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Analysis

# The fiscal implications of hurricane strikes in the Caribbean

Bazoumana Ouattara [a], Eric Strobl [b,c,*]

[a] Swansea University, United Kingdom
[b] Ecole Polytechnique, France
[c] IPAG Research Lab, France

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ABSTRACT

This paper empirically traces the fiscal impacts of hurricane strikes. To this end, a hurricane damage index is derived from a physical wind field model for a panel of Caribbean countries over 36 years. Results, based on panel VAR and impulse response functions analysis, show that, overall, hurricane strikes exert a short-term impact. Indeed, the study finds that the response of government spending is positive and significant while public investment, debt and tax revenue do not appear to respond (significantly) to hurricane strikes. Moreover, the study finds that Governments respond to hurricane strikes by engaging in short term deficit financing.



## 1. Introduction

Natural disasters are generally associated with considerable economic losses, often causing substantial and sustained disruption to normal economic activity. Particularly vulnerable in this regard are small countries, whose limited budgetary capacity prevents them from establishing sufficient financial reserves to such a relatively large negative shock. Additionally, the high debt level of most small economies limits their ability to access credit in the aftermath of a natural disaster, high transaction costs associated with the relatively small market limits access to private catastrophe insurance, and international assistance is often too little and comes too late. For example, when Hurricane Ivan struck the island of Grenada in 2004 causing over US $800 million in damages, the country was no longer able to finance its public service bill and was forced to introduce a number of revenue enhancing measures and delay efforts of recovery and reconstruction in order to deal with the immediate problem of the fiscal shortfall, thus likely further amplifying the long term effects of the hurricane.

However, despite the arguable policy relevance of understanding the immediate fiscal impact of natural disasters, a review of the literature reveals that there are only a handful of studies that have addressed the issue, treating natural disasters as homogenous and using potentially measurement prone assessments of ex-post damages. To be sure, much of the literature on the effect of natural disasters has focused on its impact on gross domestic product (Cavallo et al., 2010; Fomby et al., forthcoming; Hochrainer, 2009; Loayza et al., 2009; Noy, 2009; Noy and Nualsri, 2011; Raddatz, 2007; Skidmore and Toya, 2002; Strobl, forthcoming-a[1]; among others). The evidence provided by these studies is generally mixed; indeed, while some studies find that natural disaster exert an adverse effect on output dynamics (see Hochrainer, 2009; Noy, 2009; Raddatz, 2007) others suggest a positive growth impact of natural disaster (see Loayza et al., 2009; Skidmore and Toya, 2002).

The fiscal implications of natural disasters, on the other hand, have been under-investigated notwithstanding the fact that natural disasters can have severe implications for public sector finances and provide a major obstacle to recovery (IMF, 2009; Inter American Development Bank, 2009; World Bank, 2001). As a matter of fact, to the best of our knowledge only three studies (Lis and Nickel, 2009; Melecky and Raddatz, 2011; Noy and Nualsri, 2011) have examined the fiscal effects of natural disasters.[2] Noy and Nualsri (2011) construct a country level panel data set and find that the fiscal impact of natural disasters depend on the country-specific macroeconomic dynamics occurring in the aftermath of the disaster shocks. For example, while developed countries are characterized by a counter-cyclical fiscal reaction, developing countries respond via procyclical decreasing spending and increasing revenues. Also, Lis and Nickel (2009), similarly in a cross-country panel data context, discover that the negative budgetary impact of extreme weather events can be up to 1.1% of GDP, where the effect is generally larger for developing countries. Melecky and Raddatz (2011), using annual data

* Corresponding author at: Département d'Économie, Ecole Polytechnique, 91128 Palaiseau Cedex, France. Tel.: +33 1 69 33 34 16; fax: +33 1 69 33 34 27.
*E-mail address:* eric.strobl@polytechnique.edu (E. Strobl).

[1] The author looks at the particular case of Caribbean countries, which are the focus of the present study.

[2] It is worth stressing that we are referring to studies that use an econometric method.

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for a sample high and middle-income countries over 1975–2008 and panel VAR, find that government expenditure increases while revenue experience an insignificant change to climate shocks; moreover, the results show that the budget deficit worsens following the climate shocks.

Although much of the studies reviewed, above, use econometrics as their tool for capturing the fiscal effects of natural disasters, it is worth noting that alternative methods, such as the CatSim model (see Hochrainer and Mechler, 2009), have been used to calculate the financial resource gap, and obtain country-level estimates for the most hazard-exposed countries. For example, Mechler et al. (2010) suggest that many highly exposed countries are highly financial vulnerable and experience a resource gap.

This present paper is an attempt to add to the limited number of studies that have looked at the public finance implications of natural disasters. In particular, the paper looks at the specific case of hurricane strikes in the Caribbean. Hurricane strikes in the Caribbean are arguably an ideal case study for the question on hand, as hurricanes tend to be frequent, albeit still unpredictable events, and Caribbean countries tend to be small and heavily indebted. However, our contribution to the literature is also with respect to other aspects. Firstly, rather than using measurement prone ex post loss data or simple incidence dummies as proxies for these disaster events – as was done in the literature cited above – we here employ *ex ante* data on the nature of the striking hurricanes in conjunction with a physical wind field model to develop a proxy of potential damages incurred that will arguably provide a much more accurate measure of large exogenous negative shocks to a small economy. One may want to note in this regard that this approach of using pre-defined information of a natural disaster event to proxy its impact has recently not only gained popularity in academic circles,[3] but also appears to have generated interest among policy makers. For instance, the recently established Caribbean Catastrophe Risk Insurance Facility, set up by the World Bank to deal with short term windfalls in public financing, now uses the local maximum wind speed derived from a hurricane wind field model to determine the amount of funds to disperse in the case of a hurricane strike for participating countries. Secondly, we employ our hurricane destruction index within a panel VAR framework that allows us to include other exogenous shocks.

The main findings of the paper is that hurricane strikes in the Caribbean countries lead to short run increase in government spending, a worsening of the budget deficit-but an insignificant (in statistical term) change in public spending, tax revenue and debt. These findings are robust to various specification tests.

The remainder of the paper is organized as follows. The next section describes the construction of our potential hurricane destruction index. Section 3 describes the data and introduces the econometric methodology. Section 4 presents and discusses the estimation results. Section 5 concludes.

## 2. Hurricane Destruction Index

Accurate measurement of the impact of hurricane strikes on fiscal aspects of countries in the Caribbean crucially rests on obtaining a reasonable proxy of hurricane incidence and its potential destructive power. One possibility could be to use the, in the literature widely popular, EMDAT database, which has collected information on natural disasters, including hurricanes across the global over time. However, use of this database to identify hurricane strikes and their destruction is potentially problematic with regard to two aspects. Firstly, as noted by Strobl (forthcoming-a), although likely exhaustive in recent years, for earlier periods a number of significant hurricane events are missing, thus introducing considerable measurement error. Secondly, natural events like hurricanes may or may not translate into natural disasters and this will in part depend on local economic factors such as, for instance, ex-ante government policies. This could introduce a sample selection bias in the selection of storm events if whether these translated into natural disasters depends on factors that also are correlated with a country's fiscal policy. Thus, ideally, one would like to obtain an exhaustive set of all relevant storm events in the Caribbean, regardless of whether these eventually created natural disasters or not. In this section we set out to construct exactly such an ex-ante potential destruction index, based on modeling the wind speeds of hurricanes over their life time and paths through the Caribbean.

Our hurricane potential destruction index is based on the physical characteristics of a hurricane. In this regard, one should recall that hurricanes are tropical cyclones which form in the North Atlantic and the North East Pacific region and obtain wind speeds of least 119 km/h. The season for hurricanes in the two regions can start as early as the end of May and last until the end of November. 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. 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 tornadoes. The typical structure of a hurricane is depicted in Fig. 1 (Appendix B). Hurricane strength tropical cyclones are typically about 500 km wide, although they can vary considerably.

Physical damage due to hurricanes typically takes a number of forms. Firstly, the strong winds associated with the storm may cause considerable structural damage to buildings as well as crops. Secondly, the high winds pushing on the ocean's surface can cause the water near the coast to pile up higher than the ordinary sea level, and this effect combined with the low pressure at the center of the weather system and the bathymetry of the body of water results in storm surges. Generally these surges are the most damaging aspect of hurricanes. In particular, storm surges can cause severe property damage, as well as destruction and salt contamination of agricultural areas.[4] Such flooding may extend up to 40 km or more from the coast for maximum strength storms. Finally, there is generally strong rainfall associated with a hurricane, which can also result in extensive flooding and, in sloped areas, landslides. One may want to note that while the latter two effects are not directly related to wind, the extent of damage to these is highly correlated with the wind speed of a hurricane, and thus the potential strength of a hurricane is typically measured in terms of its wind speed. A popular classification has been the Saffir–Simpson (SS) Scale, where values from 1 through 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 damages only occur once a hurricane reaches a strength of 3 on the SS scale in approaching the coast and/or making landfall.[5]

Our hurricane wind damage 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. To do so we rely on the meteorological wind field model developed by Boose et al. (2004),[6] which provides estimates of wind field velocity at any point relative to the ‘eye’ of the hurricane. This model, based on Holland's well

[3] See, for instance, Strobl (forthcoming-b) who finds that the economic growth impact in the Latin American and Caribbean regions of a hurricane strike was 0.7 percentage points.

[4] Yang (2007).

[5] For instance, for the United States Pielke et al. (2008) that over 85% of total damages are due to hurricanes of strength 3 and above, although these have only comprised 24% of all U.S. landfalling tropical cyclones. Similarly Vickery et al. (2006) show using the loss functions of the HAZUS-MH model that loss ratio is minimal for wind speeds below 177 km/h.

[6] This wind field model was, for instance, verified by the authors on data for Puerto Rico.