle rental, travel agency services, and recreation and entertainment are listed as tourism industries in Taiwan tourism satellite account.

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