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The effects of natural disasters on international tourism: A global analysis

Jaume Rosselló [a,b,c,*], Susanne Becken [b,d], Maria Santana-Gallego [a]

[a] Departament d'Economia Aplicada, Universitat de les Illes Balears, Spain
[b] Griffith Institute for Tourism, Griffith University, Australia
[c] Departament of Economics, University of California, Berkeley, USA
[d] School of Hospitality Management and Tourism, University of Surrey, United Kingdom

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Tourism is shaped by a wide range of factors and forces, including exogenous ones that have no direct link with the tourism sector. Natural disasters and unexpected events are prime examples of such determining factors, as they have profound effects on individuals and society, and as a result have the potential to affect tourism flows considerably. Several theoretical arguments exist why natural disasters and unexpected events could influence tourist destination choices. However, empirical research to confirm the nature and extent of impacts of disasters on tourism is lacking. To address this gap, this paper incorporates a dataset on natural and man-made disaster events into a model of international tourism flows to evaluate the effect of different types of disasters on international arrivals at the national level. Findings provide evidence that the occurrence of different types of event change tourist flows to varying degrees. Although in some cases a positive effect is estimated, in general the impacts are negative, resulting in reduced tourist arrivals following an event. Understanding the relationship between disaster events and tourism is helpful for destination managers who make critical decisions in relation to recovery, reconstruction and marketing.

1. Introduction

Earthquakes, tsunamis, floods, bush fires, hurricanes, droughts and heatwaves have always occurred. These events have formed part of the wider 'riskscape' that humans have learned to manage and live with. However, more recently the impacts of disasters have increased substantially, partly because of the exacerbating effects of climate change, but also due to the growing complexity of socio-ecological systems in a highly connected and globalized world (Becken, Mahon, Rennie, & Shakeela, 2014). For instance, the year 2017 recorded a series of hurricanes (Harvey, Irma and Maria) in the Caribbean and a severe earthquake in Mexico, amongst other events, and these resulted in the highest incurred losses ever recorded (US$ 135 billion) (Munich, 2018).

Disasters constitute abrupt changes that shock the system in which tourism is embedded (Shondell Miller, 2008). The nature and extent of impacts depend on the type of shock and the resilience of the affected system (OECD, 2014). Most disasters have profound impacts on individuals, organizations and communities, and consequently on tourism activities. The repercussions of a disaster are likely to affect tourism directly at a destination country, but indirect consequences for travel to and from the affected region are also conceivable (Jin, Qu & Bap. 2019; Ruan, Quan & Liu, 2017). Understanding, managing and responding to these risks, therefore, has to be an integral component of sustainable tourism management (Shakeela & Becken, 2015). Consequently, it is not surprising that the topic of risk management and disaster mitigation is attracting increasing attention in tourism research. An emerging body of literature has provided both theoretical and empirical insights into multiple aspects of disasters and tourism.

Research to date has largely focused on crisis management and disaster risk reduction (Becken & Hughey, 2013; Faulkner, 2001; Ritchie, 2008). In particular, academics and practitioners have been interested in how sustainable development and marketing strategies should include plans to prepare, protect and rebuild a destination after a disaster, both in terms of physical assets and destination image (Aljerf & Choukaife, 2016; Okuyama, 2018). The perceptions of safety is an important aspect of destination image, and different types of risks and events have been studied in the context of visitor travel information seeking and decision making (Sharifpour, Walters, Ritchie, & Winter, 2014; Trumbo et al., 2016; Williams & Baláž, 2015). Re-establishing public perceptions of safety and attractiveness following a disaster is crucial to attract and reassure potential visitors to travel to the destination and, by doing so, assisting the affected area to regain functionality and economic recovery (WTTC, 2018). In addition to understanding visitor perceptions, it has been found that addressing risk

* Corresponding author. Departament d'Economia Aplicada, Universitat de les Illes Balears. Carretera Valldemossa km 7.5, 07122, Palma de Mallorca, Spain.
E-mail address: jrossello@uib.es (J. Rosselló).

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perceptions and behaviours of relevant tourism stakeholder is critical for effective disaster response and recovery (Kozak, Crotts, & Law, 2007; Park & Reisinger, 2010).

Tourism is exposed and vulnerable to multiple types of hazards (Becken, Zammit, & Hendrikx, 2015), and disasters have the potential to deter visitors from travelling to affected destinations (Bhati, Upadhayaya, & Sharma, 2016). However, empirical research that confirms or quantifies the relationship between disasters and tourism activity is scant. Existing studies have taken a case study approach (e.g. for Chinese outbound tourism, see Jin, Qu, & Bao, 2019), but a global analysis is missing (Ghaderi, Mat Som, & Henderson, 2014; Jónsdóttir, 2011; Mazzocchi & Montini, 2001; Rucińska & Lechowicz, 2014). It is therefore timely to undertake a global study that uses a consistent approach to measuring the impact of disasters on international tourism movements. To increase the value of such a study for tourism managers, it needs to be designed in a way that includes a wide range of disaster types and magnitudes in the same model (Ghimire, 2016).

Consequently, the aim of this research is to explore the effect of various types of natural and man-made disasters on international tourism movements. To that end, this research integrates two different global datasets, namely one on disasters and another one on bilateral international tourist flows. A gravity model for international tourism flows is defined to quantify the effects of different disaster events on international tourist arrivals to the affected country. More precisely, we analyze the impact of droughts, earthquakes (ground movements and tsunamis), epidemics, cold and heat waves, floods, industrial accidents, landslides, wildfires, storms and volcanic activities. Moreover, we use three different proxies to measure the impact of disasters; namely the number of deaths, affected people and economic costs. Results will support the tourism sector and other key players (e.g. international insurance companies) in developing adequate responses to managing risk and recovery. To the best of our knowledge, the present research is the first attempt to undertake such an integrated analysis at a global scale.

The rest of this article is organized as follows: the next section contains a literature review of the arguments behind the expected relationship between disaster events and tourism demand. The third section explains the methodology, data and the research design. The fourth section presents the empirical application. Finally, a concluding discussion is presented that provides recommendations and an outlook on future research.

2. Literature review

The general perception might point towards an increase in the frequency of natural disasters over time, but this assumption needs to be verified. In fact, it has been suggested that, in some cases, the definition of disasters can become too fluid for statistical time series consideration (Horlick-Jones, Fortune, & Peters, 1991). Neumayer and Barthel (2011) analyzed the economic damage from climate-related disasters and they found no significant upward trends in normalized data over the last 30 years globally. However, the same study acknowledged that the frequency of weather-related natural disasters indicates an upward trend.

Other research suggests that the combination of climate change, industrialization and urbanization has accelerated the magnitude and occurrence of natural disasters around the world and the extent of the resulting damage (Becken et al., 2015; Park & Reisinger, 2010). Population growth (often occurring in exposed areas such as coastal environments) is recognized as a key driver to explain why natural disasters affect more and more people (Berke, 1998; Wachinger, Renn, Begg, & Kuhlicke, 2012). Aside from natural disasters, Richardson (1994) notes that man-made disasters are becoming more severe because of the increasingly more powerful technology that is being used.

Perceptions of the frequency and extent of disasters are just as important as statistical facts. A key factor in this growing risk perception is the media (Gierlach, Belsher, & Beutler, 2010). For a the general public, who is exposed to mass media, it may appear that we live in an increasingly disaster prone world (Faulkner, 2001). The saying 'perceptions are reality' is nowhere more pertinent than in tourism, where potential visitors chose their destinations based on a mix of objective and subjective factors. Destination (risk) perception has emerged as one of the critical factors in the decision-making process (Becken, Jin, Chen, & Gao, 2016).

Disasters and other forms of crises (e.g. epidemics, conflict, pollution) can lead to a reduction in visitation to the affected area (Bhati et al., 2016). Several examples in the literature provide empirical evidence of reductions in tourist arrivals following major events. For instance, Mazzocchi and Montini (2001) evaluated the impact on visitation to the Umbria region in Central Italy, following a major earthquake in September 1997. The data showed that arrivals fell drastically the first month after the main shock, with ongoing loss in tourism activity being recorded until June 1998. A case study of a volcanic eruption at the Eyjafjallajökull glacier in Iceland on 14th March 2010 showed that tourism numbers to Iceland reduced by 49% until 28th April 2011 (Jónsdóttir, 2011). Huang and Min (2002) analyzed the Taiwan earthquake in September 1999, using an integrated moving average model to explore the recovery process. Their study revealed that the island's inbound arrivals had not yet fully recovered from the earthquake's devastation after 11 months. Kuo, Chen, Tseng, Ju, and Huang (2008) also used a time series model to investigate the impacts of infectious diseases, including Avian Flu and severe acute respiratory syndrome, on international tourist arrivals in Asia. The empirical results indicated that the numbers of affected cases had a significant impact in the case of SARS (see also Mao, Ding, & Lee, 2010; McAleer, Huang, Kuo, Chen, & Chang, 2010), but for Avian Flu.

Man-made crises, such as the BP oil spill in the Mexican Gulf in 2010, have also been found to reduce demand for travel to the affected area (Ritchie, Crotts, Zehrer, & Volsky, 2013). Often, declines in visitation spread to neighboring areas, even when they are not impacted by the event. A recent example has been the dramatic down turn in tourism in the Caribbean region, following the devastating hurricane season in 2017 (WTTC, 2018). Events within one country or a region can lead to notable structural breaks in international tourism arrivals, which was demonstrated by Cró and Martins (2017a) in a recent study on various forms of crises in 25 countries.

There are several reasons why visitation to disaster areas declines in the immediate aftermath of an event. The most direct inhibitor relates to the damage inflicted by a disaster that prevents the affected areas from engaging in tourism activity. Secondly, the decline in tourist arrivals is due to people's risk perceptions and avoidance of regions that are deemed unsafe (Kozak et al., 2007; Sönmez, Apostolopoulos, & Tarlow, 1999). Thirdly, and related to the second issue, is that potential travelers may feel uncomfortable or have ethical concerns about travelling to a disaster region. These underlying factors are discussed in more detail.

In many cases, disasters pose significant physical constraints on the delivery of tourism services, thus severely limiting the supply side of tourism (Shaw, Saayman, & Saayman, 2012). Depending on the type and extent of the disaster, critical infrastructure could be compromised or dysfunctional. Prominent examples include airports and ports, land transport infrastructure, and electricity and telecommunication networks (Ghobarah, Saatcioglu, & Nistor, 2006; Parajuli & Haynes, 2006). In addition, core tourism assets could be damaged and not ready for business, such as accommodation establishments and key attractions. For instance, the 2015 earthquake in Kathmandu, Nepal, resulted in wide-spread destruction of UNESCO listed World Heritage sites, and several trekking routes were deemed unsafe due to risks of rock fall and movements following further aftershocks or heavy rain events (Becken, 2015).

Even longer-term and insidious disasters, such as a drought, may impede the ability of a destination to cater for tourism. A recent example was the water shortage in Cape Town, South Africa, that led to a reduction in tourism and a notable loss in income for local businesses. The decline was possibly influenced by requests to conserve waters, but also due to perceptions by visitors that the destination is not able to host tourists (Wendell, 2018).

In addition to uncertainty around whether the destination is safe or tourism-ready, there are other psychological factors that influence tourists' decision making. Frequently, media coverage of disasters conveys the resulting loss of life, human suffering, public and private property damage, and economic and social disruption. The ensuing negative publicity often characterizes the period after a disaster, lasting until full recovery is achieved and pre-disaster conditions resume (Sönmez et al., 1999). For instance, Cohen (2005) points out that religious beliefs relating to the bodies of the tsunami victims trapped in sediment and rubble were behind a group of Asian tourists deciding to abandon their plans to visit Thailand after the 2006 Tsunami. Others may simply consider it inappropriate to visit a disaster zone.

Apart from religious or ethical concerns, some travelers do not wish to impede the recovery effort and place additional burden on the destination's resources and infrastructure (e.g. Becken, 2015). In some cases, the delayed recovery towards previously tourism figures is deliberate and led by the local tourism organizations. This was the case for the Christchurch (New Zealand) earthquake (2011), where extensive destruction of the city made tourism impossible, or at best would have led to unsatisfactory tourist experiences, leading Christchurch Canterbury Marketing to de-market Christchurch but promote surrounding regions instead (Orchiston & Higham, 2014). Optimal timing and stages of recovery were examined by Okuyama (2018) for the case of avian flu in Japan.

Whilst both theory and empirical evidence point to a decline in tourism following a disaster, several factors might promote travel to an affected area. Providing information about hazards and their effects draws human attention and may even cause a level of fascination (e.g. the 'ring of fire', referring to tectonic activities around the edges of the Pacific Ocean). In this way, the number of tourists might be influenced by the coverage that media devote to natural disasters in other countries. Media often use extreme natural phenomena as material for captivating stories, and travel bloggers, tourism campaigners and social media multiply the lure of these. An example of a disaster turning into a tourist attraction is the Eyjafjallajokull volcano in Iceland, with "the prospect of a new eruption bring[ing] a mix of trepidation and anticipation" (Lawless, 2016, p. 1).

Media coverage about a natural, or perhaps also man-made, phenomenon plays an informative role as a motivating factor to visit a region. Rucińska and Lechowicz (2014) argue that mass media and marketing are influential factors in the development of various forms of disaster-related tourism, as information on catastrophes popularizes the host location and the type of the phenomenon. Such coverage could be both educational and simultaneously stimulate the interest of the audience. Additionally, natural disasters and unexpected events can cause the arrival of people from other countries for humanitarian reasons but also for visiting friends and relatives who have been victims of those events. According to the statistical framework used by the United Nations World Tourism Organization, these arrivals are captured as international tourists.

Finally, the decision to visit a disaster area for a range of motivations has been conceptualized as Dark Tourism (Rucińska & Lechowicz, 2014). This type of tourism involves travelling to places historically associated with death and tragedy (Foley & Lennon, 1996). According to Rucińska (2016), tourists might decide to travel to a region that has experienced a disaster because they want to feel emotions, risk, and the dynamics of natural hazards. Overall, the present research hypothesizes a negative relationship between national disasters and inbound tourism; however, it also considers the motivating factors pointed out by Rucińska (2016) that might lead to an increase in visitation after a disaster. The model developed in the following section will capture the cumulative impact of both effects.

3. Methodology and data

3.1. Gravity model for tourism demand

This research develops a gravity model for international tourism flows to quantify the effects of different types of natural and man-made disasters on tourist arrivals to the affected countries. Gravity models are commonly used in the trade literature (Anderson, 2011), and increasingly in tourism research (Fourie, Rosselló-Nadal, & Santana-Gallego, 2019; Khadaroo & Seetanah, 2008; Santeramo & Morelli, 2015). These models consider that international flows between two countries are directly proportional to their economic size, and inversely proportional to the distance between them. Consequently, the level of bilateral tourism flows can be explained by a set of determining variables as in a demand equation. Morley et al., 2014 have shown that gravity models to explain bilateral tourism can be derived from consumer choice theory. Accordingly, the formulation of a gravity model can also be interpreted as a tourism demand equation.

Analytically:

$$LnTou_{ijt} = \beta_0 + \beta_1^d X_{jt}^d + \beta_2^k X_{ijt}^k + \beta_3^l Y_{jt}^l + \lambda_{ij} + \lambda_{it} + \varepsilon_{it} \quad (1)$$

where, the dependent variable $LnTou_{ijt}$ is the logarithm of tourist arrivals from country i, to destination country j, at year t; X_{jt}^d is a set of d destination-specific time-variant variables such as income level or population while X_{ijt}^k is a set of k country-pair time-variant determinants such as belonging to the same regional trade agreement. The variables of interests for this research are included in Y_{jt}^l which is the set of l variables capturing the effect of l different disasters typologies (e.g. earthquake, tsunami, volcano, etc.) occurred in destination j during year t. This research uses three alternative proxies to measure the effect of disasters; namely number of deaths (D) in thousands, people affected (A) in millions and economic costs (C) in billions of US$. Finally, β_0, β_1^k and β_2^l are parameters to be estimated.

Due to the panel nature of data used in these kinds of models, and since our variables of interest are destination-country time variant, country pairs fixed effects λ_{ij} and origin-year fixed effects λ_{it} are also considered for estimation purposes. One of the consequences of this choice is that time-invariant country pair characteristics (such as distance or common borders) and time-variant origin country characteristics (such as income or population in the origin countries) are not explicitly included in the model. Specific consideration is not necessary, because all these variables are captured by these fixed effects, as also suggested by Balli, Ghassan, and Jeefri (2019), Fourie et al. (2019) or Giambona, Dreassi, and Magrini (2018). This is a common practice in the development of gravity models in order to avoid omitted factor bias, and instead focus on the variables of interest for the particular research question.

3.2. Data selection

As dependent variable, $LnTou_{ijt}$, we consider the natural logarithm of international tourist arrivals from country i to country j in year t. This dataset originates from the Compendium of Tourism Statistics compiled by the United Nations World Tourism Organization (UNWTO, 2015). This database contains tourism movements between 171 countries for the period 1995–2013, with missing data for some years and countries.

In reference to the d variables determining tourism flows (X_{jt}^d), and according to the considerations mentioned above about the no inclusion of time-invariant country pair characteristics and time-variant origin country characteristics, we consider the logarithm of the real GDP per capita ($LnGDPpc_{jt}$) as a proxy for the development level at each destination, and the logarithm of population ($LnPop_{jt}$) to control for the size of the destination country (Lim, 2006; Yap & Saha, 2013). Both variables were taken from the World Development Indicators (WDI) elaborated by the World Bank. Third, we also consider an instability indicator that concerns safety and security of visitors when they travel to a destination. Whilst there are different ways for evaluating safety and security at international level (See Cró & Martins, 2017b; Cró, Martins, Simões, & Calisto, 2018; Fourie et al., 2019 or Santana-Gallego, Fourie, & Rosselló, 2020) in this case, and due to data coverage reasons, we use a proxy of the crime rate defined as the number of homicides per 10,000 inhabitants in the destination country ($Crime_{jt}$). Data also stem from the WDI. On the other hand, vector X^k_{ijt} includes a variable to control for the intensity of the economic relationship between a pair of countries, which is also time varying. The idea is to capture the presence of trade agreements between country pairs as an indicator of bilateral relationships that could boost tourism. This variable (RTA_{ijt}) is a dummy variable for being a signatory to the same regional trade agreement and stems from the Regional Trade Agreements Information System compiled by the World Trade Organization.

Data for the occurrence and impact of disasters were retrieved from the Centre for Research on the Epidemiology of Disasters (CRED), which makes data available through the Emergency Events Database (EM-DAT). EM-DAT was created with the initial support of the World Health Organization (WHO) and the Belgian Government. The main objective of the database is to inform humanitarian action at national and international levels. The initiative aims to rationalize decision making for disaster preparedness, as well as provide an objective base for vulnerability assessment and priority setting. EM-DAT contains core data on the occurrence and effects of over 22,000 mass disasters in the world from 1900 to the present day. The database is compiled from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies.[1]

According to the objectives of this present research, the disaster types included in EM-DAT and considered in our analysis are presented in Tables 1 and 2. For the gravity equation estimation we are limited by the availability of the tourist database (1995–2013). All other datasets provide data for this timeframe as well, leading to a database that covers a total number of 7885 events from the period of 1995–2013. These are described using three types of impact metrics (Table 1). More specifically, of all events, 74.8% report information on the number of deaths, 59.3% report the extent of affected people (beyond deaths) and 31.7% state an estimated amount of damage measured in economic terms.

With regards to people killed by different disaster types, Table 2 shows that ground movements emerge as the most fatal type of disaster, with a reported number of 338.000 deaths during the period 1995–2013. Tsunamis and storms accounted for almost 250,000 deaths in the same period. In terms of affected people, floods and droughts have the greatest impact, with about 1,7 and 1 billion of people impacted upon, respectively. Concerning the economic costs of disasters, storms rank first, with a total amount of 798,32 billion dollars of damage recorded in the database. Storms make up 38% of total economic costs for the selected disasters in the EM-DAT during the period 1995–2013.

The distribution of disasters across different regions, indicates considerable variation both in terms of event type and resulting impacts. For instance, in the case of storms, although only 16.8% take place in the Americas, the impact in terms of deaths, affected people and costs is comparatively high (42.5%, 60.3% and 66.1%, respectively) than in other regions. A similar result is obtained for earthquakes in the Asia-Pacific regions (44.5% of events), with disproportionally high impacts in relation to the number of deaths (49.2%), affected people (85.2%) and costs (73.4%). Europe, with some exception, is characterized by a lower incidence of deaths and affected people, but a higher occurrence of costs.

Table 3 shows the most important events for each type of disaster in the database. For example, it can be observed that the Earthquake of Haiti in January 2010, which led to 222,570 deaths, was the worst event in terms of fatalities. The major storm (Cyclone Nargis) that occurred in Myanmar during May 2008 resulted in 138,366 deaths, the second largest number in the records. In terms of affected people, the drought affecting India during 2015 and 2016 was the most significant event reported in the database (330 million people impacted). Disasters also cause substantial economic damage. The highest economic loss recorded was tropical hurricane Katrina that made landfall in New Orleans, USA. It caused a total amount of damage of $125 billion.

Table 1
Disaster typology and main descriptive magnitudes (1995–2013).

Disaster type	Category	Events			
		Total (N)	With Deaths	With Affected	With Cost
Drought	Climatological	296	27	212	83
Earthquake (Ground)	Geophysical	454	338	339	222
Earthquake (Tsunami)	Geophysical	25	25	17	16
Epidemic	Biological	710	610	664	–
Cold wave	Meteorological	236	189	61	22
Heat wave	Meteorological	113	102	6	18
Flood	Hydrological	2744	2122	2267	1069
Industrial accident	Industrial	779	632	161	56
Landslide	Geo/ Hydrological	316	303	113	45
Wildfire	Climatological	235	191	30	24
Storm	Meteorological	1896	1348	743	933
Volcanic activity	Geophysical	81	14	66	10
TOTAL		7885	5901	4679	2498

Notes: Cold Waves include severe winter conditions. Epidemic episodes are not characterized by economic costs.

3.3. Data preparation and analysis

Although the disaster database includes the exact day of the event, for the purpose of this analysis we are limited by the yearly nature of tourism data. Following guidance from the previous literature (Jónsdóttir, 2011; Mazzocchi & Montini, 2001; Rucińska & Lechowicz, 2014) we consider two alternatives: distributing the potential consequences of each of the disasters to the time frame of the following 12 months and alternatively to the next 6 months after an event. Thus, for instance, if a hypothetical disaster occurred in September of year 2000, in the first case, 4/12 of the amount of damage (measured in deaths, affected or costs) would be attributed to the year 2000 and 8/12 to 2001. In the second case, 4/6 of the amount of damage would be allocated to the year 2000 and 2/6 to 2001.

Another important issue to be considered is the multicollinearity that can arise between the different types of impacts related to the same specific disaster. Thus, it is expected (and found) that the consequences of a certain disaster in terms of deaths will be correlated to other impacts measured in terms of affected people and economic costs. The increase in the variance of the coefficient estimates could drive them to be unstable and difficult to interpret. Consequently, our first strategy is to consider the three impact metrics (i.e. deaths, affected people and cost) separately in different equations. Additionally, for each of the three metrics, we evaluate the possibility to distribute the effects within 6 and 12 months. This results in 6 specifications: three for each of the impacts, times the two evaluation periods (6 and 12 months).

Importantly, according to the theoretical argumentation, the relationship between disasters and arrivals is not unidirectional and necessarily negative, but an increase in tourist arrivals could be observed in certain circumstances. For this reason, a second research strategy considers the inclusion of all the variables in a *general regression* that is reduced using statistical testing strategies in order to get a *specific regression* encompassing every other parsimonious regression that is a

[1] EM-DAT can be downloaded free of charge from http://www.emdat.be.

Table 2
Disaster typology by Regions and main descriptive magnitudes in terms of people.

	TOTAL	Europe	Asia & Pacific	Americas	Africa	Middle East		TOTAL	Europe	Asia & Pacific	Americas	Africa	Middle East
Drought	296	31	63	71	126	5	Flood	2744	536	819	540	788	61
		10.5%	21.3%	24.0%	42.6%	1.7%			19.5%	29.8%	19.7%	28.7%	2.2%
Deaths	17,260	0.0%	4.8%	0.3%	94.9%	0.0%	Deaths	151,525	1.7%	55.8%	30.6%	11.0%	0.9%
Affected	1000.40	0.9%	75.1%	2.7%	21.1%	0.2%	Affected	1715.19	0.5%	95.3%	2.1%	2.1%	0.0%
Costs	75.24	17.6%	28.0%	52.9%	1.5%	0.0%	Costs	555.11	18.6%	65.8%	13.8%	1.1%	0.6%
Earthquake	454	113	202	105	34	0	Indus. Accident	779	220	257	150	125	27
		24.9%	44.5%	23.1%	7.5%	0.0%			28.2%	33.0%	19.3%	16.0%	3.5%
Deaths	454,098	4.4%	49.2%	45.7%	0.6%	0.0%	Deaths	22,591	10.7%	55.0%	7.5%	25.5%	1.4%
Affected	109.01	4.1%	85.2%	10.7%	0.0%	0.0%	Affected	1.26	8.3%	17.6%	65.3%	8.8%	0.0%
Costs	346.04	13.5%	73.4%	11.7%	1.3%	0.0%	Costs	20.50	6.3%	1.2%	89.0%	3.3%	0.1%
Tsunami	25	0	18	3	4	0	Landslide	316	39	153	87	33	4
		0.0%	72.0%	12.0%	16.0%	0.0%			12.3%	48.4%	27.5%	10.4%	1.3%
Deaths	205,130	0.0%	99.8%	0.1%	0.1%	0.0%	Deaths	17,617	3.8%	71.6%	17.9%	5.6%	1.0%
Affected	4.81	0.0%	93.2%	0.8%	6.0%	0.0%	Affected	4.80	1.2%	96.2%	2.2%	0.5%	0.0%
Costs	210.58	0.0%	99.7%	0.2%	0.1%	0.0%	Costs	4.09	19.0%	59.1%	22.0%	0.0%	0.0%
Epidemic	710	45	139	87	428	11	Fire	235	39	92	39	51	14
		6.3%	19.6%	12.3%	60.3%	1.5%			16.6%	39.1%	16.6%	21.7%	6.0%
Deaths	116,125	0.5%	11.2%	7.3%	80.7%	0.2%	Deaths	1051	11.5%	55.1%	18.4%	8.5%	6.5%
Affected	9.10	2.1%	16.4%	29.0%	52.4%	0.1%	Affected	2.56	1.2%	78.7%	1.6%	18.5%	0.0%
Costs	–	–	–	–	–	–	Costs	41.29	51.7%	41.3%	5.7%	1.2%	0.0%
Cold wave	236	135	40	56	5	0	Storm	1896	862	464	319	240	11
		57.2%	16.9%	23.7%	2.1%	0.0%		1	45.5%	24.5%	16.8%	12.7%	0.6%
Deaths	15,269	39.9%	44.3%	15.4%	0.4%	0.0%	Deaths	207,866	11.2%	38.0%	42.5%	7.9%	0.5%
Affected	89.95	4.1%	91.8%	3.9%	0.3%	0.0%	Affected	541.66	4.1%	35.0%	60.3%	0.6%	0.0%
Costs	27.43	12.1%	78.4%	9.6%	0.0%	0.0%	Costs	798.32	28.8%	5.0%	66.1%	0.1%	0.0%
Heat wave	113	57	35	12	8	1	Volcanic activity	81	3	32	37	8	1
		50.4%	31.0%	10.6%	7.1%	0.9%			3.7%	39.5%	45.7%	9.9%	1.2%
Deaths	143,744	92.8%	6.0%	1.1%	0.1%	0.0%	Deaths	620	0.0%	53.7%	12.1%	33.2%	1.0%
Affected	0.53	0.0%	96.7%	3.3%	0.0%	0.0%	Affected	1.73	0.0%	40.1%	42.6%	17.3%	0.0%
Costs	17.64	68.5%	3.2%	28.3%	0.0%	0.0%	Costs	0.31	6.4%	1.6%	89.1%	2.9%	0.0%

Notes: Affected People in thousands. Costs in US billions of dollars.

valid restriction of the general regression (Hoover & Perez, 1999 and 2004). In other words, we integrate the three impact metrics into a single equation. Through this strategy, it is possible to explore in detail if effects arise that counteract the initially expected negative relationship between disaster impacts and tourism flows. Again, two impact time-frames are considered.

The gravity model for bilateral tourism flows as defined in equation [1] is estimated by using the Correia (2017) procedure to estimate linear models with many levels of fixed effects. This procedure is a generalization of the panel-fixed effects estimator with both country-pair and origin-year fixed effects. Database includes 171 countries for the period 1995–2013.

4. Results

Table 4 presents the results of estimating equation [1] for the bilateral tourist arrivals ($LnTou_{ijt}$) as dependent variable and including each disaster impact measure separately. As previously mentioned, because our variable of interest is destination-country time variant, country pairs fixed effects and origin-year fixed effects are included in the model to control for any type of determinant at origin or country-pair level. Therefore, only time variant country-pair and destination-specific determinants are required. Each column shows the estimate of different disaster consequences (D = deaths, A = affected people, and C = economic costs) and the two alternatives for distributing the effects across the following 6 and 12 months. It is important to mention that we are interested in estimating the short-run effect of the natural disaster on inbound tourism. Exploring how the tourism sector at the destination country recovers in the long-run is beyond the objective of the paper.

In general, for all the estimates, control variables considered as determinants of tourism flows are statistically significant and with the expected sign. The coefficients for both $LnGDPpc_{jt}$ and $LnPop_{jt}$ are significantly positive and slightly higher that unity, implying that a 1% increase in the destination GDP per capita and population will lead to an increase higher than 1% on tourist arrivals to the country. The coefficient for the RTA_{ijt}, that controls for the existence of a trade agreement between country pairs during specific years, is also significant and positive. In this case, due to the binary nature of the explanatory variable used, the estimated coefficient (slightly higher that 0.04) implies that the existence of a trade agreement increases the number of tourists to a destination by more than 4%. Finally, and as expected, the variable related to low levels of security and safety at the destination country ($Crime_{jt}$) shows a negative effect, indicating that an increase in the number of homicides (per 10,000 inhabitants) reduces tourist arrivals.

In reference to the different types of disasters, for events associated with *Tsunamis*, *Floods* and *Volcanoes*, all the significant parameters are found to be negative, indicating that these three types of disasters constitute substantial negative motivators for prospective visitors. A more detailed examination of coefficients highlights that volcanic eruptions appear most deterring to international tourists. This circumstance could be related to the severity of the damage caused by volcanic eruptions, including potentially irreversible damage to infrastructure or the complete loss of a natural asset. For the occurrence of an eruption, and for every increase in the number of deaths (for every 1000 people), affected (in millions of people) and costs (in millions of US$), there will be a decrease in international tourists to the destination between 1.07% and 1.32%, 2.13%–1.78% and 4.51%–3.44%, respectively (according to whether the 6 or 12 months delay is considered).

Wildfires, Earthquakes, Industrial Accidents, and *Storms* present mixed effects on international tourist arrivals. For all types of disasters, and

Table 3
Main Disasters in terms of affected population, deaths and economic costs.

Deaths	People	Date	Country	Description
Drought	143	1999-2003	Pakistan	Drought
Earthquake (Ground movement)	222570	Jan/2010	Haiti	Earthquake Ground movement
Earthquake (Tsunami)	165708	Dec/2004	Indonesia	Tsunami/Tidal wave
Epidemic	6908	Oct/2010-Nov/2011	Haiti	Bacterial disease. Cholera
Cold wave	1317	Jan-Feb/2008	Afghanistan	Severe Winter Conditions+ Avalanche (Snow, Deb)
HeatWave	55736	Jun-Aug/2010	Russia	Heat wave
Flood	30000	Dec/1999	Venezuela	Flash flood
Industrial accident	1127	Apr/2013	Bangladesh	Collapse. Textil factory building.
Landslide	1765	Aug/2010	China	Landslide
Wildfire	240	Sep/1997	Indonesia	Forest fire
Storm	138366	May/2008	Myanmar	Tropical cyclone
Volcanic activity_Ash fall	322	Oct/2010	Indonesia	Ash Flow (Mt. Merapi)
Affected	Million People			
Drought	300.00	Jan/2015-Dec/2016	India	Drought
Earthquake (Ground movement)	45.98	May/2008	China	Earthquake. Ground Movement. Slide
Earthquake (Tsunami)	2.67	Feb/2010	Chile	Tsunami/Tidal wave
Epidemic	0.94	Jan/2011	Brazil	Viral disease. Dengue
Cold wave	77.00	Jan-Feb/2008	China	Severe winter conditions
HeatWave	0.50	Nov/1995	Australia	Extreme temperature
Flood	238.97	Jul/1998	China	Riverine flood. Broken Dam/Burst ban
Industrial accident	0.55	Apr/2003	Brazil	Poisoning
Landslide	2.10	May/2010	China	Landslide
Wildfire	1.00	Jul/2007	Macedonia	Forest fire
Storm	100.00	Mar/2002	China	Convective storm
Volcanic activity_Ash fall	0.30	Aug/2006	Ecuador	Ash fall (Tungurahua)
Costs	Billion US$			
Drought	20	Jun/2012	USA	Drought
Earthquake (Ground movement)	100	Jan/1995	Japan	Ground movement + Fire
Earthquake (Tsunami)	210	Mar/2011	Japan	Earthquake+Tsunami+Fire+Industrial accidents
Epidemic	-			-
Cold wave	21.1	Jan-Feb/2008	China	Severe winter conditions
HeatWave	4.4	Jul-Aug/2003	Italy	Heat wave
Flood	40	Aug/2011-Jan/2012	Thailand	Riverine flood. Slide
Industrial accident	20	Apr/2010	USA	Explosion+ Oil spill. "Deewater Horizon"
Landslide	0.89	May/1998	Chiina	Landslide
Wildfire	8	Sep/1997	Indonesia	Forest fire
Storm	125	Aug-Sep/2005	USA	Katrina. Tropical cyclone+ Flood
Volcanic activity_Ash fall	0.15	Aug/2006	Ecuador	Ash fall (Tungurahua)

Table 4
Estimation results.

	D_12M	A_12M	C_12M	D_6M	A_6M	C_6M
$LnGDPpc_{jt}$	1.046***	1.026***	1.031***	1.050***	1.032***	1.035***
$LnPop_{jt}$	1.063***	1.044***	1.030***	1.064***	1.047***	1.033***
$Crime_{jt}$	−0.769***	−0.762***	−0.761***	−0.769***	−0.765***	−0.763***
RTA_{ijt}	0.041**	0.042**	0.040**	0.041**	0.042**	0.040**
$Drought_{jt}$	1.129***	−0.002***	0.004	1.029***	−0.001***	−0.001
$Earthquake_{jt}$	0.002***	0.002	−0.003***	0.002***	−0.017***	−0.002***
$Tsunami_{jt}$	0.000	−0.109***	−0.003***	0.000	−0.085***	−0.002***
$Flood_{jt}$	−0.005	−0.001*	−0.007***	−0.008**	0.000	−0.007***
$Industrial_{jt}$	0.228***	0.839***	−0.008***	0.177***	0.485***	−0.006***
$Wildfire_{jt}$	−0.244	0.353***	−0.034***	−0.126	0.340***	−0.037***
$Storm_{jt}$	0.018***	0.004***	−0.003***	0.024***	0.003***	−0.003***
$Volcano_{jt}$	−1.074***	−2.131***	−4.515***	−1.326***	−1.789***	−3.444***
Observations	187,407	187,407	187,407	187,407	187,407	187,407
R-squared	0.962	0.962	0.962	0.962	0.962	0.962
Adj R-squared	0.958	0.958	0.958	0.958	0.958	0.958
Within R-sq.	0.036	0.037	0.036	0.036	0.037	0.036
Root MSE	0.668	0.668	0.668	0.668	0.668	0.668

Note: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Dyadic and origin-year fixed effects are included in the model but estimates are not reported. Robust standard errors clustered by pairs.

when economic costs are considered, a negative and significant relationship is found. In other words, the economic damage from these events, for example to infrastructure, is likely to reduce tourist arrivals. *Wildfires* appear as the second most detrimental type of disaster when measured in economic damage, leading to an expected fall of 0.03% of tourist arrivals for every million US$ cost associated with the disaster. Interestingly and perhaps paradoxically, a significant positive relationship is evident between the number of people affected by *Wildfires* and tourist arrivals. For every million affected people, an increase between 0.34% and 0.35% is expected. Consequently, and considering the negative effect of economic damage mentioned above, the net effect of *Wildfires* on tourism should consider the two different types of disaster impact measures. *Earthquakes* show a similar negative impact compared with *Tsunamis* (see above) in terms of the economic costs of the disaster, with falls around 0.002% for every million US$ cost. However, the other impact metrics do not show a negative relationship. In terms of number of fatalities, there is even an increase in tourism for the number of deaths per 1000 people by 0.002%. Thus, the overall impact of an earthquake is a combination of decreases in response to economic damage and number of deaths. *Industrial Accidents* and *Storms* show similar patterns in that there is a positive relationship between the number of fatalities and affected people, but a negative relationship between the economic impact of the disaster and tourism arrivals. For example, for *Storms* there is a decrease in arrivals by 0.003% for every million US$ cost but increases between 0.018% and 0.024% for every death/1000 people and between 0.018%-0.024% and 0.03–0.04% for every million people affected.

Droughts emerged as the only type of disaster that did not show a significantly negative relationship between disaster cost and tourism, but instead arrivals were significantly linked to the two other disaster impact metrics. More specifically, for every death/1000 people an increase higher than 1% is obtained, while for every million people affected a decrease of −0.001% is estimated. It is perhaps not surprising that the relationship between disaster costs and tourism is not significant for *Drought*. Overall, it is less likely that drought conditions produce direct impacts on tourism-relevant infrastructures and supplies, as tourism businesses might absorb the extra costs of supplying water during water constrained times. There could be indirect costs, for example due to more expensive food supplies, but such effects do not seem to result in significant changes in visitation.

Epidemics, *Landslides*, *Cold waves*, and *Heat waves* do not achieve significant results for any of the six regressions considered, and for this reason they were not considered in the final estimation presented in Table 1. In the case of *Epidemics*, and *Landslides* we should note that these two variables have a strong structural component. For instance, epidemic episodes, such as Cholera, Dengue, and Ebola, as well as land movements with consequences on people are recurrent in the same types of countries at different times, but rarely are these factors extended to other countries. In a similar way Rosselló, Santana-Gallego, and Waqas (2017) evaluated the effects of Dengue, Ebola, Malaria, and Yellow Fever on international tourism flows showing how these diseases have a strong structural component and are often recurrent in the same countries.

The case of *Cold* and *Heat* waves is different. It should be noted how travel booking decisions (especially in international travel) are often taken months in advance, when no reliable weather predictions exist. Although it is possible to cancel travel plans in case of extreme temperatures, tourist might assume the conditions are temporary and unlikely to impact their trip. In terms of longer lasting risk perceptions of a destination, heat or cold waves might not be seen as particularly threatening, and hence easily forgotten. Visitors might expect that their tourism service provider is dealing with adverse conditions, for example by providing air conditioning or heating. Instead, extreme temperatures are more likely to impact local people (e.g., farmers) leading to wider economic damage (but not attributed to tourism). Regarding the distribution of the potential effects of each one of the disasters during the next 12 months (columns from one to three) and during the next 6 months (columns from four to six) no significant but only minor differences are found. Additionally, different attempts to discriminate disaster by geographical regions did not yield significantly different conclusions.

Table 5
Estimation results.

	12M	6M
$LnGDPpc_{jt}$	1.029***	1.042***
$LnPop_{jt}$	1.031***	1.041***
$Crime_{jt}$	−0.774***	−0.777***
RTA_{ijt}	0.040**	0.040**
$C\_Earthquake_{jt}$	−0.002***	−0.002***
$C\_Tsunami_{jt}$	−0.002***	−0.002***
C_Flood_{jt}	−0.002*	−0.006***
$C\_Industrial_{jt}$	−0.013***	−0.009***
$C\_Wildfire_{jt}$	−0.125***	−0.103***
C_Storm_{jt}	−0.003***	−0.004***
$D\_Drought_{jt}$	1.928***	1.631***
$D\_Earthquake_{jt}$	0.004***	0.003***
$D\_Tsunami_{jt}$	0.001***	0.001***
$D\_Industrial_{jt}$	0.159***	0.139***
$D\_Wildfire_{jt}$	1.080***	0.872***
D_Storm_{jt}	0.018***	0.025***
$A\_Drought_{jt}$	−0.001***	−0.001***
$A\_Tsunami_{jt}$	−0.091***	−0.064***
A_Flood_{jt}	-	0.001***
$A\_Industrial_{jt}$	0.512***	0.313***
$A\_Wildfire_{jt}$	0.505***	0.445***
A_Storm_{jt}	0.001***	0.001***
$A\_Volcano_{jt}$	−2.075***	−1.731***
Observations	187,407	187,407
R-squared	0.962	0.962
Adj R-squared	0.958	0.958
Within R-sq.	0.038	0.038
Root MSE	0.668	0.668

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Dyadic and origin-year fixed effects are included in the model but estimates are not reported. Robust standard errors clustered by pairs.

As mentioned earlier and in order to explore the bidirectional effects between disaster events and tourism flows, a second research strategy is implemented. Based on two initial general regressions (one for each of the delay periods considered), including all the considered variables, a reduction is undertaken in order to get the *specific regressions* presented in Table 5.

Regarding the distribution of the potential consequences of each type of disaster during the next 12 months (columns one to three) and during the next 6 months (columns four to six), in general, no significant differences are found. With the exception of *Floods* and *Storms*, the coefficients for the remaining disasters (in absolute terms) are higher for the 12 month impact regressions than for the 6 months ones, thus, indicating that effects are probably better captured by longer time lags. In contrast, the effects of *Floods* and *Storms* seem to have a shorter life span, since the 6 month timeframe captures a higher impact.

The analysis of the different disaster impacts reveals how, on the one hand, costs always present a negative relationship with international tourist arrivals. This confirms that the economic costs of a disaster are an important measure for tourism managers, probably because of the inherent damage to local infrastructure that is captured. On the other hand, the impact of some types of disaster evaluated in terms of deaths shows a positive relationship with tourist arrivals. This does not mean that the occurrence of these disasters will have a *net* positive effect on the arrival of tourists, since the negative effect of the associated costs must be taken into account when deriving an overall estimate of impact. As outlined earlier, the number of deaths could be related with the arrival of people for humanitarian reasons, or with a flow of people who travel to see (and support) friends and relatives affected by the event. This could present a significant effect in relative terms for those countries with a low base level of arrivals. The total effect also should consider the impacts of the number of affected people that for some disasters have a reducing effect (*Droughts, Tsunamis* and *Volcanoes*), while for others there seems to be an increase in the number of tourists (*Industrial Accidents, Wildfires* and *Storms*).

5. Discussion and conclusions

Natural disasters and unexpected events have wide reaching effects on all spheres of life, including tourism. From a theoretical point of view, it has been assumed that a negative relationship between disasters and inbound tourism dominates (e.g. a Cró & Martins, 2017a). However, because of some motivating factors identified in the literature, and due to the methodology and definition used by the UNWTO in collecting international tourist arrivals, an increase in visitation after a disaster seems also plausible.

The number of inbound tourism arrivals directly impacts the performance of the national tourism industry, and ultimately the government, especially in countries where tourism is a major contributor to the national economy and fiscal revenue (Massidda & Mattana, 2013). It is therefore of great importance for policymakers to improve their understanding of how disaster events affect visitor demand. This research highlights the need to consider different types of disasters and their varied consequences when assessing the consequences for tourism.

5.1. Significance of different types of disaster impacts

The empirical research presented in this paper draws on two sets of data to explore in depth the relationship between international tourist arrivals and global disasters, measured through three different impact metrics (costs, deaths and affected people). The effects that these different disasters might have on inbound flows at a national level were investigated though a gravity model, estimated by panel data with destination-fixed effects and using yearly data. By doing so, spurious potential determinants related to the destination but not the disaster can be avoided. As a result, however, recurrent disasters affecting the same destination and those with a very short-run effect have not been captured.

Findings of this analysis provide evidence that the economic consequences of a disaster in a particular country generally affect international tourism arrivals negatively. This is likely due to damages to infrastructure, key attractions and a wider weakening of the economy in the host country. All of these reduce the destination ability to cater for tourism, undermine investment into tourism supply, and reduce destination attractiveness, at least in the short-term.

At the same time, the analysis reveals that evaluating the tourism impacts of a disaster in terms of deaths and affected people is more ambiguous. Our research found a dominance of positive effects in the case of deaths related to a disaster. Thus, whilst disaster damage seems to prevent tourists to visit the affected destination, the number of fatalities and affected people seem to be less of a deterrent. Tourists may not see a risk to their own safety. Also, there could be an increase in tourism for some disasters due to the arrival of humanitarian 'tourists' and people visiting friends and relatives. Whilst generally, this observation might be testimony to tourism resilience, and indeed reassuring for destination managers, there may be situations where continuous tourism demand after a disaster is hindering recovery works or impacting the well-being of residents. More research on 'optimum' recovery timeframes that take into account resident needs, would be useful (e.g. Okuyama, 2018).

5.2. Reductions in demand differ for disaster types

It is useful for decision makers to understand that not all disasters cause similar impacts. The comparison of different disaster types showed, for example, that volcanic eruptions typically cause the most significant and substantial negative impact on tourism. Specifically, for every million people affected by an eruption a fall between 1.7% and 2.1% in the international tourism arrivals is expected, if a six-month period or a twelve –month period is considered, respectively. Other disasters have smaller and shorter-term impacts (e.g. *Floods* and *Storms*). Furthermore, floods and tsunamis are detrimental without nuance, although it is difficult to discerne whether the negative effect is due to the possible destruction or disablement of infrastructure or to the negative image of the destination generated by these types of event.

When a destination is affected by a wildfire, an earthquake, an industrial accident, a storm or a drought, mixed effects may be expected. For example, when these types of disasters result in economic damage, a negative and significant relationship can be established, indicating that damage to infrastructure and built assets, and maybe business capability, is likely to reduce tourist arrivals. Finally, this research revealed that some types of events are unlikely to have a major effect on arrivals, for example an unexpected epidemic, a landslide, a cold wave and a heat wave. It should be noted how these natural disasters are characterized by little or no impact on infrastructure and no long-term risk to tourists after the event has finished.

5.3. Managerial implications

Natural disasters and unexpected events are traumatic experiences for the resident population and may cause lasting damage to destination infrastructures, which requires adequate and adaptive tourism management (Hystad & Keller, 2008). Strategies used to predict natural disasters and mitigate hazard risks in the first place need to be deployed to minimize the impacts. Examples include the implementation of appropriate building codes, zoning regulations, and emergency training and preparedness for key stakeholders. New policies and practices may require additional resources, but investments into preparedness are likely to generate positive returns in the long term. In general, the empirical results in this paper confirm that disaster events are challenging news for tourism managers who need to deal with an unexpected fall in tourism demand. Clearly, economic damage from an unexpected event leads to some reductions in tourist arrivals. In those cases, efforts by destination managers should focus on the recovery of necessary infrastructure and business capability. Proactive planning, for example around business continuity, business support networks, and recovery assistance programs, could accelerate this effort (Hystad & Keller, 2008). Leadership may come from government agencies, destination management organizations, or businesses themselves. Related research in New Zealand revealed that leadership is "mainly provided by tourism stakeholders with a community-value orientation, and to a lesser extent by those who are mainly business-driven" (Hughey & Becken, 2016, p. 69). In other words, response and recovery is often led by individuals who have a strong commitment to, and engagement with, the affected community.

For some events, it is not necessarily the economic damage that is the most significant impact, but it could be the number of people affected or killed. For some disaster types, for example wildfires and storms, this research even established a positive impact. The positive relationship between number of tourists and affected people of fatalities by some disasters implies that these can attract visitors to the destination, a circumstance that should be taken into account by the managers of the destination. There are many different reasons why visitors might want to visit a destination that had been affected by a disaster (e.g. Rucińska & Lechowicz, 2014 on dark tourism), and understanding this non-orthodox typology of visitor types could be useful for destination managers. Regardless, marketing activities have to be designed with great care to attract the right types of visitors at the right time, considering potentially ongoing limitations around tourism capacity (Okuyama, 2018; Orchiston & Higham, 2014). Marketing campaigns implemented by businesses, local tourist destinations or national tourism bureaus should ideally align in their messaging and magnitude, implying a particular need for vertical integration following a disaster (Hughey & Becken, 2016).

5.4. Limitations

This research has several limitations, including the availability, accuracy and granularity of data, which is outside the control of the research team. It could be argued that some impacts on tourism are significant, yet short-lived. Given that the data used here is provided on an annual basis, short-term effects are likely to be missed or underestimated in this research. Besides the limitations about the estimation method and the nature of the data of the UNWTO we have imposed a homogenization for each disaster. That means that a specific disaster in a developed country has the same effect than in an less developed one. In reality, this might not be the case. Consequently, results obtained in this paper should be considered as average responses. Future research should further explore this matter and investigate if differences among countries in reference to their level of development exist. Our attempt to discriminate the different disaster by region did not obtain significant results. Future research on the positive impacts of certain types of disaster consequences would also be beneficial in developing a potential tourist typology consisting of 'dark tourism' segments, humanitarian arrivals or other presently unidentified markets.

Author contribution

Jaume Rosselló-Nadal as an expert in tourism demand modelling and the quantitative analysis of tourism has contributed with the knowledge of the specific literature of demand modelling and the identification of the gap in the literature. Susanne Becken as an expert in sustainable tourism and climatic change issues has contributed with the knowledge of the specific literature of natural hazards and potential effects on tourism and Maria Santana Gallego as an expert within the fields of gravity models in a special way in the design of the methodology and in the exploitation of the results. He has also been responsible for the first model estimations.

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Jaume Rosselló-Nadal has a PhD in Business and Economics, is Full Professor at the Universitat de les Illes Balears (Spain) and Adjunct Professor at Griffith Institute for Tourism (Australia). His research interests include tourism demand modelling and environmental issues with special interest in climatic change issues. Jaume has led different research projects in Spain and Europe.

Dr Susanne Becken is a Professor of Sustainable Tourism at Griffith University, Australia. Susanne has led a large number of research programmes and consulting projects in Asia Pacific in the area of climate change, risk management and sustainable tourism. She contributes through various industry and Government advisory roles and panels, and is on the editorial boards of nine tourism journals.

Maria Santana-Gallego is PhD in Economics and Assistant Professor in the Department of Applied Economics, University of the Balearic Islands, Spain. She teaches tourism economics and macroeconomics. Her research interests include quantitative analysis of tourism and gravity models.