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How Do Hurricanes Impact Achievement in School? A Caribbean Perspective

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ABSTRACT

How Do Hurricanes Impact Achievement in School? A Caribbean Perspective*

This study examines whether hurricanes have any impact on performance in standardized examinations. The analysis uses a panel of thirteen Caribbean countries and over 800 schools for the period 1993 through 2010. In particular, the effect on subjects in the humanities and sciences are examined. A generalized difference-in-difference technique is utilized to study the relationship at the school, parish, year and country level. The results show a negative and significant effect on performance in the sciences if hurricanes strike when school is in session and a positive or no effect when school is not in session. In addition, subjects in the humanities remain unaffected.

JEL Classification: I2, Q54

Keywords: human capital, rate of return, hurricanes

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1. Introduction

Classroom attendance is identified as a leading factor in student learning. The importance of being in school has been advocated by many who share the view that students' success depends on daily attendance and them being present at school strongly affects standardized test scores (Balfanz and Byrnes, 2012). Educational research highlights the impact of school attendance on academic achievement as being positive (including Caldas, 1993; Lamdin, 1996; Johnston, 2000, Roby, 2003; Dobkin, Gil and Marion, 2010). Thus, being in the classroom is likely to result in better academic performance. In general, researchers in this area explicitly use data on attendance and test scores to establish a relationship between the two. Such studies face the problem of attendance being endogenously determined with student performance. Those who deal with this endogeneity issue, use proxies of student motivation such as reported hours of studying (Park and Kerr, 1990), teaching evaluations (Sheets et al., 1995), reported levels of motivation (Devadoss and Foltz, 1996) and prior information on student achievement (Caviglia-Harris, 2006). Students who are motivated are more likely to have higher attendance rates (Stanca, 2006). From the foregoing, it is clear that the literature is trying to solve the endogeneity of attendance. This study adds to the current literature by addressing this problem of endogeneity in a different way. It does so by using hurricane as an exogenous event to identify the difference in classroom attendance. Further, this approach to identifying the impact of classroom time on student performance is generalized by using many hurricanes. Why can one take this approach?

The literature on natural disasters has shown that such random events can negatively impact the educational system. Research has pointed to the occurrence of natural disasters as causing students to be absent from the classroom (Jacoby & Skoufias, 1997; Pane et al., 2006; Baez and Santos, 2007; Baez et al., 2010; Santos, 2007). Following the passage of a storm, roads become impassable, transportation is limited, schools' infrastructure is damaged and schools remain closed until administration declares that it is safe to accommodate students. Moreover, some have shown that cancelled instruction days disrupt teachers' productivity in the classroom and worsen the learning environment (Holmes, 2002; Baez et al., 2010). Against this background, attention has been directed towards studying the effect of natural disasters on student achievement (including Holmes, 2002; Baggerly and Ferretti, 2008; Pane et al., 2008 and Sacerdote, 2012). Some researchers have found an effect on students' performance while others have found no significant effects on students' scores. Since it has been established that classroom attendance is important for success then it should be clear that if hurricanes prevent students from attending school then there can be implications for students' performance. Understanding these implications is important for effectively designing policies to mitigate the impact of hurricanes on human capital accumulation in developing countries. To address the endogeneity of attendance, this study uses hurricane data to understand the impact on test scores from standardized examinations[1] in an attempt to establish a relationship between classroom time and academic performance for Caribbean secondary schools. Eight subject areas from the humanities and the sciences are considered: English, Geography, Spanish, French Mathematics, Chemistry, Physics and Biology. In contrast to the other studies, a technique aimed at determining the causal relationship between hurricanes and test scores is implemented. This approach is a generalized difference-in-difference method since it is important to control for the unobservable factors that might exist in the different levels of the data: year, country, schools and parish.

[1] These test scores are from Caribbean secondary schools and the standardized examinations are administered by the Caribbean Examination Council®

The results indicate that the effect that hurricanes have on performance in Biology, Chemistry and Physics when school is not in session are negative and statistically significant. This is not surprising since hurricanes occurring during the academic year increases the possibility that schools days are lost and hence the number of days of classroom instruction is reduced. Moreover, the results show that as long as hurricanes occur outside of the academic year test scores are not adversely affected since school attendance is not impacted. The estimated results also suggest that unlike the sciences, performance in the French, Geography and Spanish are not affected by hurricanes occurring outside of the academic or within the academic year. Furthermore, statistical tests reveal that there is variation in the way hurricanes impact performance in the mandatory subjects – Mathematics and English across countries.

The rest of the paper is organized as follows. The next section presents background information on Caribbean Secondary School Examinations as well as evidence of the impact of hurricanes in the Caribbean. It also discusses studies that focus on the impact of natural disasters on attendance and test scores. In addition, it emphasizes the importance of attendance and academic performance. Section 3 presents a review of the literature. Section 4 describes the data on test scores and hurricanes. Section 5 presents the methodology. Section 6 discusses the results and implications. Section 7 looks at the robustness checks used. Section 8 details the impact of hurricanes on the returns to schooling and Section 9 concludes.

2. Background

2.1 Caribbean Secondary Education

The Caribbean Examination Council® (CXC®) established in 1973 with headquarters in Barbados administers the Caribbean Secondary Education Certificate (CSEC) examinations. These examinations are standardized and are used to evaluate students across the Caribbean as they exit secondary schools. Students obtaining a CSEC on the basis of satisfactory performance in the examinations are generally accepted in four year universities programmes. They also have the opportunity to enter into other tertiary institutions such as community and teachers' colleges in the Caribbean. The CXC® oversees approximately thirty three (33) subject areas (Table 1, appendix) of which only eight (8) are covered in this study due to data constraints. For the period 1993 to 2010, students sitting these examinations come from nineteen (13) Caribbean territories. (See Table 2, appendix) Except for Saba whose official language is Dutch, the other territories speak English as their main language. Along with English, countries such as Anguilla, British Virgin Islands, Grenada and St. Maarten speak either French, Dutch, Spanish or a combination thereof.

2.2 Hurricanes in the Caribbean

The impact of hurricanes in the Caribbean varies by region. There is also variation in the impact at different geographical locations within each region. Between 1993 and 2010, Caribbean countries experience damages from at least seventeen (17) hurricanes. These storms result in extensive damage to buildings including schools due to heavy rainfall, strong winds and extensive flooding. Such damages result in loss in millions of dollars for the region. There is little doubt that these impacts can filter through to the school system. Hurricane Mitch, the most destructive in 1998, for example, caused roads to be flooded and left many people homeless in Jamaica. Hurricane Lenny, 1999 also resulted in flooding in St. Maarten, St. Kitts while Antigua & Barbuda dealt with contaminated water. These conditions would make it difficult for students to either attend school or for schools to be opened. Similar impacts are carried through to the twenty first century. For example, in 2002, Hurricane Lili, the deadliest for the season destroyed homes in St. Lucia and Barbados; and schools in St. Vincent and Grenadines. Loss of electricity and flood damage were also experienced by the impacted islands. A memorable hurricane for most people was Hurricane Ivan in 2004 that wrecked countries such as Grenada, Jamaica and the Cayman Islands. After the passage of Ivan, Hillsborough Secondary School in Grenada experienced damage; and 1,000 public schools in Jamaica sustained severe damages[2] and over 204,000 children were affected (ECLAC, 2004b). Temporary locations had to be sourced for classes to be held until schools were rebuilt and refurnished.[3] Evidence indicates that school attendance was affected. In the Cayman Islands, for example, it was reported that 25 – 40 days were lost (ECLAC, 2004a; ECLAC, 2009a). The number of days is in line with what Pane et al. (2006) mention in his study of Hurricane Katrina. In fact, a significant amount of students were missing from schools even after the schools reopened. (ECLAC, 2004b) Grenada reported delays in reconstruction resulting in 12% of schools not being able to open its door to students. With temporary arrangements, majority of the islands' schools were able to reopen within two to three months. (World Bank, 2005) For Grenada, 93 schools were affected in 2004 which displaced

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[2] For more information go to: http://www.jis.gov.jm/news/archive/3888-education-hurricane-ivan-damaged-1-public-schools

[3] For more information go to: http://www.unitedcaribbean.com/carriacouhillsboroughsecondary.html

over 30,000 students; while 2005 saw 21 schools and 6,854 students being affected from Hurricane Emily. (ECLAC, 2009b) Hurricane Keith in 2000, damaged 51 schools in Belize preventing over 2,000 students from attending school at least two and half weeks. (ECLAC, 2000) Countries in the Netherland Antilles also faced challenges in their schools. For example, in Saint Maarten, furniture and educational materials were destroyed by Hurricanes Luis and Marilyn in September 2005 putting students out of school until mid-October. (ECLAC, 2005) Other storms such as Hurricanes Wilma, 2005 and Dean, 2007 had minor effects and did not significantly affect the school system since they occurred during the summer vacation period. The preceding discussion is just a preview into the impact that hurricanes can have schools. As was mentioned, these storms do play a role in reducing number of days students attend classes. Some stay home from school because of impassable roads, loss of electricity, destruction of school properties and personal belongings. Table 4 features some hurricanes and their impacts on the education sector in countries for which detailed data is available. Looking at these different effects of hurricanes, a question that may arise is whether the effect that one is trying to estimate in this paper is attributable to just the loss of instruction days or can also be due to hardships experienced by those affected. Well, there is no indication that students stopped from school due to hardships but if we take into account this possibility, the results are an overestimate of the effects of loss of instruction days. However, each school in every country has a guidance counseling department that caters to the needs of students experience hardships. This may be a reason why there is no information to suggest that a lack of attendance is due to hardships.

3. Literature Review

Jacoby & Skoufias (1997) research on rural India reveal that with unanticipated negative shocks to income, agrarian households are more likely to take their children out of school. The primary reason behind the change in school attendance is that these poor families use child labor as a form of insurance when shocks to income are unexpected. The data capture ten different villages in India with varying climate. They compare the differences in the percentage of children negatively affected by rainfall and who are enrolled schools in the regions of Cote d'Ivoire to differences in enrollment for regions with normal rainfall. The results indicate that school enrollment for both boys and girls decline by twenty percentage points in the affected regions but they find noticeable increases for the unaffected areas. (Jenson, 2000) In the case of Hurricane Katrina, Pane et al. (2006) point out that the median student evacuee stays out of school for five weeks and while some returned to their original schools, others relocated to other schools in Louisiana. Raeburn (2013) also identifies a reduction in school attendance due to hurricane Ivan that hit Jamaica in September 2004. Using a difference in difference analysis, she finds that the probability of high school students attending is not affected while the number of school days attended decreases for rural and metropolitan schools.

Ureta (2005) finds that extreme rainfall from Hurricane Mitch reduced school retention and progression rates in Nicaragua. In their difference-in-difference analysis, Baez and Santos (2007) observe that Hurricane Mitch resulted in a 58% increase in labour force participation for children in the affected areas. The authors find that because of the hurricane, children attending school and working at the same time increased from 7.5% to 15.6%. This point is supported by Baez et al. (2010) in their attempt to assess the impact of natural disasters on health, education, nutrition and the human capital. The authors mention that if disasters made people worse off economically then children may be taken out of school and sent to work to reduce economic burden and increase income.

3.3 Natural Disasters and Academic Achievement

Recently, increasing attention has been given to effects of natural disasters on student performance on examinations. Research in this area highlights disruptions in school operations following natural disasters as well as enrollment and academic challenges faced by students (including Cook, 2006; Provenzo and Fradd, 1995). Holmes (2002) explore the effects of Hurricane Floyd in 1999 and a snow storm in January 2000 on standardized test scores from elementary and middle schools in North Carolina. He uses a difference-in-difference estimation on school and student level data. The results indicate that growth in performance was inhibited due to the occurrence of the storms in 1999-2000. Using test scores from Louisiana public schools, 2004-2007, Sacerdote (2012) look at the effects on long term academic performance for students who were affected by Hurricanes Katrina and Rita. The difference-in-difference results show that in the first year after the hurricanes, the test scores for displaced students drastically declined. The results also indicate an improvement in performance in the years following the storms. Using a similar approach, Pane et al. (2008) finds the same results as Sacerdote (2012) with the same sample of schools. In a survey involving students exposed to Hurricane Hugo, Shannon et al. (1994) also reports poor performance. On the contrary, Baggerly and Ferretti (2008) use a multivariate analysis of covariance (MANCOVA) to compare the test scores between 2004 and 2005 for students from schools affected by the hurricanes of 2004 as well as those not affected as much. The findings show no impact on the Florida Comprehensive

Assessment Test Scores for Math and Reading. Overall, these studies examine one or two hurricanes rather than a set of hurricanes and as a result their treatment (affected) groups may not be truly representative. Furthermore, it is questionable whether one can generalize the results using a limited number of hurricanes and treatment groups. (Belasen and Polachek, 2008) The more generalized approach that is used in this study is better in the sense it considers many hurricanes and many treatment groups.

From the foregoing, it is clear that the general direction of the literature is that poor attendance results in low academic achievement. In addition, natural disasters including hurricanes do affect school attendance and can subsequently impact students' performances on tests.

4. Data

The Caribbean Examination Council provided data on test scores for the eight subject areas (Table 1, appendix) highlighted in the introduction. Students sitting CXC® exams receive a score from grades 1 to 6 where 1-3 are passes and 4-6 are failing grades. The test scores represent students in thirteen (13) different Caribbean countries (Table 2, appendix) for eighteen years (18) – 1993-2010. These scores have been aggregated by CXC® to represent the average scores within each school/examination centre instead of using the individual level data. The difficulty with using individual level data is that control variables at the individual level are difficult to obtain. In total, there are approximately 869 in 75 parishes across 13 countries[4]. Thus, the data has four main dimensions: country, year, school and parish. Any variation at these levels is controlled for with the respective fixed effects. Other controls include: age at the time examination is taken and gender. Table 3 showing the descriptive statistics of these variables can be found in the Appendix. Hurricane wind indices are also used. The North Atlantic Hurricane database and the National Hurricane Center provide the necessary data to create these indices. The hurricane indices represent a more comprehensive way of estimating hurricane destruction. They take into account the wind speeds and the distance between the eye of the hurricane and each parish. Additionally, these indices are cubed on physical grounds of energy dissipation of the hurricanes. A more detailed description of the hurricane indices is provided in the appendix, Table 5.

[4] The maps for these countries are shown in the appendix, Figures 3.1-3.7.

5. Model Specification

As was mentioned in the introduction, a generalized difference-in-difference (GDD) identification strategy is used. Similar techniques are being increasingly used in the literature to estimate the impact of exogenous events including hurricanes (Belasen and Polachek, 2008; McIntosh, 2008; Groen and Polvika, 2008). For our dependent variable, the technique here considers changes in standardized test scores when a hurricane strikes and changes in the same scores when there is no hurricane for a set of affected schools or the experimental/treatment groups. These changes are then compared to changes for a set of unaffected schools or control groups. In contrast to studies in the literature that look at the impact of a single natural disaster on academic achievement, a more generalized approach is used here. More specifically, many hurricanes are used so that the treatment groups are more representative. Thus, the results can be generalized. More interestingly, one is able to compare the impact on performance if hurricanes strike during the school year to performance if hurricanes occur outside of the school year.

The estimation process starts out with a general specification which allows the slopes of the hurricane variables for all countries to vary. This means that no assumption is made about the impact of hurricanes being the same across countries. Majority of Caribbean countries are inherently vulnerable to hurricanes because of their physical size – that of being small islands. Although being small, they each have different sizes and other physical features. For example, Jamaica is mountainous in nature with land area amounting to four thousand two hundred and forty four square miles; it is twenty five and a half times the size of Barbados - a low-lying island with gentle slopes. The smallest island in this education dataset is Saba which has a land area of five square miles and a lot of woodland forest. Thus, it is reasonable for one not to assume that the impact might be the same across countries. The general specification (**Model 1**) is as follows for each subject:

$$AvgScore_{sit} - AvgScore_{sit-1} = \gamma_1 + \gamma_2 c_d * (H^I_{sit} H^{insch}_{sit}) + \gamma_3 c_d * (H^I_{sit} H^{outsch}_{sit}) + \gamma_4 c_d * (AvgAge_{sit} - AvgAge_{sit-1}) + \gamma_5 c_d * Female_{sit} + parish_i + year_t + \mu_{sit-1}$$

Eqn. (1)

The fixed effects are parish (*parish*) and year (*year*); and c_d represents a value for each country. The dependent variable $(AvgScore_{sit} - AvgScore_{sit-1})$ is the change in the average score between period t and $t-1$ for school s located within parish i and for a specific year t. H^I_{sit} represents the hurricane index[5]; this is interacted with two hurricane dummies. H^{insch}_{csit} is the dummy capturing a hurricane strike within the school year and receives a one (1) if a storm occurred within the academic year, zero otherwise. On the other hand, H^{outsch}_{csit} takes a value of one (1) if a hurricane strike outside of the school year, zero otherwise. Students are in school September to June leaving July and August as outside of the school year. Basically, if a hurricane strikes within the academic year, it is possible that students' performance can be affected since the standardized examinations are taken within the academic year. With this is mind, the expectation is that γ_2 should be negative indicative of a worsening of test scores while γ_3 is expected to indicate no effect from the occurrence of the hurricane.

[5] For an explanation of this index see Table 5 in the appendix.

As was mentioned in Section 3 on data description, students sitting the CXC® exams receive a score from grades 1 to 6 where 1-3 are passes and 4-6 are failing grades. Thus, if a score lowers then this indicates and improvement in performance and a worsening if the score get higher. For ease of interpretation, these scores were normalized so that a lower score means a decline in performance while a higher score indicates better performance.

$AvgAge_{sit}$ is the average age of candidates at the time of sitting an exam and the dummy variable $Female_{sit}$ takes a value of one (1) if the proportion of candidates is female while zero is assigned for males.

The second step in the estimation process involves testing whether flexibility in equation 5 is warranted. Since eight subjects are used (see Table 1), a regression for each subject is done. For each of the eight regressions, an F- test is implemented to determine if the slopes should be equal across countries for all the specified explanatory variables. Thus, the null hypothesis tested if the slopes are equal across countries while the alternative was that all slopes are not equal across countries. The slopes of the hurricane variables across countries were tested together. The null hypotheses are as follows. The second subscript represents each country in alphabetical order.

Hurricane: $\gamma_{21} = .. = \gamma_{213} = \gamma_{31} = ...\gamma_{313} = 0$

Age: $\gamma_{41} = .. = \gamma_{413} = 0$

Female: $\gamma_{51} = .. = \gamma_{513} = 0$

The tests reveal that the slopes γ_2 and γ_3 for the compulsory subjects English and Mathematics should vary across countries. This suggests that hurricanes do not impact performance in these subjects in the same way from country to country. In this case, model 1 is applied. For the other subjects, the tests indicate that these slopes should not vary across countries. The slopes for age and gender vary across countries for all subjects.

In the case where γ_2 and γ_3 do not vary, **Model 2** as follows is implemented:

$$AvgScore_{sit} - AvgScore_{sit-1} = \gamma_1 + \gamma_2 (H^{I}_{sit} H^{insch}_{sit}) + \gamma_3 (H^{I}_{sit} H^{outsch}_{sit}) + \gamma_4 c_d * (AvgAge_{sit} - AvgAge_{sit-1}) + \gamma_5 c_d * Female_{sit} + parish_i + year_t + \mu_{sit-1}$$

Eqn. (2)

6. Discussion of Results

6.1 Compulsory Subjects

The results for Mathematics and English are reported in Tables 6 and 7[6] in the Appendix. The first two columns list the estimated hurricanes coefficients for each country while the last two columns show the results for age and gender. As was documented in the previous section, it appears as though hurricanes do not impact the performance in these subjects in the same way across the Caribbean and so the tables show the estimates across countries for the explanatory variables described in the previous section. In this case, one is implementing the general specification in equation 5. Mathematics and English are subjects that students are automatically enrolled in at Caribbean secondary schools and are regarded as compulsory. Recall that the expectation for hurricanes occurring when school is in session is that scores will be worsened because school days are lost. In contrast, when hurricanes strike when school is not in session, no school days are lost and so the expectation is that there will be no impact on test scores. In looking at Table 5, for Mathematics, if hurricanes strike when school is in session, as expected test scores are worsened significantly but affects only seven countries. What immediately becomes obvious is that majority of these countries are the relatively smaller islands, such as, Saba which is of area 5 square miles; Anguilla, 35 square miles; Montserrat, 39 square miles; and British Virgin Islands, 59 square miles. In Saba, for example, hurricanes reduce mathematics scores by 0.009 points or by approximately 0.01 standard deviations; in Montserrat, a decline by almost 0.05 points or 0.06 standard deviations and in British Virgin Islands a fall by 0.02 points

[6] For all tables displaying the estimated results, only 13 countries are shown. The other countries did not experience any hurricanes during the 1993 to 2010 period.

or 0.03 standard deviations. The results show that when school is not in session there is either a positive or no impact on test scores in most countries as expected. On the other hand, a significant reduction in scores is seen for Antigua, Montserrat and St Maarten by 0.03, 1.72 and 0.2 standard deviations respectively. The latter countries are two of the relatively smaller territories and it is possible that there is slow recovery for the education system even though the hurricanes strike outside of the academic year. Overall, only Anguilla, British Virgin Islands and St. Lucia satisfied both expectations – that is – reduction in scores during the academic year and a positive or no impact outside of the academic year. Compared to Mathematics, there is less effect on English scores. Moving our attention to Table 7, we observe a decline in scores by 0.03 standard deviations for Barbados and Saba. In brief, these estimated results suggest that performance in these subjects is more resilient to the effects of hurricanes for the majority of countries. Although all the countries speak English, a good way to learn how to write, understand and communicate this language is to read and this activity can take place outside of the classroom. Conversely, Mathematics requires more guided teaching but also relies on practicing problems to be able to do well. Thus, the most of the time required for learning for these subjects can take place outside of the classroom.

Finally, for the control variables - the average school age is statistically significant for most countries indicating an increase of scores by as little as 0.02 and up to 0.07 standard deviations with an increase in age. This does not mean that the older a student is, the higher his or her score should be. It worth mentioning that the average age of sample is 19 years with the lowest candidate being around 14 years at the time of sitting the exams. This seems to imply that typical high school student, around age 19, may have more experience with working problems and taking more classes in preparation for the exam hence a increase in score is expected. In general, females tend to do better in Mathematics than males while males appear to do better than females in English. This outcome in gender performance can be attributed to the number of males and females taking these exams. This data was not available by country but from the annual reports published by the Caribbean Examination Council, a relatively large number of females sit these two exams. Take the case of 2010 - candidates taking the exams comprise of approximately 60% females and 40% males. According to the CXC 2010 annual report, for both subjects the number of females performing below standard was higher than the number of males. However, for mathematics, 60% of the top performers were females.

For the compulsory subjects, we observe that hurricanes have an effect of less than one point on the exams which appears to be a small impact. However, if we take into account that each student taking these exams in the various island territories loses the estimated number of points, then the aggregated loss is considerable not only to individual schools but to the education sector in the different countries.

6.2 Sciences

The estimated results for Biology, Chemistry and Physics are presented in Tables 8, 9 and 10 respectively. The first row in each table shows the estimated hurricane coefficients. The subsequent rows display the gender and age coefficients for each country. As the F-test indicated, the hurricane effects do not vary across countries for Biology, Chemistry and Physics. The estimated results met our expectation – that is, hurricanes do lower the test scores during the academic year and appear to have no effect outside of the academic year. In the case of biology and chemistry, scores are reduced by approximately 0.01 points or by 0.013 standard deviations while physics scores decrease by 0.014 points or by 0.02 standard deviations when classes are in session. A candidate's age seem to have a greater impact on improving performance in Biology when compared to the Chemistry and Physics. Scores for those taking biology increase by 0.04 points or 0.05 standard deviations in Anguilla and by 0.57 points or 0.7 standard deviations in Montserrat. As it relates to performance by gender, males appear to be better at physics than females while the opposite is true for Biology and Chemistry. This conclusion is supported by the CXC annual reports. For example, females outperform males in the 2010 biology and chemistry examinations while the males did better in physics (CXC, 2010). In summary, hurricanes seem to have a negative and significant impact on performance in the sciences. These subjects require much more than studying at home – students have to complete laboratory assignments where they make practical application of material that they are taught and therefore constitute an integral part of learning. When hurricanes disrupt classroom instruction and cause destruction that prevent students from attending school, performance in these subjects are negatively impacted. For this reason, it can be said that being in the classroom is important to learning.

For the science subjects, once again the impact appears to be small since the estimated reduction in test score is less than a point. Considering that each student across the Caribbean loses on average 0.01 points, these totals to a considerable amount for overall school losses and for the education sectors.

6.3 Humanities

Hurricane estimates on Geography, French and Spanish show no significant impact on these subjects. The results (Tables 11, 12 and 13) are not surprising since these are less technical subjects when compared to the sciences. For geography, age does not seem to be an important factor in influencing grade for majority of countries since these estimates are statistically insignificant. Nevertheless, there is a significant effect for Anguilla, British Virgin Islands, Dominica, Grenada, Saba and St. Maarten as grades increase by 0.06 standard deviations in Saba and by 0.2 standard deviations in St. Maarten. There is a similar effect for French and Spanish but age appears to be less important in determining performance in these subjects across countries. For performance by gender, except in the case of Anguilla, females outperform males in geography while surprisingly the opposite is true for French and Spanish for most countries. As was mentioned earlier, all countries speak English. However, a few speak additional languages such as Dutch, French and Spanish. For example, for Anguilla, the estimated results show that performance in French increase by 0.59 points or by almost 0.7 standard deviations for an increase in age. This increase is quite high compared to Antigua, Barbados and Montserrat where only English is spoken. Although French is not Anguilla's official language that observed increase might be driven by the fact that Anguillan students are exposed to French which is also spoke by some in the country. To conclude the discussion on the humanities, since hurricanes did not impact the performance, one can conclude that being away from the classroom[7] is not detrimental to learning in these subjects.

[7] World Bank (2005) mentions that schools reopen within three months; thus being away from the classroom up to three might not negatively impact learning in these subjects.

7. Robustness Checks

One useful task to test the validity of the regression estimates is to modify the hurricane variables and observe the behavior of the coefficients. If they behave in such a way to support the conclusions drawn above then the original estimated coefficients are said to be plausible. The adjusted hurricane variable is one that captures wind speed at or above 178 km/hr. On the Saffir Simpson Scale, hurricanes carrying wind speeds at this level are considered to be major hurricanes and can cause catastrophic damage for a number of weeks up to months. Thus, this variable serves as a measure of hurricane intensity.

Table 14 compares the hurricane results from Model 2 and the subsidiary (robustness check) regressions for Biology, Chemistry, Physics, Geography, Spanish and French from the adjusted model that uses hurricane variable with wind speed at or above 178 km/hr. However, by using this index which is representative of more destruction, one is assuming that winds below 178 km/hr are not important. As can be seen from Table 14, the results from using the new hurricane variable support the original conclusions. If the estimates are rounded off, the results are exactly the same. This implies that the results from the original model are being driven by the impact of the more destructive hurricanes.

A more solid robustness check is to attempt to disprove the estimated results. In essence, one can use a falsification test to accomplish this by using a lead in the test score variable. This will enable one to look at the pattern in the test scores in the period before the hurricane occurrence. If the estimates from this falsification test turn out to be different from the original estimates or even insignificant then this would imply the results from the original model are not random and that sufficient time varying factors are controlled for. Table 15 presents the results from this test for Biology, Chemistry, Physics, Geography, Spanish and French. As the table shows, all the estimates are now different and statistically insignificant except for the out of school hurricane effect for French. However, this estimate was insignificant in the original model.

8. Impact on Returns to Schooling

A primary reason why people invest in education is to improve their jobs and earning potential. It is known that investing in one's education especially at the secondary level involves attending school. With hurricanes reducing the number of days in school and hence academic performance, it is instructive to use the estimated results of this paper to ascertain the impact on returns to schooling. Psacharopoulos and Patrinos (2002) present estimates of social and private returns to education for secondary school level in Latin America and the Caribbean. The social return is 12.9% while the private return in 17%. To derive an estimate of the impact on the returns to schools, these rates of return, the average salaries of three[8] Caribbean countries along with the corresponding school populations are used.

The estimated impacts are presented in Tables 16, 17 and 18. The econometric results on the sciences are used since academic performances in Biology, Chemistry and Physics are not resilient to hurricane strikes. Recall from section 6 that hurricanes reduce scores in biology and chemistry by 0.01 standard deviations and by 0.02 standard deviations in physics. Taking the average score for biology which is 3.8, a 0.3% (0.01/3.8) reduction in test scores is calculated. The same reduction applies to chemistry. This decrease in scores implies that there is 0.3% less schooling. Similarly for physics, we calculate 0.5% less schooling. Using the average salaries and the rates of return to schooling, the value of each year of schooling is then calculated. This allows a derivation of the impact on this value for each student as a result of the hurricane. Finally, one is able to compute the aggregate private and public losses. As Table 16 shows, Jamaica's loss amounts to at most US$4 million if we consider the impact on physics. In the

[8] The unavailability of data restricts the analysis to a few countries.

eastern Caribbean, Table 17 shows the loss to St. Kitts & Nevis to be approximately US$60,000 while for St. Lucia (Table 18), the loss equals almost US$174,000.

9. Conclusion and Policy Implications

Natural disasters seem to be a regular item on the news. Hurricane is one such disaster and has devastated countries that lie in their path. Their frequencies and destructiveness appear to be on the increase. There is little wonder why educational researchers have been quantifying the impacts that hurricanes have the education system and its stakeholders. One avenue of research looks at the relationship school attendance and academic performance. Studies looking at this relationship have explicitly used data on attendance. However, such data is not readily available across Caribbean countries. In the absence of data on school attendance, in this study the impact that hurricanes have on test scores from standardized examinations that are administered in Caribbean secondary schools is examined in order to address whether being the in classroom is important to learning. The issue of learning can be addressed in this way because it has been documented that hurricanes affect school attendance. In fact, they reduce the number of days students attend school up to five weeks as was discussed in Section 2. Basically, if hurricanes occur during the academic year then schools days are lost and if they strike outside of the academic year then no school days are lost. With strong evidence that lack of attendance adversely affects academic performance, one can easily appreciate that if hurricanes reduce the number days students attend school then performance can be impacted.

Using a generalized difference-in-difference technique the estimated results imply that being in the classroom does not always affect learning. For the more technical and lab-oriented subjects – Biology, Chemistry and Physics, the results show a negative and statistically significant relationship between hurricanes and test scores when the storms occur during the academic year. On the contrary, if the storms strike when school is not in session then test scores are not adversely affected. In effect, for the sciences one can conclude that being in the classroom is important to learning and hence performance of examinations. For subjects in the humanities – French, Spanish and Geography, the results indicate that hurricanes do not impact performance on these standardized examinations. This does not imply that students can pass these exams without attending school but what the results suggest is that students can perform satisfactorily in these subjects with a reduction in school days. Finally, hurricanes apparently do not impact the two compulsory subjects - Mathematics and English in the same way from country to country. In general, hurricanes seem to have a greater impact on scores in Mathematics than for those in English. For Mathematics, most of the smaller Caribbean territories experience a negative and significant reduction in scores but this is true for English scores in only two countries. Thus, if one categorize English under humanities and Mathematics as being a part of the sciences, one conclusion can be drawn. Hurricanes adversely affect performance in the sciences if they strike when school is in session but there is hardly an impact if any at all on performance in the humanities subjects. Therefore, if one is enrolled in a science subject then being in the classroom is important to learning but enrollment in a humanities subject imply there will be no significant effect on performance if school days are missed. These results have important implications and can better equip educators and policy makers with the insight needed to design and implement policies to alleviate the impact on performance. Recall that when hurricanes destroy school infrastructure, temporary locations are often set up to instruct students. Since the more technical subjects are negatively affected, educators and heads of the education sector can prioritize when it comes to setting up locations for these classes. Moreover, this calls for more innovative ways for students to carry out their lab work assignments. It might be interesting for these science labs to take place outside by observing the disruptions in the natural environment due to the passage of a hurricane rather than doing experiments inside a lab. For example, biology students can conduct field research on plants and microorganisms that might appear because of the winds and rainfall moving them from their original habitat. In conclusion, one can prevent the occurrence of hurricanes or their destructive power but mechanisms can be put in place to mitigate their negative impact on important examinations such as those that students have to take in order to from graduate high school.

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Appendix

Table 1 Caribbean Secondary School Subject Areas

Agricultural Science	**English Language**	Integrated Science	Principles of Business
Biology	English Literature	**Mathematics**	Religious Education
Building Technology	Food & Nutrition	Mechanical Engineering	**Spanish**
Caribbean History	**French**	Music	Social Studies
Chemistry	**Geography**	Office Procedures	Technical Drawing
Clothing & Textiles	Home Economics Management	Physical Education & Sports	Theatre Arts
Economics	Human & Social Biology	**Physics**	Visual Arts
Electrical & Electronic Technology	Information Technology	Principles of Accounts	Typewriting

Table 2 Caribbean Territories

Anguilla	Jamaica	Tortola, British Virgin Islands
Antigua and Barbuda	Montserrat	Trinidad & Tobago
Barbados	Saba, Netherland Antilles	Turks & Caicos
Belize	Saint Kitts & Nevis	
Dominica	Saint Lucia	
Grand Cayman	Saint Maarten	
Grenada	Saint Vincent & Grenadines	
Guyana	Suriname	

Table 3 Descriptive Statistics

Variable	Observations	Mean	Std. Dev.
Subjects			
Biology	14253	3.8	0.8
Chemistry	13149	3.6	0.8
English	27101	3.6	0.8
French	4953	4.1	0.9
Geography	15208	3.8	0.8
Mathematics	27046	3.1	0.8
Physics	11518	3.8	0.9
Spanish	13601	3.9	1.1
Hurricane Index	28035	2.22e+08	4.85e+08

Table 4 Reported Impact of Hurricanes on the School System

Country	Hurricane	Statement of Effect on Schools	Source
Anguilla	Luis, September 1995	"Existing school infrastructure sustained damages…..roof structures, ceilings, window panels were destroyed. Furniture, books and other teaching materials were damaged." *Total damage to education sector: US$523,000*	ECLAC, 1995
Belize	Keith, September 2000	"Schools suffered damage to their roofs and structures. Some 51 schools were damaged both in rural and urban areas; over 2,000 children were unable to attend school for at least two and half weeks; some stayed out of school for up to four weeks in order to sanitize the facilities. Losses/Damages: libraries, computer labs, desks, chairs and educational materials" *Total damage of education sector: US$1519.15*	ECLAC, 2000
Cayman	Ivan, September 2004	"Students lost school supplies: books, uniforms and there newly refurbished schools destroyed; roads were cut in some sections; schools days lost amounted to between 25-40 days per student; an estimated 64% of the student population was affected; Damage to technology - 250 teachers were trained to use technology in teaching so this might prove to be a set back in using technology to teach;	ECLAC, 2004a

		private schools experienced a 47% drop in enrollment following Ivan; public schools saw a 40% drop in enrollment." *Total damage to education sector: US$54.6 million*	
Dominica	Dean, August 2007	"Hurricane occurred during summer vacation so impact was little. Damages: school roofs, windows, library, access road to school impassable." *Total damage to education sector: US$4.4 million*	ECLAC, 2007b
Grenada	Emily, July 2005	"A total of 21 schools and some 6,854 students affected by Emily; five schools were destroyed and over 1700 students could not attend school" *Total damage to education sector: US$4.9 million*	Organization of Eastern Caribbean States, 2005
Jamaica	Ivan, September 2004	"33% of schools damaged with 90% requiring repair; 204,000 students affected; damages included roofs, training sites, furniture." *Total damage to education sector:US$12 million*	ECLAC, 2004b
Jamaica	Emily and Dennis, July-August 2005	"Minimal impact since storms hit when students were on summer break. Damages: Leaking roofs"	Planning Institute of Jamaica, 2005a
Jamaica	Wilma, October 2005	"Minimal damage to educational facilities. Schools were closed for one week to	Planning Institute

		facilitate restorative activities and ensured it was safe for students & teachers to return to school."	of Jamaica, 2005b
Saint Maarten	Luis and Marilyn, September 2005	"Classrooms destroyed completely while some had minor damages; Furniture and educational materials destroyed; School was out for a number of weeks and started in mid October; School children and teachers ednured stress due to losing their homes and schools; counselling was provided for them." *Total damage to education sector:US$15.6 million*	ECLAC, 2005
Saint Lucia	Dean, August 2007	"Minor damages; little or no disruption in school system since storm hit during vacation period. Damages: roof and windows. One secondary school delayed in opening on time." *Total damage to education sector: US$851,851*	ECLAC, 2007a

Table 5: Description of Hurricane Index

The hurricane indexes are constructed in the following way: $H_{c,s,h,t} = \sum_{0}^{\tau} V^{3}_{c,s,h,t}$ c represents country; s, school; h, storm; and t, year. This calculates annual total destruction in locality s by aggregating all its values over year *t*.		
Hurricane indices are based on the Boose, Serrano and Foster (2004) wind field model which is a version of Holland's (1980) equation. $V = GF\left[V_m - S\left(1-\sin(T)\right)\frac{V_h}{2}\right]\left[\left(\frac{R_m}{R}\right)^{B} \exp\left(1-\left[\frac{R_m}{R}\right]^{B}\right)\right]^{\frac{1}{2}}$		
V_m: 'maximum sustained wind velocity at any point in the hurricane'	T:'clockwise angle that falls between the forward path of the hurricane and a radial line from the hurricane centre to the point of interest - *parish*'	V_h: 'forward speed of the hurricane'
R_m - 'radius of the maximum wind speed'. *The radius is the distance between the eye of the hurricane and the point at which the strongest winds occur. As the 'highest winds' increase, it is expected that the radius of these winds will lower.*	R: 'distance from the center of the hurricane to the *parishes*'	G: 'wind gust factor' *The wind gust is any unexpected increase in wind speed*
F: 'parameter taking account of any friction occurring at the surface' *When the waves of the sea and the hurricane winds interact, friction is created and the waves can actually cause the surface winds of the hurricane to decrease. Hurricanes can produce surface winds[9] that are destructive and so it is important to take the surface friction factor into consideration when constructing a hurricane index.*	B: 'parameter to account for the shape of the wind profile curve' *This is related to the hurricane wind asymmetry which results from the forward movement of the storm.*	S: 'parameter to take account of the asymmetry due to forward path of the storm' *A hurricane has four quadrants. There is a higher probability that the strongest hurricane winds are located at the right front quadrant or the right rear quadrant (Xie et al. 2011) while the left rear has less wind (Lyons, 2008). Thus, the distribution of wind tends to be uneven in the quadrants. This explains the asymmetry of winds.*

[9] Surface winds determine the category of a hurricane.

Table 6 Mathematics

Countries	Hurricane In Academic Yr (HIAY)	Hurricane Out Academic Yr (HOAY)	Age	Gender
Anguilla	-0.0178***	0.1088***	-0.0419**	0.3383***
	(0.0008)	(0.0178)	(0.0180)	(0.0189)
Antigua	0.0044	-0.0244***	0.0343***	0.1800***
	(0.0036)	(0.0067)	(0.0057)	(0.0312)
Barbados	-0.0103	0.0222*	0.0414**	0.0489
	(0.0115)	(0.0111)	(0.0181)	(0.0334)
British Virgin Islands	-0.0244**	0.0333	0.0429**	0.1659***
	(0.0133)	(0.1043)	(0.0193)	(0.0619)
Cayman Islands	-0.0333	0.0377***	0.0314**	0.0959
	(0.0200)	(0.0111)	(0.0139)	(0.0937)
Dominica	0.0089	0.1177	0.0151***	0.1385***
	(0.0311)	(0.0932)	(0.0042)	(0.0361)
Grenada	-0.0022	-0.0644	-0.0323*	0.2203***
	(0.0266)	(0.0799)	(0.0165)	(0.0583)
Jamaica	-0.0022	-0.0022	0.0016	0.1780***
	(0.0044)	(0.0044)	(0.0048)	(0.0180)
Montserrat	-0.0466***	-1.3786***	0.0249***	0.4975***
	(0.0044)	(0.0266)	(0.0009)	(0.0211)
Saba	-0.0097***		0.4198***	0.4352***
	(0.0003)		(0.0022)	(0.0021)
St. Maarten	-0.0091***	-0.1621***	0.0627***	0.2794***
	(0.0058)	(0.0089)	(0.0006)	(0.0008)
St. Kitts	-0.0155***	-0.4240	0.0048	0.1255**
	(0.0067)	(0.2642)	(0.0447)	(0.0630)
St. Lucia	-0.0311***	0.0311**	0.0338	0.0954**
	(0.0089)	(0.0133)	(0.0412)	(0.0370)
Constant	-0.1877***			
	(0.0308)			
Observations	25,153			

Robust standard errors are in parentheses.

***,**,* 1% 5% 10%

Table 7 English

Countries	Hurricane In Academic Yr (HIAY)	Hurricane Out Academic Yr (HOAY)	Age	Gender
Anguilla	0.0022***	-0.5062***	0.0072***	-0.4120***
	(0.0004)	(0.0222)	(0.0013)	(0.0031)
Antigua	0.0038	-0.0422***	0.0315**	-0.5116***
	(0.0034)	(0.0044)	(0.0145)	(0.0132)
Barbados	-0.0266**	0.0111	0.0100	-0.4899***
	(0.0133)	(0.0155)	(0.0068)	(0.0382)
British Virgin Islands	0.0111	0.0666	0.0225	-0.2548*
	(0.0089)	(0.1132)	(0.0271)	(0.1331)
Cayman Islands	-0.0089	0.0133	-0.0103**	-0.3100*
	(0.0355)	(0.0178)	(0.0048)	(0.1624)
Dominica	0.0178	-0.0200	-0.0181	-0.5457***
	(0.0266)	(0.1154)	(0.0134)	(0.0718)
Grenada	-0.0067	0.0644	0.0543***	-0.4437***
	(0.0111)	(0.0444)	(0.0111)	(0.0674)
Jamaica	-0.0006	-0.0004	-0.0104***	-0.4171***
	(0.0022)	(0.0044)	(0.0037)	(0.0328)
Montserrat	0.0333***	-0.0511**	0.0391***	0.0271***
	(0.0008)	(0.0244)	(0.0003)	(0.0015)
Saba	-0.0244***		0.0599***	-0.0471***
	(0.0007)		(0.0006)	(0.0033)
St. Maarten	0.0005	0.7570***	0.0083***	-0.5318***
	(0.0003)	(0.0155)	(0.0007)	(0.0011)
St. Kitts	0.0044	-0.3774***	0.0558**	-0.3999***
	(0.0089)	(0.1021)	(0.0231)	(0.0853)
St. Lucia	0.0311*	0.0067	0.0870***	-0.5390***
	(0.0155)	(0.0200)	(0.0153)	(0.0327)
Constant	0.1156***			
	(0.0337)			
Observations	25,257			

Robust standard errors are in parentheses.

***,**,* 1% 5% 10

Table 8 Chemistry

Hurricane In Academic Yr (HIAY)	-0.0097** (0.0049)	Hurricane Out Academic Yr (HOAY)	0.0083 (0.0050)

Countries	Age	Gender
Anguilla	-0.1039***	-0.4438***
	(0.0108)	(0.0043)
Antigua	0.0041	0.1316***
	(0.0199)	(0.0361)
Barbados	-0.0223**	-0.0621
	(0.0103)	(0.0627)
British Virgin Islands	0.4282	-0.0278
	(0.2592)	(0.2802)
Cayman Islands		
Dominica	0.0562	0.0395
	(0.0693)	(0.0433)
Grenada	-0.0156	0.0890
	(0.0536)	(0.0841)
Jamaica	-0.0048	0.1676***
	(0.0152)	(0.0239)
Montserrat	-0.0144	-0.1255***
	(0.0163)	(0.0041)
Saba	-0.3872***	-1.7588***
	(0.0339)	(0.0288)
St. Maarten	0.2249***	0.1165***
	(0.0097)	(0.0085)
St. Kitts	-0.1196**	-0.0659
	(0.0578)	(0.2004)
St. Lucia	0.1380***	0.1698**
	(0.0207)	(0.0849)
Constant	0.1005**	
	(0.0412)	
Observations	11,149	

Robust standard errors are in parentheses.

***,**,* 1% 5% 10

Table 9 Physics

Hurricane In Academic Yr (HIAY)	-0.0137***	Hurricane Out Academic Yr (HOAY)	0.0102**
	(0.0050)		(0.0050)
Countries	Age	Gender	
Anguilla	0.3247***	-0.3841***	
	(0.0107)	(0.0045)	
Antigua	0.0567***	-0.0361**	
	(0.0171)	(0.0158)	
Barbados	0.0450	-0.0018	
	(0.0558)	(0.0359)	
British Virgin Islands	0.0686	-0.0413***	
	(0.0459)	(0.0104)	
Cayman Islands	0.0000	0.0000	
	(0.0000)	(0.0000)	
Dominica	-0.0205	0.0692	
	(0.0856)	(0.0856)	
Grenada	-0.0657***	0.0837	
	(0.0220)	(0.0541)	
Jamaica	-0.0006	0.1270***	
	(0.0165)	(0.0322)	
Montserrat			
Saba			
St. Maarten	0.4000***	0.3620***	
	(0.0115)	(0.0095)	
St. Kitts	0.4753***	-0.1012	
	(0.1070)	(0.1213)	
St. Lucia	0.1074***	0.0122	
	(0.0255)	(0.0701)	
Constant	0.0788**		
	(0.0371)		
Observations	9,719		

Robust standard errors are in parentheses.

***,**,* 1% 5% 10

Table 10 Biology

Hurricane In Academic Yr (HIAY)	-0.0091**	Hurricane Out Academic Yr (HOAY)	0.0034
	(0.0041)		(0.0041)

Countries	Age	Gender
Anguilla	0.0469***	-0.0395***
	(0.0071)	(0.0035)
Antigua	0.0092	0.1353**
	(0.0385)	(0.0601)
Barbados	0.0692***	0.0884*
	(0.0205)	(0.0520)
British Virgin Islands	0.2024**	0.1329**
	(0.0908)	(0.0512)
Cayman Islands	0.0450***	0.0900***
	(0.0023)	(0.0037)
Dominica	0.2129***	0.0880
	(0.0463)	(0.0819)
Grenada	0.0805***	0.1250*
	(0.0219)	(0.0726)
Jamaica	-0.0047	0.1875***
	(0.0133)	(0.0177)
Montserrat	0.5709***	0.2285***
	(0.0159)	(0.0047)
Saba	-0.0868***	0.6947***
	(0.0179)	(0.0146)
St. Maarten	0.2987***	0.3621***
	(0.0092)	(0.0072)
St. Kitts	0.0088	0.0997
	(0.1348)	(0.0634)
St. Lucia	0.2192***	0.2611***
	(0.0734)	(0.0676)
Constant	-0.0836**	
	(0.0413)	
Observations	12,319	

Robust standard errors are in parentheses.

***,**,* 1% 5% 10

Table 11 Geography

Hurricane In Academic Yr (HIAY)	-0.0029	Hurricane Out Academic Yr (HOAY)	0.0015
	(0.0033)		(0.0045)

Countries	Age	Gender
Anguilla	0.0761***	-0.2639***
	(0.0093)	(0.0047)
Antigua	0.0014	0.0978*
	(0.0063)	(0.0509)
Barbados	0.0390	-0.0350
	(0.0444)	(0.0238)
British Virgin Islands	0.2875*	0.1706
	(0.1505)	(0.1109)
Cayman Islands	0.1027	-0.1593
	(0.1147)	(0.1373)
Dominica	0.1463***	0.2210***
	(0.0377)	(0.0660)
Grenada	0.0803***	0.1521***
	(0.0298)	(0.0256)
Jamaica	-0.0060	0.1190***
	(0.0101)	(0.0136)
Montserrat	0.1110	-0.1224***
	(0.1347)	(0.0227)
Saba	0.0504***	1.1219***
	(0.0027)	(0.0080)
St. Maarten	0.1894***	0.3908***
	(0.0079)	(0.0041)
St. Kitts	0.0339	0.0544
	(0.1200)	(0.0877)
St. Lucia	-0.0953	0.0874***
	(0.0743)	(0.0139)
Constant	0.0211	
	(0.0697)	
Observations	13,011	

Robust standard errors are in parentheses.

***,**,* 1% 5% 10

Table 12 Spanish

Hurricane In Academic Yr (HIAY)	-0.0026	Hurricane Out Academic Yr	0.0020
	(0.0067)	(HOAY)	(0.0076)
Countries	Age	Gender	
Anguilla	-0.4293***	-0.3374***	
	(0.0114)	(0.0056)	
Antigua	-0.0209	-0.1431***	
	(0.0191)	(0.0467)	
Barbados	0.0715***	-0.1322**	
	(0.0105)	(0.0581)	
British Virgin Islands	0.3512	0.1548***	
	(0.3082)	(0.0284)	
Cayman Islands	0.1337	-0.0096	
	(0.0888)	(0.0505)	
Dominica	-0.0581	-0.2762**	
	(0.0606)	(0.1366)	
Grenada	0.0338	-0.0056	
	(0.0269)	(0.0543)	
Jamaica	-0.0353**	0.0465*	
	(0.0147)	(0.0279)	
Montserrat	0.0085	0.4047	
	(0.1956)	(0.3404)	
Saba	0.0953***	-0.2337***	
	(0.0119)	(0.0076)	
St. Maarten	0.2759***	0.2978***	
	(0.0103)	(0.0110)	
St. Kitts	-0.1816**	-0.1484*	
	(0.0755)	(0.0807)	
St. Lucia	0.1830***	0.0151	
	(0.0216)	(0.1094)	
Constant	-0.0019		
	(0.0481)		
Observations	10,797		

Robust standard errors are in parentheses.

***,**,* 1% 5% 10

Table 13 French

Hurricane In Academic Yr (HIAY)	0.0014	Hurricane Out Academic Yr (HOAY)	0.0052
	(0.0118)		(0.0149)

Countries	Age	Gender
Anguilla	0.5910***	-0.4034***
	(0.0196)	(0.0117)
Antigua	0.1505**	-0.1547***
	(0.0732)	(0.0245)
Barbados	0.1389***	-0.2688**
	(0.0145)	(0.1204)
British Virgin Islands		
Cayman Islands		
Dominica	-0.0725*	-0.2234***
	(0.0385)	(0.0484)
Grenada	-0.0863	-0.0400
	(0.0775)	(0.0353)
Jamaica	-0.1120	-0.0360
	(0.1035)	(0.0334)
Montserrat	0.4510***	-0.7764***
	(0.0257)	(0.0087)
Saba		
St. Maarten	0.0249	0.5131***
	(0.0220)	(0.0214)
St. Kitts	0.1842	-0.1498
	(0.2665)	(0.1173)
St. Lucia	-0.0934	-0.1695***
	(0.1013)	(0.0237)
Constant	0.1429	
	(0.1189)	
Observations	3,856	

Robust standard errors are in parentheses.

***,**,* 1% 5% 10

Table 14 Regression Results

	Model 2	≥ 178 km/hr	Model 2	≥ 178 km/hr	Model 2	≥ 178 km/hr
	Chemistry		**Physics**		**Biology**	
Hurricane in School	-0.0097**	-0.0081**	-0.0137***	-0.0114**	-0.0091**	-0.0075**
	(0.0049)	(0.0041)	(0.0050)	(0.0043)	(0.0041)	(0.0035)
Hurricane out of School	0.0083	0.0069	0.0102**	0.0086**	0.0034	0.0030
	(0.0050)	(0.0042	(0.0050)	(0.0042)	(0.0041)	(0.0034)
	Geography		**Spanish**		**French**	
Hurricane in School	-0.0029	-0.0026	-0.0026	-0.0024	0.0014	0.0011
	(0.0033)	(0.0028)	(0.0067)	(0.0059)	(0.0118)	(0.0104)
Hurricane out of School	0.0015	0.0013	0.0020	0.0018	0.0052	0.0039
	(0.0045)	(0.0037)	(0.0076)	(0.0065)	(0.0149)	(0.0127)
	Replication of Results In Standard Deviations					
	Model 2	**≥ 178 km/hr**	**Model 2**	**≥ 178 km/hr**	**Model 2**	**≥ 178 km/hr**
	Chemistry		**Physics**		**Biology**	
Hurricane in School	-0.0122**	-0.0102**	-0.0152***	-0.0126**	-0.0113**	-0.0094**
	(0.0061)	(0.0052)	(0.0056)	(0.0048)	(0.0052)	(0.0043)
Hurricane out of School	0.0103	0.0087	0.0113**	0.0095**	0.0042	0.0037
	(0.0062)	(0.0052)	(0.0055)	(0.0046)	(0.0051)	(0.0042)
	Geography		**Spanish**		**French**	
Hurricane in School	-0.0036	-0.0032	-0.0032	-0.0030	0.0016	0.0013
	(0.0041)	(0.0035)	(0.0084)	(0.0074)	(0.0131)	(0.0115)
Hurricane out of School	0.0019	0.0017	0.0025	0.0022	0.0057	0.0043
	(0.0056)	(0.0047)	(0.0095)	(0.0081)	(0.0166)	(0.0141)

Robust standard errors are in parentheses.

***,**,* 1% 5% 10

Table 15 Robustness Check Results

	Model 2	Lead	Model 2	Lead	Model 2	Lead
		Chemistry	**Physics**		**Biology**	
Hurricane in School	-0.0097**	0.0035	-0.0137***	0.0021	-0.0091**	0.0013
	(0.0049)	(0.0040)	(0.0050)	(0.0042)	(0.0041)	(0.0037)
Hurricane out of School	0.0083	0.0028	0.0102**	0.0055	0.0034	0.0037
	(0.0050)	(0.0065)	(0.0050)	(0.0063)	(0.0041)	(0.0046)
		Geography	**Spanish**		**French**	
Hurricane in School	-0.0029	0.0006	-0.0026	-0.0050	0.0014	-0.0058
	(0.0033)	(0.0032)	(0.0067)	(0.0065)	(0.0118)	(0.0084)
Hurricane out of School	0.0015	0.0017	0.0020	0.0059	0.0052	0.0431***
	(0.0045)	(0.0045)	(0.0076)	(0.0071)	(0.0149)	(0.0147)
			Replicated Results in Standard Deviations			
	Model 2	**Lead**	**Model 2**	**Lead**	**Model 2**	**Lead**
		Chemistry	**Physics**		**Biology**	
Hurricane in School	-0.0122**	0.0043	-0.0152***	0.0023	-0.0113**	0.0016
	(0.0061)	(0.0050)	(0.0056)	(0.0047)	(0.0052)	(0.0047)
Hurricane out of School	0.0103	0.0035	0.0113	0.0061	0.0042	0.0046
	(0.0062)	(0.0081)	(0.0055)	(0.0070)	(0.0051)	(0.0057)
		Geography	**Spanish**		**French**	
Hurricane in School	-0.0036	0.0007	-0.0032	-0.0062	0.0016	-0.0065
	(0.0041)	(0.0039)	(0.0084)	(0.0081)	(0.0131)	(0.0093)
Hurricane out of School	0.0019	0.0022	0.0025	0.0074	0.0057	0.0479
	(0.0056)	(0.0057)	(0.0095)	(0.0089)	(0.0166)	(0.0163)

Table 16 Impact on Returns to Schooling: Jamaica

Subject	Biology/ Chemistry	Physics
Annual Average Salary 2012 (US$) (*Source: Statistical Institute of Jamaica*)	11,326	11,326
Reduction in Schooling (%)	0.3	0.5
School Population 2012 (*Source: Education Policy & Data Center*)	240,247	240,247
Public Rate of Return (%)	12.9	12.9
Each year of schooling (US$)	1,461	1,461
Hurricane Impact (US$)	(0.003)*(1461) = 4.38	(0.005)*(1461) = 7.31
Aggregated Public Loss (US$)	(4.38)*(240247) =1.1 million	(7.19)*(240247) =1.7 million
Private Rate of Return (%)	17	17
Each year of schooling (US$)	1925	1925
Hurricane Impact (US$)	(0.003)*(1925) = 5.78	(0.005)*(1925) = 9.63
Aggregated Private Loss (US$)	1.4 million	2.3 million
Total Loss (US$)	2.5 million	4 million

Table 17 Impact on Returns to Schooling: Saint Kitts & Nevis

Subject	Biology/ Chemistry	Physics
Annual Average Salary 2006 (US$) (*Source: Ministry of Sustainable Development, Saint Kitts)*	10,761	10,761
Reduction in Schooling (%)	0.3	0.5
School Population 2012 (*Source: Education Policy & Data Center*)	3,673	3,673
Public Rate of Return (%)	12.9	12.9
Each year of schooling (US$)	1,388	1,388
Hurricane Impact (US$)	4.16	6.94
Aggregated Public Loss (US$)	15,280	25,491
Private Rate of Return (%)	17	17
Each year of schooling (US$)	1,829	1,829
Hurricane Impact (US$)	5.49	9.15
Aggregated Private Loss (US$)	20,165	33,608
Total Loss (US$)	35,445	59,099

Table 18 Impact on Returns to Schooling: Saint Lucia

Subject	Biology/ Chemistry	Physics
Annual Average Salary (US$) (*Source: Central Statistics Office, Saint Lucia*)	7,888	7,888
Reduction in Schooling (%)	0.3	0.5
School Population (*Source: Education Policy & Data Center*)	14,721	14,721
Public Rate of Return (%)	12.9	12.9
Each year of schooling (US$)	1,018	1,018
Hurricane Impact (US$)	3.054	5.09
Aggregated Public Loss (US$)	44,958	74,930
Private Rate of Return (%)	17	17
Each year of schooling (US$)	1,341	1,341
Hurricane Impact (US$)	4.02	6.71
Aggregated Private Loss (US$)	59,178	98,778
Total Loss (US$)	104,136	173,708

Figure 1 Maps of Anguilla, Antigua and Barbados

Anguilla Antigua Barbados

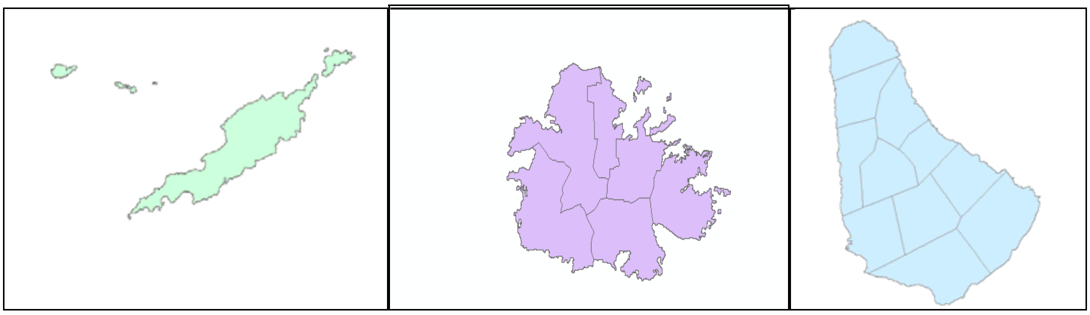

Figure 2 Maps of Belize and British Virgin Islands

Belize British Virgin Islands

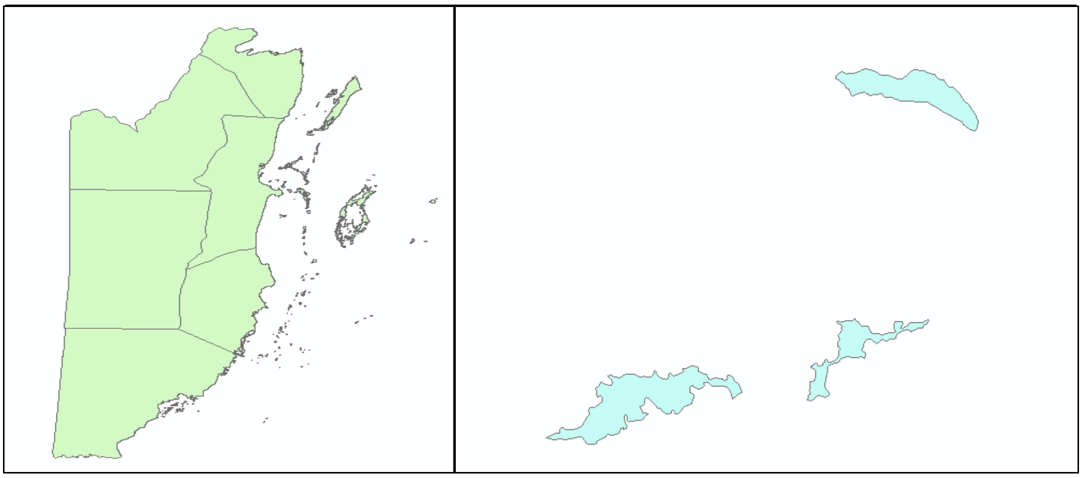

Figure 3 Maps of Cayman Islands and Dominica

Cayman Islands

Dominica

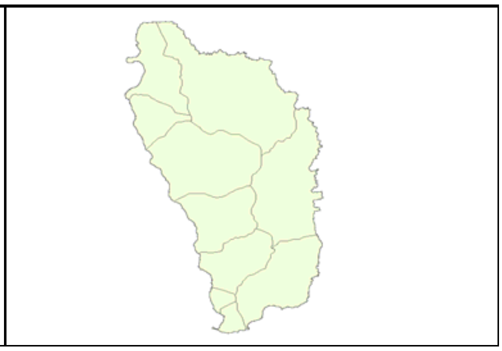

Figure 4 Maps of Grenada, Guyana and Jamaica

Grenada Guyana Jamaica

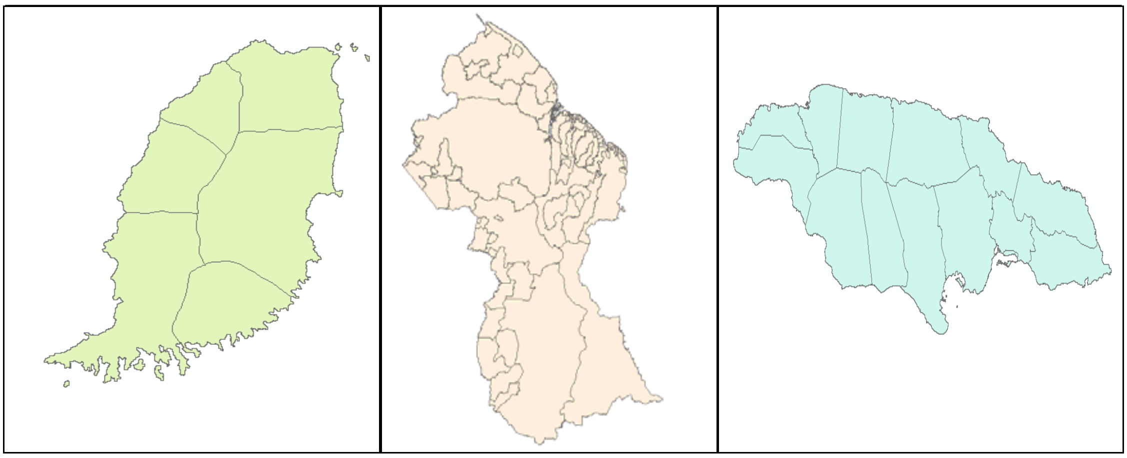

Figure 5 Maps of Montserrat, Saba and Saint Kitts

Montserrat | Saba | Saint Kitts

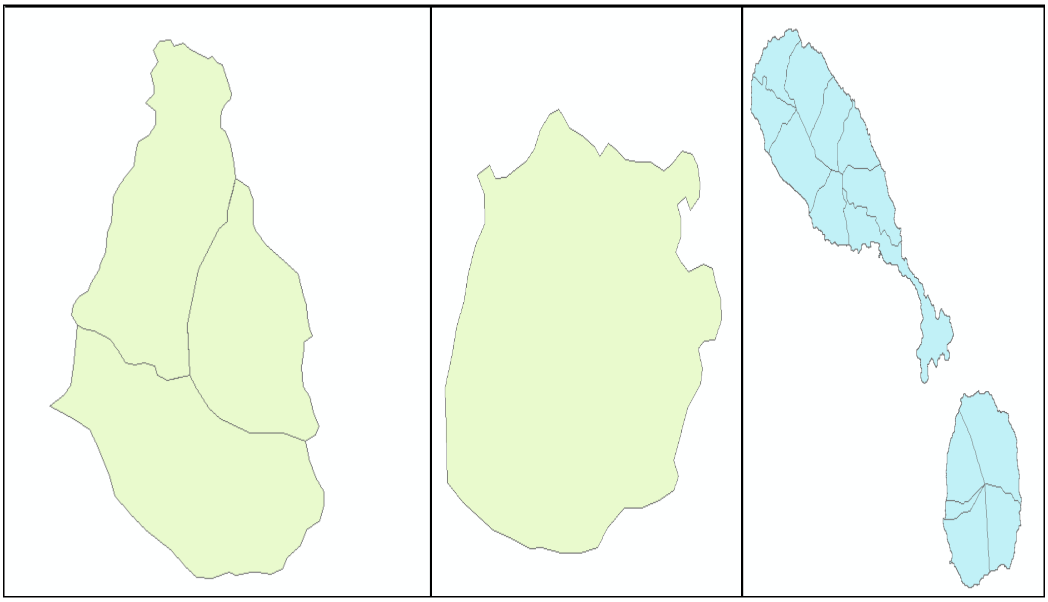

Figure 6 Maps of Saint Lucia, Saint Maarten and Saint Vincent & the Grenadines

Saint Lucia Saint Maarten Saint Vincent & the Grenadines

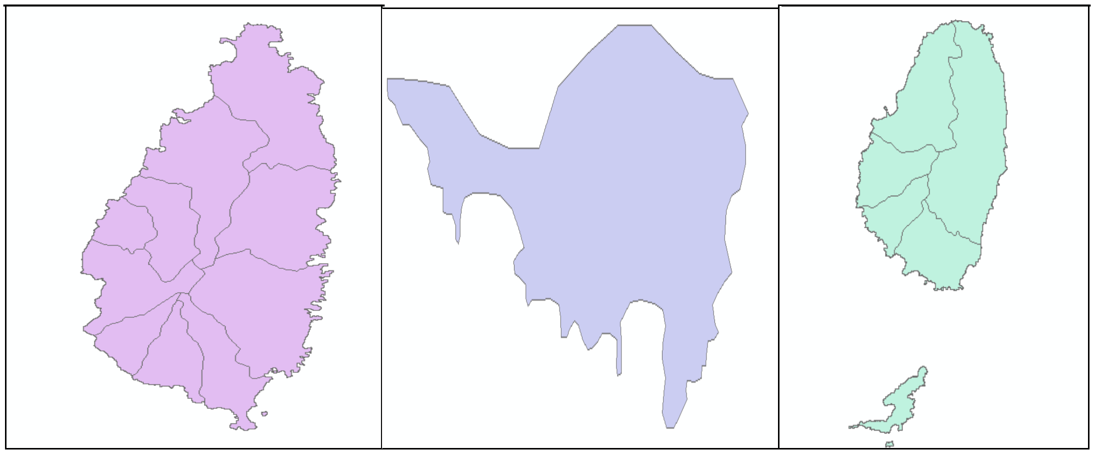

Figure 7 Maps of Suriname, Trinidad & Tobago and Turks & Caicos

Suriname Trinidad & Tobago Turks & Caicos