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Critical Issues of Predicting Extreme Weather Events' Impacts on Tourist Flow

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Abstract : While climate change intensifies the impact of weather extremes on tourist flow, there is a lack of an efficient and affordable approach for the post-event tourist forecasting. To bridge this knowledge gap, this paper explores the limitation of current major research for a weather extreme case. It is further argued such forecasting model should reflect the relationship between event scale, media catalyst, tourism resource, external environment and tourist behaviour, which dominates the degree of tourist displacement in the post-event period. Finally, the paper integrates these inputs and proposes a feasible tourist forecasting method for weather extremes.

Keywords: Climate change, forecasting, displacement, recovery

Introduction

The increasing frequency of high-magnitude extreme weather events forecast under conditions of global and regional climate change are likely to have a significant influence on the tourism industry (IPCC 2012). Yet, current research suggests that there is relatively little knowledge with respect to historical extreme weather event's impacts on tourism, and even less in predicting its influences in the future (Scott *et al.* 2012). However, without the development of an appropriate knowledge base, destinations may find it increasingly difficult to respond to future changes and the impacts of such events.

The aim of this research is to provide observations on the development and improvement of tourist forecasting models under a post-extreme weather event scenario. There are five parts in this paper, including the trend of extreme weather event and its relation with climate change, the impacts of historical extreme weather events on tourist flow, the key factors of tourist displacement after extreme weather events, the current issues of tourist-flow forecasting models, and conclusion. Finally, a forecasting method is advised in order to help tourism business estimate tourist loss and initiate effective recovery strategies.

Extreme Weather Events and Climate Change

Over 85% of natural disasters are associated with climatic factors in the last two decades (CEA 2007). In total, weather-related disasters were responsible for a loss of US$ 2.1 trillion from 1990 to 2009 (Harmeling 2010). Thus, the understanding of extreme weather events and their impacts is relatively important. The Intergovernmental Panel on Climate Change (IPCC 2007: 81) defines extreme weather event is " an event that is rare at a particular place and time of year". In this case, rare means as rare as or rarer than the 10th or 90th percentile of the observed probability density function. The characteristics of extreme weather event change from place to place, but its incidences are mostly sudden, powerful, uncontrollable, destructive, relatively brief, and sometimes predictable (Bell *et al.* 1990).

Although the precise contribution of anthropogenic climate change to extreme weather event is still unclear, research has illustrated its potential relationship with weather extremes in terms of frequency, intensity, spatial extent, duration, and timing (Brooks and Adger 2003; IPCC 2012). Based on B1, A1B, A2 emission scenarios, the trend of extreme weather events in the 21st century includes: (1) it is likely (=>66% probability of occurrence) that the frequency of heavy precipitation activities will increase; (2) it is likely that the tropical cyclone events (also called as typhoon, hurricane) will intensify in terms of wind speed and precipitation; (3) It is very likely (=>90% probability of occurrence) that the occurrence of heat wave events will increase in length, frequency, and intensity; (4) it is virtually certain (99-100% probability of occurrence) that the frequency and magnitude of warm daily temperature extremes will increase on a global scale; (5) it is virtually certain (99-100% probability of occurrence) that the number of cold extreme events will decrease; (6) there is a medium confidence that the duration and intensity of droughts will increase in specific regions (IPCC 2012).

The magnitude of weather extremes is usually evaluated by its mortal or financial consequences, such as the Hurricane Katrina is ranked as the most destructive disaster from 1975 to 2008 with a loss of US$125 billion (ISDR 2009). In general, the impact of a compound-event case, where two events occurring simultaneously or successively, is often more detrimental, such as the 2003 European heat wave and drought disasters (IPCC 2012). By 2100, climate change is projected to exacerbate the damage caused by extreme weather events. For example, it is likely to lead an additional economic loss of US$84 billion in cyclone and storm events (Mendelsohn and Saher 2011). Since tourism development is highly associated with climatic and weather conditions, this one-trillion dollar international business is recognized as one of the most vulnerable industries to climate change and weather extremes (Murphy and Bayley 1989; Giles and Perry 1998; IPCC 2011; UNWTO 2012).

The Impacts of Historical Extreme Weather Events on Tourist Flow

Tourism development often depends on the climate-induced destinations, and weather-reliant activities (Bentley and Page 2008; Scott and Lemieux 2010). However, the occurrence of extreme weather event may devalue the incentives and image of these climatic environment or products with a result of tourist retreat, especially in nature-based destinations. For example, coast areas and small islands are likely to be affected by cyclone events (Mirza 2003; Becken and Hay 2007; Becken *et al.* 2011). Mountain tourism business is likely to be suspended due to the wild fire disaster caused by heat wave (UNWTO, UNEP and WMO 2008). Moreover, when an extreme weather event is found threatening to the comfort, safety and health of tourists, or the access to infrastructure, the tourist flow may drop in either local or national level (Yu 2004; Becken *et al.* 2010; Scott and Lemieux 2010).

Historical extreme weather events have evidenced the changes of tourist flow, including temporal and spatial tourist displacement, which may contribute a shortly or long-term tourist decrease in affected destination (Sun et al. 2011; Luna *et al.* 2011; Machado 2012). The temporal tourist displacement indicates visitors may change the time of their visit, cancel booking, shorten their stay, or just not plan to go due to the adverse change of site condition (Hall and Shelby 2000; Lehto *et al.* 2008). The degree of temporal displacement would vary from days, weeks, months to years. For example, a 2011 snow storm in New Zealand forced the Mt Hutt ski areas to close for three days to customers, but the effect of 2008 Snow storm event in south China lasted nearly a month with a loss of 15,800 tour groups and 300,000 tourists (Christchurch and Canterbury Tourism 2011; BBC 2008). On the other hand, the recovery period of visitor numbers may extend from months to years, and the seasonal tourist pattern would adjust accordingly (UNWTO, UNEP and WMO 2008). The spatial tourist displacement means customers might change the place of visit (Hall and Shelby 2000; Lehto et al. 2008). The affected destination could be replaced by domestic attractions or other place in foreign country, depending on the severity of the event. For example, the subsequent four hurricane events in Florida have swept a large number of convention tourists to Arizona State (USA Today 2005a). The tourist flow in France transferred from south to north because of the heat wave event in 2003 (UNWTO, UNEP and WMO 2008).

The degree of tourist displacement is influential to tourism business in a post event period since it is highly related to local income, operational cost, employment, hotel occupancy rate, and even to the survival of tourism operators (UNWTO, UNEP, and WMO 2008). For instance, tourist decline resulted in a loss of 20,000 jobs and a drop of 25% hotel occupancy rate in Myrtle Beach and Grand Strand area after the 1989 Hurricane Hugo event in South Carolina (Sönmez and Backman 1992). Similarly, the 2010 high-precipitation event in the Island of Madeira, Portugal, contributed to a loss of 20% room occupancy rate, 12.5% of revenue, and 7% employment rate (Luna et al. 2011; Machado 2012). In the 2008 snow storm case, the economic loss even reached US$968.1 million in south China (BBC 2008). Therefore, it is important to predict tourist displacement and recovery timing in the destinations or country level in order to initiate efficient resilience strategies.

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The Key Factors of Tourist Displacement After Extreme Weather Events

This paper argues the tourist displacement after extreme weather events is mainly decided by the factors of event, media, tourist, and externals. The key points are illustrated as follows:

1. Event scale

The scale indicators of extreme weather event are generated as climatic characteristic, intensity, duration, coverage area, frequency, and the level of damage in this research. It is assumed that the high-magnitude event would cause severe loss in casualty, infrastructure, and economics, which often resulting in a higher cost of repairing, rebuilding and marketing the victim destinations. Thus, a longer period of tourist recovery is usually required in such case. While evaluating the impact of a high magnitude event on tourist flow, Sun et al. (2011) suggested adopting the variables of place, timing and local capacity. For example, developing countries are found to be more vulnerable to weather extremes due to their low ability of adaptation (Mirza 2003). This study excludes the less predictable events, like the long-length drought event (IPCC 2012), and mainly focuses on the following weather extremes:

(1) Tropical Cyclone, Typhoon and Hurricane

Tropical cyclone is also called as typhoon and hurricane, depending on geographical location. The intensity of tropical cyclone is mostly measured by wind speed and storm surge or velocity only (Table 1). A category 4 event or higher is considered as extreme (FEMA 2012). The multiple impacts of tropical cyclone, like strong wind, floods, landslides, high wave and strong storm surge, often lead to serious destruction for victim destination (ISDR 2009). Globally, about 78 million people are exposed to wind hazard and 1.6 million to storm surge every year. Bangladesh is ranked as the most vulnerable country in terms of mortality risk. In monetary value, US$ 1,284 billion of GDP is threatened annually. Japan has the largest amount of economic capital exposed to tropical cyclone (Nordbeck et al. 2005)

Table 1. The magnitude classification of tropical cyclone, typhoon, and hurricane

	Adopted Area	Magnitude	Source
Tropical Cyclone	Southwest Pacific Ocean and southeast Indian Ocean	Category 1: Winds (km/hr) 118-153. Surge: < 2 m Category 2: Winds (km/hr) 154-177. Surge: 2-3 m Category 3: Winds (km/hr) 178-210. Surge: 3-4 m Category 4: Winds (km/hr) 211-249. Surge: 4-5 m Category 5: Winds (km/hr) > 249. Surge: 5-10 m	Saffir-Simpson Scale
Typhoon	Northwest Pacific Ocean and South China Sea	Tropical depression: wind (knots) ≦33. Tropical storm: wind (knots) 34-47. Severe tropical storm: wind (knots) 48-63.. Typhoon: wind (knots) ≧64	Typhoon Committee, WMO
Hurricane	North Atlantic Ocean and the northeast Pacific Ocean	Category 1: Winds (MPH) 74-95. Surge: 4-5 feet Category 2: Winds (MPH) 96-110. Surge: 6-8 feet Category 3: Winds (MPH) 111-130. Surge: 9-12 feet Category 4: Winds (MPH) 131-155. Surge: 13-18 feet Category 5: Winds (MPH) >155. Surge: >18 feet	Saffir-Simpson Scale

Reference: Neumann 1993; ISDR 2009; FEMA 2012; WMO 2011a

(2) High precipitation

By WMO's definition (Serve weather Information Center 2012), heavy precipitation is an event with more than 50 mm rainfall in a 24 hour period. However, the classification may differ between countries, for example extreme rainfall is classified as more than 35 mm in a 24 hour period in the case of Taiwan (Taiwan Weather Bureau 2012). An extreme rainfall event is often linked with tropical cyclone activity, and may result in catastrophic flooding (WMO 2009). For example, heavy rainfall events in China resulted in severe floods and landslides and 1500 deaths in 2010 (WMO 2011b). Since the intensity of extreme rainfall is mostly decided by precipitation and duration (Hand et al. 2004), the figures, like hourly and daily maximum rainfall, and the total sum of rainfall generation, are relatively important.

(3) Heat wave

There is no international-consistent definition of heat wave since it is associated with local climate. For example, the maximum temperature of heat wave event is defined as over 30?C in France, but over 35? in South Australia (Poumad`ere et al. 2005). However, it is generally agreed a heat wave event would last a period of time (more than 2 days) with abnormally dry hot or humid hot condition. The event magnitude is often consider with mortality rate, and evaluated by air temperature and duration, humidity, wind speed, and cloud cover, but the first two figures are more commonly used in heat health warning systems. The heatwave event can be destructive to tourism business because it not only influences the comforts of tourist experiences, but also causes a high possibility of hearted-disease or death.

Urban centres are more threatened by heat wave events than rural areas because of urban heat island effects (USEAP 2006; WHO 2008).

(4) Cold wave

A cold wave or cold spell is a period with a sharply dropping temperature, usually having the average degree less than the 10th percentile of winter distribution (CRED 2012; de Vries et al. 2012). Although the number of cold extreme events is predicted to decrease in the future as a result of climate change, cold waves are still significant because of their destructive capacities, including extreme low temperature, heavy snow and serve snow storm (IPCC 2012; BBC 2008; WMO 2010). In such extreme cold conditions, there is a likelihood of a sudden drop in tourist flows in the affected destination due to the infrastructure damage, and the temporary termination of transportation and electricity supply (Sun et al. 2011; WMO 2012). For example, the 2009/2010 cold wave event meant that many northern hemisphere countries experienced an extreme winter, the temperature in France reached as low as -20.1°C , and the snow accumulation was as high as 142 cm in Virginia, United States. Its major impacts include the cancellation of 655 flights in the Beijing Airport as well as a result of more than 450 casualties in Europe (WMO 2010). The high mortality is often related to cardiovascular, cerebrovascular, circulatory and respiratory diseases caused by the extreme cold conditions (United Nations 2006).

Multiple weather events, e.g. the four hurricane events in Florida in 2004, or compound events, e.g. the 2009 Morakot Typhoon and 812 Floods in Taiwan, usually result in negative multiplier effects on tourism demand, such as a decrease of tourist flow in the short time and a change of seasonality in the long term (Hall 2002; USA Today 2005a; Ministry of Interior, Taiwan 2011). Thus, it is important to carefully evaluate the factor of event scale when conducting post-event tourist forecasting, which is often neglected in previous studies.

2. Media communication

Media communication, which covers the factors of message source, and the frequency and intensity of media attention, plays an important role in delivering information on natural disaster (Mcdonald et al. 2007). For example, international tourists who visited Tropical North Queensland in the post-event period, mainly received the news of Cyclone Larry from TV, newspaper and internet (Prideaux et al. 2008). Sensational media reporting is influential on tourist perception of event risk, including accessibility, product attraction, travel experience, personal health and safety. It is argued there is a correlation between media exposure, tourist perception, and travel decision (Perry 2001; Reisinger and Mavondo 2005; Becken et al. 2009; Rittichainuwat and Chakraborty 2009; Bomersback 2011; Scott et al. 2012). As the media repeatedly delivers the message, it often causes a sudden drop of inbound tourists after a natural disaster (Huang et al. 2008). However, the degree of media impact is hard to assess (Buzinde et al., 2010). The following research may consider rating the international travel warning or online news with respect to extreme weather event, then benchmarking the information as a media impact indicator (Löwenheim 2007).

3. Tourist characteristics

In an extreme weather case, tourist characteristics are found highly associated with their perception of disaster news, the acceptable level of risk, and the change of travel decisions (Gössling *el al.* 2012). Since the occurrence of an extreme weather event is often more evident, immediate, and detrimental than other types of climate change phenomenon, it is assumed the alteration of travel decisions is more rapid and significant for weather extremes. Tourist features, such as visit motives, the level of commitment, interest, cultural background and personal experience, often play as catalysts in the above process. It is noted tourists who travel for leisure are more likely to change plans than the ones who travel for business or family via friend visit due to their high sensibility to disaster events (Gössling and Hall, 2006; Forsyth et al., 2007; Becken *et al.*, 2010). Also, tourists with less commitment are more likely to change (Agnew and Palutikof 2001). For instance, the tourist who is still planning a vacation is less loyal to their plans than the one who has booked accommodation in a heatwave case (Rutty and Scott 2009).

Although tourists are more committed to their special interests (Curtin, 2010; Dawson et al., 2011), they may withdraw their attendance in weather-dependent or weather-sensitive activities (Smith 1993: Limb and Spellman 2001). In a hiking survey, 63.6% of respondents would give up their plan to hike due to heavy rainfall event (Li 2008). In addition, the impact of tourist experience is frequently examined in such studies, but there is no agreement up to date on its effects. One group of research notes the experienced tourists are more likely to change their visiting time in order to avoid risk (Szalai and Rátz 2007; Lehto et al. 2008), while Kozak *et al.* (2007), and

Han (2005) found that frequent travelers usually have lower risk perceptions of destinations. National culture may also influence tourists' risk perception and travel decision (Eugenio-Martin et al. 2005; Law 2006; Ertuna et al. 2009). For example, American travellers show lower awareness of natural disaster threats than Chinese and Singaporean travelers. Asian tourists are more likely to change their plans for hazards than western tourists (Law 2006).

4. External factors

While evaluating the change of tourist flow in a post-event period, it also needs to consider the impact of external factors, such as local recovery progress, marketing and promotion programs, and exchange rate (WTO and WMO 1998; Zhang et al. 2009). In some cases, the influence of external factors may be higher than the event itself. For example, a travel demand study indicated "exchange rate" can better explain the alteration of international tourist arrivals in Thailand than promotion budget or other mega events (Zhang et al. 2009). Therefore, it becomes sensible to analyze the weight of these variables in advance in order to have a precise prediction of tourist backflow.

The Current Issues of Tourism Demand Forecasting Models

Under the severe threats of climate change and weather extremes, this paper explores the feasibility of tourist forecasting approaches that may be applied after a weather disaster for the tourism industry. Although there are more than five hundred studies on the focus of tourism demand modelling and forecasting since 1960 (Song and Li 2008), most are post-event studies based on retrospective analysis (Table 2). In such research, time-series models are relatively popular because they can provide an efficient and less costly solution for a short-term forecasting (Huang and Min 2002; Song and Li 2008). The ARIMA model, which was developed in 1970s (Box and Jenkins 1970), is commonly conducted to restore the non-event-impact demand trend on the basis of the historical reference. With the actual and rebuilt tourist demand data, the intervention analysis is applied for reviewing the changes of visitor arrival and growth rate in the post-event period. The recovery time is further defined as "when the real tourist demand (growth rate) matches or surpasses the ARIMA predicted demand (growth rate)", which is useful for estimating the loss of tourist number.

The forecasting accuracy of ARIMA model has been doubted because this method neglects the impacts of seasonal or external factors (e.g. new shocks) on tourist demand. Thus, the SARIMA model, and subsequently developed techniques are more often discussed in post-event studies (Song and Li 2008; Chu 2008). Since the univariate time-series model only conducts dummy variables for predicting the tourist trend, other groups of studies replaced it with causal econometric models (e.g. the error-correction model, the autoregressive distributed lag model, and the time-varying parameter) or combination models (Bonham et al. 2006; Zhang et al. 2009; Page et al. 2012; Coshall 2009) in order to fully reflect the complexity nature of tourism business or the influence of multiple crises. In general, these retrospective studies do facilitate a better understanding of previous events, but offer less value in tourist demand forecasting after a new, rare, and large weather-induced hazard (Stekler 2003).

Table 2. Examples of the post-event tourism demand research

Research Topic	Measures
Earthquake devastation and recovery in tourism: the Taiwan case (Huang and Min 2002).	SARIMA Model
Modeling and forecasting tourism demand for arrivals with stochastic nonstationary seasonality and intervention (Goh and Law 2002)	SARIMA and MARIMA models with interventions
A Study of Post-Disaster Tourist Behavior and Effective Marketing Strategies: The Case of September 21st Earthquake (Min 2003).	SARIMA Model
SARS Devastation on Tourism: The Taiwan Case (Min 2005a).	SARIMA Model
The Effect of SARS Illness on Tourism in Taiwan-An Empirical Study (Min 2005b).	SARIMA Model
Quantifying the Effects of Tourism Crises: An Application to Scotland (Eugenio-Martin et al. 2005)	causal structural time-series models
The Impact of 9/11 and Other Terrible Global Events on Tourism in the United States and Hawaii (Bonham et al. 2006)	Vector Error Correction Model
Forecasting Japanese tourism demand in Taiwan using an intervention analysis (Min 2008).	SARIMA Model; Intervention analysis
A fractionally integrated autoregressive moving average approach to forecasting tourism demand (Chu 2008)	ARFIMA Model
The Determinants of the Travel Demand on International Tourist Arrivals to Thailand (Zhang et al. 2009)	Multiple regression analysis
A Study on the Impact of Natural Disaster to the Number of Visitors of Forest Recreational Areas (Dai 2009)	Intervention model; Switching Regression
Asian Financial Crisis, Avian Flu and Terrorist Threats: Are Shocks to Malaysian Tourist Arrivals Permanent or Transitory? (Lean and Smyth 2009)	Univariate Lagrange Multiplier (LM) unit root tests
Combining volatility and smoothing forecasts of UK demand for international tourism (Coshall 2009)	Combination Model
Multi Input Intervention Model for Evaluating the Impact of the Asian Crisis and Terrorist Attacks on Tourist Arrivals (Lee et al. 2010)	ARIMA model; Multi input intervention model
Intervention analysis of SARS on Japanese tourism demand for Taiwan (Min et al. 2011).	SARIMA Model; Intervention analysis
Impact of Five Important Events on China Provincial Inbound Tourism in 2008: An Analysis In High-Resolution Based on the TBL Model (Sun et al. 2011)	Tourism Background Trend-line Model
Assessing the Impacts of the Global Economic Crisis and Swine Flu on Inbound Tourism Demand in the United Kingdom (Page et al. 2012)	Time-varying parameter (TVP) model

To further cope with unpredictable crises, Scaglione (2007) discussed the application of three post-event forecasting methods, including analogy or Delphi method, econometric model, and the Structural Time Series (STS) Model with Intervention analysis. Analogy is a conventional and quick measure to predict the change of tourist flow on the basis of expert opinions. However, its result is less credible since this judgmental method basically assumes there is a high similarity between the past and new events, which rarely happens in real life situations. On the other hand, econometric models are credited with forecasting quality by utilizing multiple scenario analyses (Song et al. 2010). This economic measure, which extensively adopts the factors of politics, economics, culture, and society in tourist forecasting, is recognized as more appropriate for large scale, e.g. global-wide events, than extreme weather cases (Prideaux et al. 2003; Chon et al. 2010). To date, the STS Model with intervention analysis is recommended as one of the most practical methods to predict the tourist displacement in a weather disaster. It can not only capture the tourist demand flow in a form of the trend, seasonality, auto-regression or cycle, and other irregular components, but also reflect the degree of event impact by adopting the explanatory variables and intervention. Scaglione (2007) suggests the STS multivariate model should be:

Observed variables =trend+ seasonal + explanatory variables+ autoreg. component or cycle+ intervention+ irregular

In order to build a tourist prediction framework for an extreme weather event case, five issues should be considered.

1. Adopting critical variables

The early research mainly observed the relationship between tourist flow and time factor on the basis of historical data. Thus, it is hard to apply previous results for a new emerging event due to a lack of a comparable baseline. To solve this issue, this paper suggests developing a tourist forecasting model for a new weather event. For this purpose, a STS model is an appropriate method which is flexible to adopt of critical variables in the travel decision process, such as event scale (intervention variable), media exposure, tourist characteristics, and external factors (explanatory variables) (Prideaux et al. 2003). Although this measure needs more efforts to integrate the information across governments, the valuable outcome would be helpful for improving the accuracy of post-event tourist forecasting.

2. Downscaling the observed data

Since current studies rarely evaluate the influence of event scale on tourist arrivals, they mainly adopt the observed data on an annually or monthly basis. Therefore, it cannot precisely reflect the duration of event impacts as well as the level of tourist changes. For example, the effect of extreme weather events may last from days to years, depending on the type and scale of incident. The small-scale typhoon may only affect one-day tourist flow for the close of airport or tourist attraction, while the large-scale typhoon would cause tourist loss for months or over a year due to the damage of roadway or facility (Maolin National Scenic Area 2011). In a post-event tourist forecasting case, it is advised to downscale the observed data with the consideration of event nature. However, it cannot be denied data availability would be an issue. For instance, developing countries often lack of resources to collect and maintain the related information. Except for cyclone events, other types of weather disasters are generally neglected (IPCC 2012).

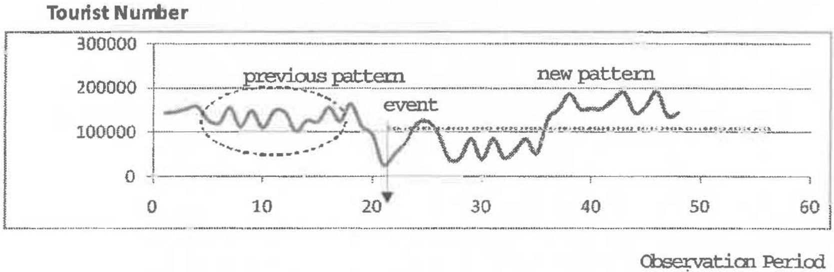
3. Applying correction coefficient

This research argued affected locations of extreme weather event would have different levels of importance to the tourism industry. For example, the 2011 Thailand Floods started from the Northern provinces in the end of July, and showed no significant influence on Thailand's inbound tourism, as its growth rate remained 6.7% in October. However, there was a sudden drop of the international tourists when the floods approached Bangkok in November (Shankar 2011). Thus, it needs to apply a correction coefficient in a post-event tourist forecasting model in order to adjust the results according to the significance of victim place to tourism business, which is especially important for studying the change of tourist flow in a large country (Amelung et al. 2007). In addition, it is often ignored that the timing of an extreme weather event would affect the degree of tourist displacement. Generally, a peak-season event would result in a greater tourist loss than one in the off-peak period (Sun et al. 2011). The time factor is also a significant correction coefficient.

4. Revising recovery concept

Previous studies often define the first month with the predicted growth rate is the timing of tourist recovery after a mega event (see fig. 1 point A) (Dai 2009; Bonham et al. 2006). However, this assumption would be misleading since the observed value may only appear briefly and decline in the next month. This study argues there might be a new configuration of tourism demand cycle after a disaster on the basis of chaos theory (Prideaux *et al.* 2003; Lean and Smyth 2009). *Thus, the definition of recovery timing should be the first month* of a new tourist pattern, which shows an above-goal-level growth rate (see fig.1 point B). Lean and Smyth (2009) proposed to use the univariate Lagrange Multiplier (LM) unit root tests for justifying if event impact on tourist flow is permanent or transitory. The method of fuzzy data classification (Höppner *et al.* 1999)is also advised to determine the new pattern of tourist flow. While the event magnitude is relatively small, the new pattern would appear similar to the original one. On the other hand, a large weather extreme is likely to lead a change of seasonality. The observation period should cross to the next year in such a case (Lim and McAleer 2001).

Figure 1. The conceptual diagram of tourist recovery



A: the recovery point defined by previous studies

B: the recovery point defined by this study

5. Considering multiple event effects

Sometimes a country, city or destination may experience a series of natural disasters in a short time, like Shanghai is subject to typhoons, tornados, strong winds and floods (IFRC 2009). It is argued that the occurrence of multiple events would cause synergistic effects on tourist flow, but current studies address little more than the influence of a single event. Dai (2009) tried to solve this issue by accumulating the impact of each hazard. However, this approach seems less feasible for not considering the time gap in such case, and undifferentiating the impacts of leading and minor events (Sun et al. 2011). On the other hand, Kim and Wong (2006) indicate the importance of simultaneously positive events, even though it shows lower impact on tourist flow than the negative disaster. Therefore, it is advised to adopt a multiplier coefficient when developing models to forecast tourist flows after multiple extreme weather events.

To predict the impact of extreme weather event on tourist flow, this section tries to accommodate the issues of previous research and discuss potential solutions. Accordingly, the steps of a novel tourist forecasting method are suggested as follows: (1) First, it needs to weight the above variables' relations with the number of tourist loss and recovery period respectively by the STS model on the basis of historical events, which is advised as being at least a decade of data in this research. Additionally, each event's recovery period should be defined by the fuzzy data classification method according to the new recovery concept. (2) After determining the coefficients for each type of weather extreme, the post-event forecasting model is developed as *equ*.1 and *equ*.2. In this model, *equ*.1 is designed to calculate the approximate loss of tourist number after a new weather extreme. Then, *equ*.2 is further applied for predicting the total of recovery period.

$Y(\iota)= \alpha_i W_i + \beta ME + \gamma EV + \delta CV + E$ ....(*equ*.1)

$Y(\iota)$= number of tourist loss

$RP(\iota)= \kappa_i W_i + \mu ME + \nu EV + \rho CV + E$ ....(*equ*.2)

$RP(\iota)$= Recovery period

ι= observed weather event

W_i = Weather factors (e.g. type of extreme weather event, the coverage area, and the level of damage), positing as auto regression components

ME= multiple event effects (e.g. time gap, surplus effect of previous events)

EV= explanatory variables (e.g. tourist characteristics, media exposure, and external factors)

CV=correction variables (e.g. the importance of local tourism business, the distance from victim place to tourist area, and the occurring timing of event)

ε= Irregular

The proposed method tends to be more objective, replicable and financially feasible. Although there might be some difficulties to measure the weight of key variables, the integration of government information with that of other research bodies would be a viable solution to help control the quality, efficiency and availability of relevant data. Also, the judgmental bias of interpreting the historical and forecasting data in such case could be minimized by further training (Scaglione 2007).

Conclusion

To respond to the growth trend of high-magnitude low-frequency extreme weather events, Scott and Lemieux (2010) urge the development of a long-term integrated approach for the tourism industry. Although tourist forecasting is recognized as one of the important issues in this subject, current methods are still not capable to cope with emerging weather events (Prideaux et al 2003; Song and Li 2008). Previous time-series based approaches only captured the relationship between time and tourist flow in the high-magnitude event cases. Without further analyzing the critical factors of post-event tourist displacement, these research results are hard to apply for an unpredictable crisis.

In order to help close the knowledge gap on tourist forecasting with respect to climate change (Hall 2008), this paper focuses on developing the tourist forecasting method for the event of weather extremes, and provides a framework to explore the key variable from the perspectives of weather nature, media effect, tourist behavior, external factors as well as their interrelationships in such model. This paper integrates these inputs and proposes a feasible tourist forecasting method for extreme weather event on the basis of STS model. To precisely estimating the change of tourist flow after weather extremes, this research also emphasizes the importance of downscaling the observation data, considering correction coefficient, and the redefining the recovery point. Since a timely tourist forecasting approach is demanded under the prospect of increased high-magnitude weather events, this paper encourages further improvements and testing of the proposed model in order to assist recovery in natural disaster affected destinations in the shortest period.

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