Are tropical storms a failure warning? Evidence from standardized school examinations

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ABSTRACT

This paper examines the impact of tropical storms on student academic achievement. It uses hurricane destruction indexes which takes into account the physical characteristics of the storms relative to the location of each school along with standardized examination test scores to quantify the impact on student performance in Jamaica for the period 1994–2010. The results indicate that the average hurricane reduces students' test scores where the impact is significantly greater for larger storms. Although in the short term, estimates also suggest that tropical storms can have a non-negligible impact on returns to schooling.

1. Introduction

Tropical storms are known to have an adverse effect school systems across the Caribbean. These effects have been noted in damages to school infrastructure, teaching materials, technology and lower attendance due to school closures [19,6,8]. The damages sustained by the education system has been disturbingly high, amounting to over US$90 million across eight Caribbean countries and ten hurricanes for 1995–2007.[1] The disaster-education literature has been growing in its analysis of what the impacts of natural disasters are on different aspects of schooling such as attendance [12,16,19,21,3,4] and performance [10,17,2,20]. The results deduced from those research have been quite inconclusive with even some indicating little or no impact academic achievement (see for instance, [17,2,23]). Studies making use of aggregated data of countries (including [23] may be disguising what takes place at the country level and in particular, at the micro localities within countries. Such disguise can be an impediment to policymakers who are keen on making decisions regarding the allocation of financial aid to vulnerable locations when disaster strikes. Generally, the number of studies aimed at disentangling the effect of tropical storms on school achievement at a disaggregated level have not only presented mixed conclusions but have been relatively few, with their focus being on a small number storms and years. This has been particularly true for many tropical storm prone countries, especially, those in the Caribbean, a high-hurricane impact region.

The fact that the hurricane-focused studies are quite inconclusive and few in number as it relates to estimated impacts on student achievement makes it difficult to draw sound quantitative conclusions

for policymaking. Holmes' [10] study shows that elementary schools in North Carolina failed to meet performance objectives after the occurrence of hurricanes Floyd and Bonnie, striking during the 1999–2000 and 1997–1998 academic years respectively, with Floyd having the most dramatic effect. For hurricane Hugo that struck South Carolina, Shannon et al. [22] show that performance for more than half (56%) of the students remain unaffected, while performance for only 29% were negatively affected. Pane et al.'s (2008) study of hurricanes Katrina and Rita in Louisiana show that affected students experienced a worsening in their test scores compared to other students, where scores reduced between 0.09 and 0.22. Using the same hurricanes, Sacerdote [20] finds a 0.13 standard deviation decline in test scores immediately after the storms struck for New Orleans evacuees. In contrast to these studies, Baggerly and Ferretti [2] find no impact on test scores in Florida with the occurrence of 2004 hurricanes.

These variation in estimated impacts can be due to a number of reasons. Majority of these studies focus on a few hurricanes and a few years, which perhaps, might be inadequate for a concrete conclusion without considering many hurricanes and many years. The scholastic level of students varies. Holmes [10], for example, focus on elementary and middle schools, while Sacerdote [20] studies all grade levels in Louisiana. Notably, students at different levels will perform and be impacted differently by hurricane strikes. Also, the focus on a special group of students such as only those who were displaced by tropical storms is another possible reason. For example, Pane et al. [17] finds that displaced students were from low performing schools and evacuation resulted in them being enrolled in schools that were high performing. This seemingly would likely result in displaced students

inherently obtaining lower scores, thus resulting in biased estimated effects. Further, the sample of locations covered in the disaster-education literature is generally from developed countries. Thus, there is a general lack of focus on developing countries which not only are vulnerable to tropical storms but are less resilient to the impacts and are certainly not able to quickly recover their educational systems as developed countries due to limited resources. A noteworthy reason that can possibly explain the quantitative variation in estimated results presented in the literature is how hurricane impact is captured. Studies capturing a tropical storm occurrence through other variables such as hurricane evacuee status [20], school characteristics such as school days lost [10] and displacement status [17] are not examining actual hurricane destruction but just merely, hurricane incidences [10]. The growing disaster literature is now making use of hurricane destruction indexes, which are more comprehensive forms of measuring destruction, taking account of wind speeds, characteristics of specific localities and wind energy (see for instance, [1,11,15,24].

This study fills the gap in the literature by using Jamaica, a developing country in the Caribbean to analyze the impact of hurricanes on secondary school academic achievement. Jamaica is a relevant case study to examine because it is frequently hit by tropical storms; between 1994 and 2010, there were approximately 16 damaging tropical storms that affected Jamaica. In particular, schools are often affected; for example, in 2004, hurricane Ivan impacted 40% of public schools with some sustaining severe damages [13]. In addition, at least 204,000 children were affected by hurricane Ivan with approximately US$12 million in damages to school infrastructure [7]. Moreover, Jamaica is found to be one of the most vulnerable countries in the Caribbean region [14]. The study makes use of hurricane destruction indexes according to Strobl [24]. The indexes are constructed using the exact locations of schools in Jamaica. Thus, one is able to capture destruction at specific school localities thereby providing a more accurate measure of hurricane impact. Holmes [10] use region dummies to capture whether a school was impacted by the storm. This study, in contrast takes it a step further by using the latitudinal and longitudinal locations and to calculate the destruction level brought about by the storm. This approach circumvents having to determine using secondary information on whether or not a school was affected by a storm. Further, this study uses many (16) tropical storms and many years (1994–2010) in contrast to previous studies using one to two hurricanes over a limited number of years. Making use of standardized test scores across all secondary schools in Jamaica avoids the selection of only schools which may have only been affected by the storms, which provides a nice control group for the analysis.

This paper finds a number of interesting results. First, hurricanes impact test scores negatively and produces a more damaging effect for larger tropical storms. Specifically, the average hurricane reduces test score performance by 0.14 standard deviations and for the maximum hurricane by 0.54 standard deviations. This study also exploits gender differences in test score performance due to tropical storm strikes. The estimates reveal that females' perform 0.02 standard deviations less than males. Further, results show that schools located in the southern and eastern parishes of Jamaica experience greater impacts on performance. Lastly, the estimates generated are used to calculate out the impact of reduction in test scores on returns to schooling. The average tropical storm impact reduces public returns to schooling by approximately US$9 million and US$35 million for the maximum hurricane. The impact on private returns to schooling is far greater.

The rest of the paper is organized as follows. The next two sections presents the data used and the methodology. The results are then discussed and the final section concludes with implications.

2. Data and summary statistics

2.1. Standardized test scores, gender and age

The Caribbean Examination Council is the source of the standardized test scores data for Jamaica, 1994–2010. This is a Caribbean institution that oversees the sitting of standardized examinations taken by students mainly at the secondary school level across the region. These test scores are an aggregation of scores for subjects taken and are disaggregated by gender and schools, which are located within 14 parishes across Jamaica. Students can obtain a score from one to six with one being the best, and six being the worst. For a more meaningful interpretation, the scores are normalized so that six is the best and one is the worst.

2.2. Hurricane destruction indexes

Using Strobl's [24] base indexes, relative to the storm's position and characteristics including maximum sustained wind speed, wind gust, distance and radius forward speed, hurricane wind damage indexes are calculated based on the latitudinal and longitudinal location of each school. Taking into account the location of schools and the features of the storm are important in accurately determining the level of destructiveness brought about by the 16 tropical storms (see Table 1) that struck Jamaica during this time period of study. The school-level hurricane indexes are constructed in the following way:

$$H_{s,p,h,t} = \sum_{0}^{\tau} V_{s,p,h,t}^3 \text{ s represents school; } h, \text{ storm; and } t, \text{ year.}$$

(1)

Eq. (1) basically calculates total destruction for each school, s, within parish, p, summed over all storms, h, within a single year *t*. Thus, the index is at the school-parish-year level. Table 2 provides more details of the construction of these indexes.

2.3. Summary statistics

Table 3 shows the descriptive statistics for all variables. The mean test score is 3.19, with the average age of students taking the standardized being approximately 20 years. The value for the average hurricane used in the calculation of the impact of test scores is 7.7E + 08. Figs. 1 and 2 shows the distribution of test scores by male and female scores. Fig. 3 shows a map of Jamaica, which features the different parishes in the island.

Table 1
Storms that affected Jamaica, 1994–2010.

Storm	Year
Gordon	1994
Mitch	1998
Lenny	1999
Iris	2001
Isidore	2002
Lili	2002
Charley	2004
Ivan	2004
Dennis	2005
Emily	2005
Wilma	2005
Dean	2007
Gustav	2008
Ike	2008
Paloma	2008
Tomas	2010