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The impact of hurricane strikes on tourist arrivals in the Caribbean

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The authors quantify the impact of hurricane strikes on the tourism industry in the Caribbean. To this end they first derive a hurricane destruction index that allows them to calculate the actual wind speed experienced at any locality relative to the hurricane eye of a passing or land falling hurricane. They then employ this hurricane index in a cross-country panel data context to estimate its impact on country-level tourist numbers. The results suggest that an average hurricane strike causes tourism arrivals to be about 2% lower than they would have been had no strike occurred.

Keywords: hurricanes; tourist arrivals; Caribbean

The Caribbean is more dependent on tourism to sustain livelihoods than almost any other region of the world in that the sector often serves as the primary industry or at least as a major earner of foreign exchange. For example, in terms of output generation, in the British Virgin Islands, Antigua and Barbuda, and Anguilla tourism constitutes over 70% of gross domestic product (GDP), while in other islands, such as Aruba, Barbados and the Bahamas, more than half of GDP is generated through tourism and related receipts (World Travel and Tourism Council, 2010). However, at the same time the Caribbean is also a region highly susceptible to natural disasters, such as hurricanes. As a matter of fact, hurricanes are famous for potentially wreaking havoc in the Caribbean, inducing substantial physical damages and disruption to normal economic activity, including tourism. For instance, in 2004 Hurricane Ivan is believed to have caused damage in Grenada of around US$1.1 billion, while also resulting in a dramatic reduction in tourism.

Given the apparent rise in the number of hurricanes in the Caribbean, possibly linked to climatic changes, over the past few years, this potential impact on tourism may be regarded as particularly worrisome for the region. However, while there are various case studies of the effects of specific hurricane strikes within the Caribbean, such as that by Benson and Clay (2001) who noted how infrastructure destruction due to hurricanes had gone hand in hand with a decline in visitor numbers by around 30% in Dominica over the 1978–1986 period, there is to date no comprehensive statistical analysis that provides any quantitative estimates of the impact on the tourism industry statistically attributable to hurricanes across the Caribbean. One partial exception is Sahely (2005) who examines tourism demand for three major non-banana producing countries (Anguilla, Antigua and Barbuda, and St Kitts and Nevis) and finds no negative effects of hurricanes, although it must be noted that the author used only hurricane incidence dummies and thus abstracted from differences in hurricane strengths and destruction. While there are no other econometric analyses of the impact of hurricanes on tourism even outside the Caribbean region of which we are aware, there are a few studies on other types of disasters. For instance, examining the case of an earthquake in Taiwan, Huang and Min (2002) find that it took the tourism industry at least a year to recover. Also, Hultkrantz and Olsson (1997) found that the Chernobyl nuclear accident caused losses of SEK2.5 billion in revenues from incoming tourism in Sweden. Moreover, there is also a relatively larger body of literature on the effects of terrorism attacks on tourism, which can similarly be viewed as an exogenous shock to the industry. Most of these seem to find a significant negative impact of terrorism; see, for instance, Sloboda (2003) and Pizam and Fleischer (2002).

In this paper we thus explicitly set out to measure quantitatively the impact of hurricanes on tourism for 26 countries in the Caribbean region over the 2003–2008 period. Essentially all of the literature cited above uses measurement prone *ex post* loss data or simple incidence dummies as proxies for these disaster events. In contrast, in this study, we employ *ex ante* data on the nature of the striking hurricanes in conjunction with a physical wind field model to develop a proxy of damage incurred that will arguably provide a much more accurate measure of large exogenous negative shocks to the tourism industry. It may be noted in this regard that this approach of using predefined information of a natural disaster event to proxy its impact has not only gained popularity in academic circles – see, for instance, Strobl (2012) – but also appears to have generated interest among policymakers. For instance, the recently established Caribbean Catastrophe Risk Insurance Facility set up by the World Bank now uses the local maximum wind speed of a hurricane partially to determine the amount of funds to release to participating countries in the case of a hurricane strike.

The remainder of the paper is as follows. In the next section we briefly discuss the nature of hurricanes and their likely impact on tourism. The subsequent section outlines the construction of our hurricane destruction index. Our data sets and some summary statistics are then provided in the fourth section. The fifth section presents the econometric analysis. Finally, we provide our concluding remarks.

Hurricanes and the tourism industry

A tropical cyclone is a meteorological term for a storm system that forms almost exclusively in tropical regions of the globe. Tropical storms in the North

Atlantic and the North East Pacific region, as are being studied in this paper, are referred to as hurricanes if they are of sufficient strength, generally at least 119 kph, and their season can start as early as the end of May and last until the end of November. Damage due to hurricanes typically takes a number of forms. First, their strong winds may cause considerable structural damage to crops as well as buildings. Second, the heavy rainfall can result in extensive flooding and, in sloped areas, landslides. Finally, the high winds pushing on the ocean's surface cause the water near the coast to rise higher than the usual sea level, resulting in storm surges. The flooding inland due storm surges generally occurs as early as 3–5 hours before arrival of hurricane and is often its most damaging aspect, causing severe property damage and destruction and salt contamination of agricultural areas. Such storm surges can also result in considerable coastal erosion. It is worth noting that hurricanes lose their strength as they move over land. While the extent of potential damage caused by hurricanes may depend on many factors, such as slope of the continental shelf and the shape of the coastline in the landfall region in the case of storm surges, it is typically measured in terms of wind speed. In this regard, it is generally agreed that considerable damage occurs only once a hurricane has reached speeds of at least 178 kph; that is, a strength of three on the Saffir–Simpson scale, in approaching the coast and/or making landfall.

A priori one should expect the impact to take place on two fronts. On the one hand, there will be direct costs, like the destruction of infrastructure and coastal degradation, which will lower the quality of the location as a tourist destination, at least in the short run. Related to this, on the other hand, one might anticipate hurricane strikes increasing the subjective perceived probability of future hurricanes, further discouraging tourists who are on the margins of choosing the affected country relative to alternatives, as well as reducing future investment in the tourist industry. In this regard, Mahon (2006, p 34) noted that 'a healthy tourist economy cannot thrive and grow unless prospective tourists perceive the islands as a safe place in which to visit and vacation. A hurricane or earthquake with tremendous damage, destruction or loss of life may create a long lasting image that Caribbean SIDS [small island developing states] are a dangerous and risky vacation setting.' Even if the tourist industry is not affected in terms of direct damage or perceived probability or reoccurrence, if a hurricane affects other sectors of the economy, such as agriculture or manufacturing, then there may nevertheless be spill-over effects through increased prices. As a consequence, wage rises could further reduce the profit margin of tourist enterprises.

Hurricane destruction index

Our hurricane destruction index is based on being able to estimate local wind speeds at any particular locality where a hurricane strength tropical storm directly passes over or nearby and assume that extent of damages is related to this wind speed. To do so we rely on the meteorological wind field model developed by Boose *et al* (2004) and based on Holland's (1980) well known equation for cyclostrophic wind and sustained wind velocity, which estimates wind speed at any point of interest on land relative to the hurricane at any point in time. We then use a version of Emanuel's (2005) destruction index to calculate total destruction due to storm r over its life time τ in any country i at time t:

$$HURR_{i,r,t} = \left(\sum_{j=1}^{J} \int_{0}^{\tau} V_{jt}^{\lambda} w_{i,j,r,t} dr\right), \text{ if } V_{jt} > 177 \text{ km/hr (SS} \geq 3\text{) and zero otherwise,} \quad (1)$$

where V are estimates of local wind speed at localities j, J is the set of localities j within country i, w are weights assigned according to characteristics of the locality to capture the 'potential' damage there, and λ is a parameter that relates local wind speed to the local level of damage and is, as suggested by Emanuel, to take on a value of three (3). In terms of the weights w we use the time varying share of population of each individual locality j at t–1.

Data and summary statistics

Hurricane data

For data on hurricanes in the Caribbean region we rely on the North Atlantic Hurricane database (HURDAT), which consists of six-hourly positions and corresponding estimates of maximum wind speed of tropical cyclones in the North Atlantic Basin over the period 1851–2008 and is the most complete and reliable source of North Atlantic hurricanes (Jagger and Elsner, 2004). Following Jagger and Elsner (2006) we linearly interpolated the positions and wind speeds between the six-hourly data to obtain three-hourly track data since hurricanes can move considerable distance in just a few hours.

We depict the total number of tropical storms over the period in Figure 1, in which darker shading indicates when these obtained maximum speeds of SS scale of three. As can be seen, while there are many tropical storms, only a few of these, and then only for parts of their track, translate into potentially damaging hurricanes.

In terms of applying our wind field model to obtain local wind intensity estimates for the Caribbean region, we followed each tropical cyclone over each point of the interpolated track and calculated the wind intensity relative to the centre of each grid cells in the schemata provided by the population data as long as these fell within 500 km of the hurricane's location. This provided us with a complete set of estimates of wind fields experienced by all spatially relevant localities relative to each position of each tropical cyclone. We were then able to calculate local destruction according to our index of Equation (1).

As a demonstration of how our HD index translates into estimates of local destruction for individual hurricane occurrences we next calculated and plotted its value over all affected localities for Hurricane Dennis, which struck the Caribbean in 2005 and caused approximately US$2.23 billion in damage, in Figure 2, where shading moving from light to dark grey indicates the rising scale of damage. As can be seen, Hurricane Dennis made landfall at hurricane strength only in Cuba, causing damage throughout the island. Noteworthy in this regard is that the extent of damage differed widely. Furthermore, while no other islands were directly struck in terms of landfall, Hurricane Dennis's

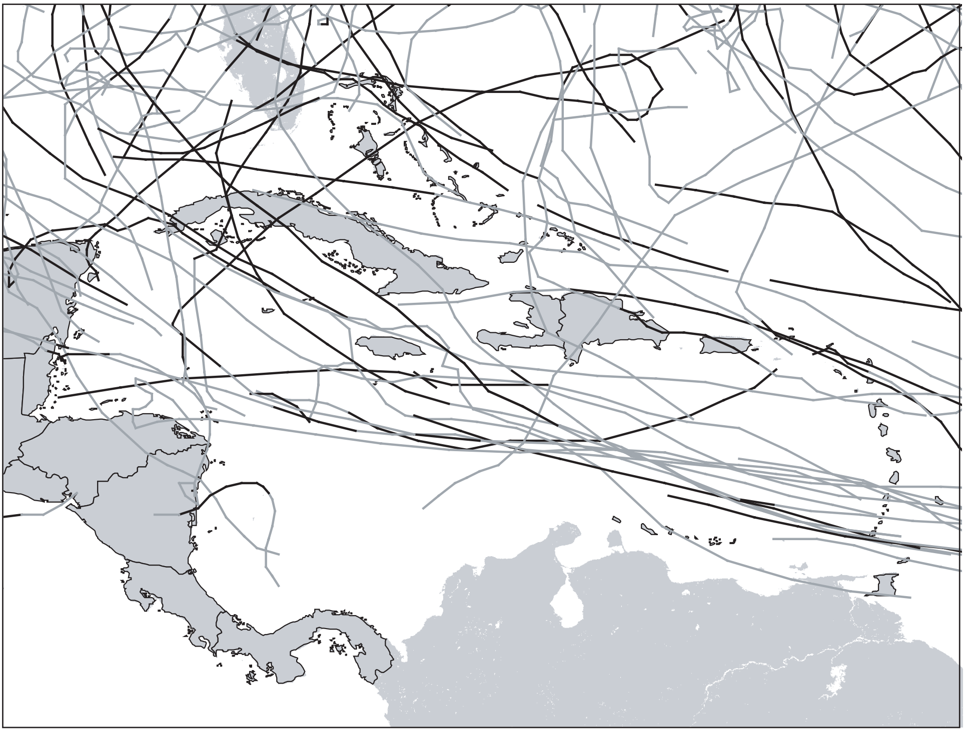

Figure 1. All tropical cyclone activity since 2003.
Note: The darker portion of the tracks constitutes the segments of tropical storm tracks that reached at least hurricane intensity.

winds were strong enough to affect Haiti, Jamaica and small parts of the Bahamas.

As can be seen from Table 1, the distribution of hurricane destruction experienced over our sample period differs widely across countries. More precisely, while there are many countries that were not affected by hurricanes, others, such as Cuba and Jamaica, have suffered large potential destruction.

Tourism data

Our source for tourism demand is the monthly tourism data for the period 2003–2008 (available online from http://www.onecaribbean.org), which is the official tourism business website of the Caribbean Tourism Organization. The data consist of information on tourism arrivals for 26 countries/territories in the Caribbean; a list of these and their average monthly tourism arrival numbers are given in Table 1. Accordingly, the Dominican Republic receives by far the most Caribbean tourists in our sample, averaging around 250,000 a month. Other popular tourist destinations include Cuba, Jamaica, the Bahamas and Puerto Rico, while countries such as Montserrat, Anguilla and St Vincent have in absolute numbers few tourists per month.

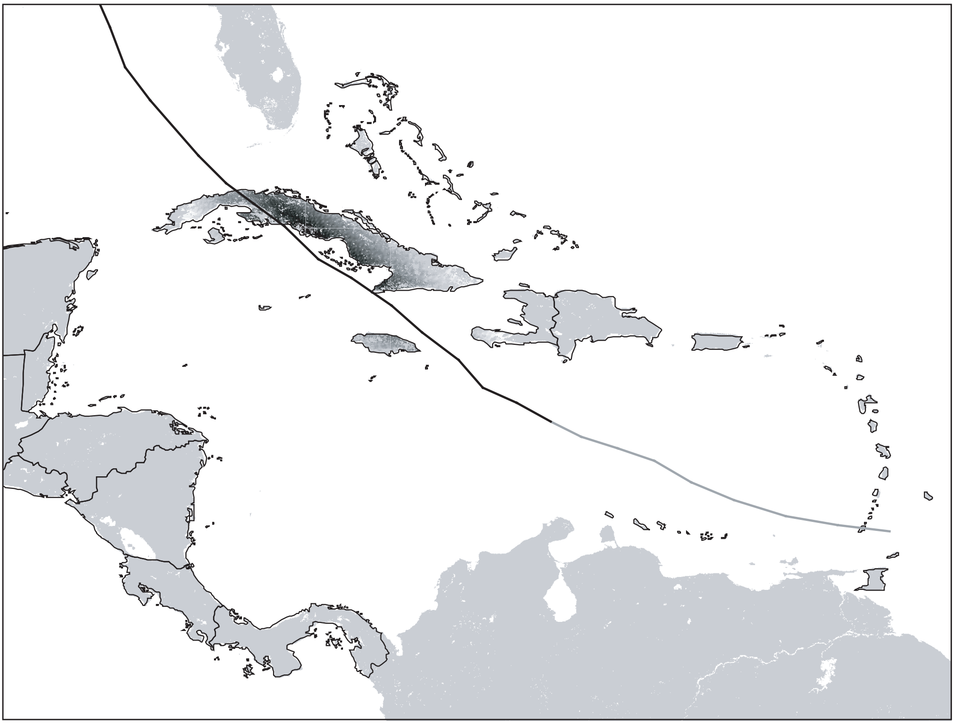

Figure 2. Destruction path of Hurricane Dennis (2005).
Note: The degree of destruction increases as the shading turns darker.

Econometric analysis

Our task is to determine econometrically the extent to which hurricane strikes affected the number of monthly tourism arrivals across Caribbean countries/territories over the sample period 2003–2008. Given that our dependent variable is a count variable but with few outliers, we thus use fixed effects Poisson model to estimate:

$$Arrivals_{it} = \alpha + \beta HURR_{it} + \gamma YD_t + \delta M_t + \mu_i + \varepsilon, \quad (2)$$

where i is a country subscript, t is a time subscript, HURR is our hurricane destruction index, YD is a set of year dummies, M is a set of monthly dummies, μ is a time invariant unobservable country specific effect, and ε is an i.i.d error term. Importantly, hurricane shocks are arguably of an exogenous nature and thus we can be reasonably confident that our estimate of β is unbiased. One possibility violating this assumption may be that, although hurricanes are not strictly predictable, there are clearly spatial patterns to likelihood. If potential tourists have some, even imperfect, information as to what the return probabilities are, then some destinations may be relatively less visited. Moreover, there may be other country-specific factors, such as geographical or climatic ones, that affect both the attractiveness of a location and its likelihood

Table 1. Summary statistics.

Country	Hurricanes	Tourist arrivals
Anguilla	574	5,302
Antigua	0	20,781
Aruba	1,821	61,052
Bahamas	2,771	123,265
Barbados	0	46,268
Belize	2,156	19,888
Bermuda	0	23,137
British Virgin Islands	0	28,159
Cayman Islands	4,486	21,984
Cuba	210,913	180,330
Dominica	0	63,978
Dominican Republic	234	255,905
Grenada	1,446	10,358
Guyana	0	9,914
Haiti	0	8,661
Jamaica	186,164	130,426
Martinique	542	39,937
Montserrat	0	712
Puerto Rico	12	116,277
Saint Kitts and Nevis	20	9,803
Saint Lucia	102	24,708
Saint Vincent and the Grenadines	13	7,386
Surinam	0	12,808
Trinidad and Tobago	982	36,558
Turks and Caicos Islands	551	14,025
US Virgin Islands	496	55,805

of being subjected to a hurricane strike. It seems reasonable in this regard to assume that such factors would be time invariant and hence are purged via our use of fixed effects.

Estimates of Equation (1) are shown in the first column of Table 2, where we simply include current values of our HURR index in addition to the year and month dummies as regressors. As can be seen, the coefficient on HURR is negative and highly significant. As a matter of fact the coefficient suggests that an average hurricane strike causes tourism arrivals to be about 98% of what it would have been had it not occurred. The largest value of HURR over our sample period, which was for Jamaica in 2004 as a result of Hurricane Ivan, in contrast reduced tourist arrivals by 20%.

We also experimented with allowing for more longer term effects on tourist numbers by including up to six lags of HURR, as shown in the second column of Table 2. However, all of these are statistically insignificant, and the coefficient on the current values is only marginally changed. Although not reported here, we also included up to 24 lags of the hurricane destruction index, but results were similar, with only an immediate effect appearing. Thus our results indicate that hurricane strikes have a potentially large negative impact,

Table 2. Poisson model of tourism arrivals.

	(1)	(2)	(3)	(4)
$HURR_t$	–1.751***	–1.667***	–0.777	–0.602
	(0.655)	(0.639)	(0.549)	(0.553)
$HURR_{t-1}$		–0.513		–0.286
		(0.562)		(0.582)
$HURR_{t-2}$		0.165		–0.135
		(1.078)		(0.800)
$HURR_{t-3}$		0.424		–0.318
		(0.748)		(0.776)
$HURR_{t-4}$		0.660		0.216
		(1.156)		(0.489)
$HURR_{t-5}$		0.035		0.086
		(0.945)		(0.747)
$HURR_{t-6}$		0.815		0.281
		(0.964)		(0.692)
Observations	1,671	1,671	1,671	1,671
Countries	26	26	26	26
Pseudo – R–squared	0.837	0.837	0.837	0.837

Notes: Standard errors are in parentheses; ***, **, and *indicate 1, 5, and 10% significance levels, respectively.

but this lasts no longer than the actual month of the strike. It should be noted that our index implicitly assumes that only wind speeds above the SS scale of three are destructive enough to matter. To verify this, we recalculated our destruction index but included all local measured speeds that were of any strength above SS scale of one but, as can be seen, this produces insignificant effects.

Conclusion

In this paper we estimate the impact of hurricanes on monthly tourist arrivals in the Caribbean. We find that an average hurricane translates into a 2% loss in arrivals for the average destruction due to hurricanes, while in contrast the very largest event caused up to a 20% reduction. Thus our results indicate that hurricanes can have considerable negative impacts on tourism-dependent Caribbean economies. There are a number of possible, but not mutually exclusive, policies that can be implemented to try to buffer these shocks. First, countries should be encouraged to undertake disaster mitigation to reduce destruction, particularly to infrastructure and housing. Second, governments might consider setting up a national relief fund, financed by taxation on the tourism industry, for aiding the tourism sector in the case of a hurricane strike and a subsequent fall in tourism demand. Third, the governments in the Caribbean might consider setting up a cross-national insurance scheme, by which governments could purchase insurance policies for shocks to their tourism sector. A successful example in this regard is the Caribbean Catastrophe Risk

Insurance Facility, which is an international insurance scheme against shortages in public revenues due to natural disasters.

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