



# The economic growth impact of natural disasters in developing countries: Evidence from hurricane strikes in the Central American and Caribbean regions

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## ABSTRACT

In this paper we investigate the macroeconomic impact of natural disasters in developing countries by examining hurricane strikes in the Central American and Caribbean regions. Our innovation in this regard is to employ a wind field model on hurricane track data to arrive at a more scientifically based index of potential local destruction. This index allows us to identify damages at a detailed geographical level, compare hurricanes' destructiveness, as well as identify the countries that are most affected, without having to rely on potentially questionable monetary loss estimates. Combining our destruction index with macroeconomic data we show that the average hurricane strike caused output to fall by at least 0.83 percentage points in the region, although this depends on controlling for local economic characteristics of the country affected and what time of the year the storm strikes.

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## 1. Introduction

Natural disasters are generally associated with considerable economic losses. Particularly alarming in this regard is not only the fact that the last three and a half decades have witnessed an increase in the number of such occurrences, but also that developing countries seem to be those bearing the brunt of these events and ultimately the economic consequences, thus possibly further adding to the perceived gap between the 'rich' and the 'poor'. For example, between 1970 and 2002, out of a total number of 6436 natural disasters 77% have taken place in the developing world. Moreover, the reoccurrence of such extreme events often tends to be concentrated in particular geographic areas, striking certain countries again and again, often with great severity. For instance, since 1984 Dominica has been struck by 9 different hurricanes, while Hurricane Georges caused losses of around 400 million US\$, constituting over 140% of GDP, in the Caribbean islands of St. Kitts and Nevis in 1998.<sup>1</sup>

While cited damage figures due to extreme events are often impressively large, the overall macroeconomic impact, in particular with regard to economic output, may in principle not necessarily be quite that apparent for a number of reasons. Firstly, as argued by Horwich (2000), natural disasters are almost always localized events and may thus only affect a limited part of the whole economy. Additionally, natural disasters generally relate to a loss in the capital stock – mostly of a physical nature, although there may also be losses

in human capital – in an economy. However, if the gross domestic product is taken as the measure of output, it may actually be enlarged by the "production of replacement capital and disaster-related rescue, [and] relief and clean-up activity" (Horwich, 2000, p. 524).<sup>2</sup> Moreover, as noted by Hallegate et al. (2007), negative shocks such as natural disasters may serve as a catalyst for re-investment and upgrading of capital goods which in turn can boost an economy.<sup>3</sup>

Arguably, however, one would expect such a 'dampening' of the negative effects due to natural disasters to play less of a role in developing countries. For instance, Horwich (2000) argues that the Kobe earthquake in Japan, which was the most severe earthquake of modern times to strike an urban area, had little observable macroeconomic consequences, while the 1988 earthquake in Armenia, which registered at a lower Richter scale, had devastating effects on the economy.<sup>4</sup> Also, in a cross-country study Noy (2009) finds that any macroeconomic costs are almost entirely due the developing country group of his sample. Such a differential effect for developing countries may not be that surprising given that most of the extreme events seem to mainly take place in developing countries and these tend to be relatively specialized in agriculture, which is likely to be the sector most affected by natural disasters.<sup>5</sup> As a matter of fact, recent evidence seems to indicate that the extent of losses due to

<sup>2</sup> Although pre-disaster components and GDP itself could fall before enough replacement capital becomes available.

<sup>3</sup> For a discussion on the growth implication derived from theoretical literature, see Noy (2009).

<sup>4</sup> International Monetary Fund (2001).

<sup>5</sup> See Albala-Bertrand (1993).

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<sup>1</sup> Rasmussen (2004).

natural disasters is very much related to the level of development; see, for instance, Anbarci et al. (2005), Kahn (2005), Toya and Skidmore (2007), and Noy (2009).

Another aspect to consider, also related to that of the level of development, is that countries in the face of risk and incomplete insurance markets may alter their behaviors to reduce the impact of natural disaster events when they do arise. As a matter of fact, in his early review of the literature on income and consumption smoothing in general, Murdoch (1995) already noted that individuals and households in low-income countries had been surprisingly innovative in dealing with risks. For example, Rosenzweig and Wolpin (1993) showed that in India bullock accumulation is used to buffer shocks, although the incompleteness of markets ensures that they are still operating inefficiently. Specifically with regard to hurricanes, Poertner (2008) examines the impact of hurricane risk on Guatemala and finds that it leads to higher fertility in landholding households, but lower fertility for the landless. Moreover, while both household types respond to risk with greater investment in education, this effect is largest for the landless. This thus suggests a shift from physical to human capital, at least for landholders, in face of hurricane risk. In terms of the effect of such on economic growth rates, Barro (2001) would argue that a higher ratio of human to physical capital could result in faster growth since this allows for an easier absorption of better technologies.

Despite the obvious ex-ante ambiguity of the net effect, evidence on how much damages due to extreme events actually translate into a fall or rise in the overall economic output is as of date sparse, and the few estimates that exist for developing countries vary considerably. For instance, Raddatz (2007) investigated the role that external shocks played in a panel of low-income countries and found that climatic disasters can only account for 13.9% of the total volatility due to external shocks. In contrast, Noy (2009) finds that natural disasters will typically cause a drop in output of 9 percentage points in developing countries.

While the few studies investigating the macroeconomic impact of natural disasters should be applauded for their novel attempts in this regard, there are a number of reasons to be skeptical about the actual quantitative size of their estimates. Firstly, almost all related studies tend to treat natural disasters as a homogenous group of extreme events affecting an assumed homogenous group of countries. Arguably, however, different types of natural disasters have different potential effects, while different geographical regions are subject to different probabilities of occurrence for these, and thus are likely to be affected non-homogeneously as the level of readiness may depend on the (perceived) probability of incidence.<sup>6</sup> Secondly, current studies essentially have all relied on aggregate damage estimates, either in financial or human loss levels or in terms of identifying the occurrence. Typically, however, damage estimates, such as those provided by the widely used EM-DAT database, come from different sources, the nature and quality of reporting may change over time, the costs may be exaggerated to attract international emergency relief, and identified events are generally subject to some threshold level for inclusion.

The purpose of the current paper is to address these shortcomings to arrive at a more reliable estimate of the macroeconomic impact of a natural disaster. We do so not only by focusing on a particular region subject to a particular type of natural disaster, but also by employing a more scientifically based proxy of its potential destruction. More specifically, our geographical focus is on hurricane strikes in the Central American and Caribbean (CAC) region, an area that has been particularly vulnerable to such storms.<sup>7</sup> However, unlike the previous

studies we, rather than using potentially measurement error prone indicators of economic damages to proxy the severity of a hurricane strike, resort to actual historical data tracking the movement of tropical storms across the affected region and employ a wind field model on these hurricane 'tracks' that allows us to calculate an approximation of the severity of winds experienced at a detailed geographical level of the countries potentially affected. These local wind estimates are then translated into a proxy of local potential destructiveness of hurricanes. We then employ our proxy within a standard growth equation to estimate the impact of hurricanes on economic growth in the region.

The remainder of the paper is organized as follows. In the next section we briefly describe the basic nature of hurricanes and their potential destructiveness. In Section 3 we outline the construction of our index of hurricane destructiveness. Section 4 describes our data sources. Some destruction estimates using our proxy are given in Section 5. We econometrically investigate the macro-economic impact of hurricanes in the region in Section 6. Finally, concluding remarks are provided in the last section.

## 2. Some basic facts about hurricanes and their destructive power

A tropical cyclone is a meteorological term for a storm system which forms almost exclusively in tropical regions of the globe. Tropical storms in the North Atlantic and the North East Pacific regions, as we study here, are referred to as hurricanes if they are of sufficient strength.<sup>8</sup> Their season officially starts on June 1st and ends the 30th of November.<sup>9</sup> In terms of its structure, a hurricane will typically harbor an area of sinking air at the center of circulation, known as the 'eye', where weather in the eye is normally calm and free of clouds, though the sea may be extremely violent.<sup>10</sup> Outside of the eye curved bands of clouds and thunderstorms move away from the eye wall in a spiral fashion, where these bands are capable of producing heavy bursts of rain, wind, and tornados. Hurricane strength tropical cyclones are normally about 483 km wide, although this can vary considerably.

Damages due to hurricanes typically take a number of forms. Firstly, their strong winds may directly cause considerable structural damage to crops as well as buildings. Secondly, the heavy rainfall can result in extensive flooding and, in sloped areas, landslides. Importantly, the extent of this rainfall is also strongly related to the maximum wind speed of the hurricane, as shown by Haiyan et al. (2008). Thirdly, hurricanes typically result in storm surges in coastal areas and consequent flooding inland as early as 3–5 h before their arrival and this is often their most damaging aspect, causing severe property damage and destruction and salt contamination of agricultural areas.<sup>11</sup> Again, the extent of such flooding is strongly related to the wind strength of the storm,<sup>12</sup> as it is the high winds pushing on the ocean's surface that cause the water near the coast to pile up higher than the ordinary sea level resulting in storm surges. Finally, one may want to also note that hurricanes lose their strength as they move over land due to increased surface roughness.

While the extent of potential damages caused by hurricanes may depend on many factors, such as the 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. A popular classification has been the Saffir–Simpson (SS) Scale, where values from 1 to 5 correspond to wind speeds of 119–153 km/h, of 154–177 km/h, of 178–209 km/h, of 210–249 km/h, and 250+ km/h, respectively. In this regard, it is generally agreed that considerable

<sup>8</sup> Generally at least 119 km/h.

<sup>9</sup> <http://www.aoml.noaa.gov/hrd/tcfaq/G1.html>.

<sup>10</sup> National Weather Service (October 19, 2005). Tropical Cyclone Structure. JetStream – An Online School for Weather. National Oceanic & Atmospheric Administration.

<sup>11</sup> Yang (2008).

<sup>12</sup> See Jordan and Clayson (2008).

<sup>6</sup> For example, tropical cyclones only affect certain regions of the world and mostly coastal areas of these, while earthquakes tend to take place near fault lines; see Woo (1998).

<sup>7</sup> For a discussion of the macroeconomic impact of hurricanes in the Caribbean see Rasmussen (2004).

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