IDB WORKING PAPER SERIES Nº IDB-WP-1479

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## Evidence from Eastern Caribbean Small Island Developing States

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September 2023

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Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Mohan, Preeya.
The impact of tropical storms on international trade: evidence from Eastern Caribbean small island developing states / Preeya S. Mohan.
p. cm. — (IDB Working Paper Series ; 1479)
Includes bibliographical references.
1. Caribbean Area-Commerce. 2. International trade-Effect of storms on-Caribbean Area. 3. Disasters-Caribbean Area. I. Inter-American Development Bank. Department of Research and Chief Economist. II. Title. III. Series.
IDB-WP-1479

http://www.iadb.org

**Abstract**[*]

Eastern Caribbean Small Island Developing States (SIDS) have a high dependence on international trade for income, employment and poverty reduction given their extreme openness, small market size, narrow range of resources and productive capabilities and specialized economic structures, making them vulnerable to external shocks, the most frequent being tropical storms. The objective of this paper is to investigate the impact of tropical storms on international trade for eight Eastern Caribbean SIDS over the period 2000-2019, as well as the mediating role of the Real Effective Exchange Rate (REER). The results indicate that hurricanes have a more long-term impact on exports, reducing exports of goods by 20 percent in the month of a strike and up to three months thereafter, while the impact on imports was just as severe but more immediate, reducing imports of goods by 11 percent in the month of a strike. The mediation analysis suggests that the REER plays no mediating role in explaining the impact of tropical storm damage on exports and imports in the region.

**JEL classifications:** F1, F4, Q54, Q56
**Keywords:** Natural disasters, Hurricanes, International trade, Small Island Developing States, Caribbean

[*] This paper was undertaken as part of the Latin American and Caribbean Research Network project "Implications of Climate Change and Natural Disasters in Latin America and the Caribbean."

## 1. Introduction

International trade is essential for countries' income, employment, and poverty reduction, particularly in Small Island Developing States (SIDS) given their limited resources, small market size, and high trade openness. At the same time, high dependence on trade makes island economies vulnerable to external shocks, the most frequent being natural disasters (Cavallo and Noy, 2009; Noy, 2009; Crowards, 2000; and Rasmussen, 2004). Disasters act as large external events inflicting huge economic costs, with climate change increasing the intensity and frequency of such occurrences (Knutson et al., 2019, and Emanuel, 2005). Disasters can have negative trade effects by interrupting the production and consumption of goods and services together with supply chains, and damage to critical transport infrastructure. On the other hand, trade can play a key role in making available essential supplies in a timely manner when a disaster hits, aiding in post-disaster recovery. In order to manage disaster disruptions to trade, mitigate their impacts and build economic resilience, it is vital to understand the mechanisms through which trade is affected (Wilkinson and Stevens, 2020, and WTO, 2018). Nevertheless, there is a paucity of research on the economic impacts of disasters on international trade in SIDS and in the literature more generally.

The majority of studies tend to estimate the economic impact of natural disasters on Gross Domestic Product (GDP). These papers provide contradictory results of growth increases following a natural disaster (Albala-Bertrand, 1993, and Skidmore and Toya, 2002), along with short-lived negative effects (Raddatz, 2007; Noy, 2009; and Noy and Nualsri, 2007). This ambiguity in the evidence on the macroeconomic impact of disasters could be because of empirical reasons, including heterogeneity in data samples, use of different natural disaster event proxies, and employment of different econometric methodologies (Klomp and Valckx, 2014). Alternatively, more recent studies illustrate that the impact of disasters is complex and differs based on various factors including the economic variables investigated, since the use of GDP can disguise heterogeneous responding forces of the underlying system including international trade (Mohan et al., 2018; Hochrainer, 2009; and Loayza et al., 2009). In this context, there is a limited but emerging strand of empirical literature which aims to identify and quantify the effects of natural disasters and weather and climatic change on international trade. This handful of studies suggests that natural disaster impact on international trade is complex and ambiguous and occurs through direct and indirect channels, with SIDS being more negatively affected (Osberghaus, 2019; Da Silva and Cernat, 2012; Meng, 2015; Oh, 2010; and Gassebner et al., 2006).

This inconclusiveness in the literature makes it difficult to confidently identify how much of a role ex ante and/or ex post disaster mitigation could and should play. It is thus important to ask how natural disasters and international trade interact. This paper therefore aims to add to the literature and bring further clarity to the issue of natural disasters and international trade by investigating hurricanes in Eastern Caribbean SIDS. In doing so, the paper makes a significant contribution to the literature on the economic impact of natural disasters in two ways. Firstly, it uses high-frequency monthly trade data, which arguably allow for estimating more precise impacts of natural disasters by capturing immediate effects versus yearly data, the commonly adopted approach. Secondly, the paper examines the channels through which natural disasters may affect international trade using mediation analysis and the exchange rate.

A fixed effects panel estimator is adopted to determine the impact of hurricanes on exports, imports and net exports of goods in the Eastern Caribbean. Additionally, the paper uses mediation analysis to disentangle the role exchange rates play in the net impact of tropical storms on trade in the spirit of Acharya et al. (2016). The paper uses monthly trade data from the Eastern Caribbean Central Bank (ECCB) Dashboard-Data databank. Potential hurricane destruction is measured using a wind field model applied to the Hurricane Database (HURDAT) combined with the History Database of the Global Environment (HYDE) 3.2 gridded population database to provide an ex ante economic exposure to damage index based on estimated localized wind speeds and measures of local population.

The rest of the paper is structured as follows. Section 2 gives an overview of natural disasters and international trade in Eastern Caribbean SIDS. Section 3 provides a literature review on natural disasters and international trade. Section 4 outlines the data and methodology used. Section 5 gives the results. Section 6 offers a discussion of the main findings of the paper and their policy implications.

## 2. Eastern Caribbean SIDS

The Eastern Caribbean is arguably particularly apt for the study of the impact of tropical storms on international trade. In the region there is an excessive dependence on international trade given countries' small market size, narrow range of resources and productive capabilities, and specialized economic structures (Herbert, 2019, and Briguglio, 1995). In Antigua and Barbuda, for instance, exports equal 71 percent of GDP, while the figure for imports is 69 percent (World Bank, 2022). Trade in these countries is essential for income, employment and poverty reduction (World Bank, 2015a). Firms involved in export activities in the Caribbean account for 34 percent of formal employment, while the direct and indirect share of employment, which excludes exporting firms' workers, is 17 percent; both figures are above the average for other developing countries (World Bank, 2015a). Caribbean exporting firms also employ a large share of vulnerable groups, such as women, relative to other developing countries (World Bank, 2015a). Moreover, agriculture is a main merchandise export from Eastern Caribbean islands and is susceptible to climatic disasters. Agriculture value added as a percent of GDP for Dominica is 17 percent, St. Vincent and the Grenadines 6 percent, and Grenada 5 percent, with agricultural employment as a percent of total employment for St. Lucia and St. Vincent and the Grenadines at 10 percent (World Bank, 2022). Eastern Caribbean SIDS are also deeply reliant on imports, which play a central role in energy and food security (World Bank, 2015a). Food imports as a percent of total merchandise imports is 28 percent for St. Vincent and the Grenadines, 27 percent for Antigua and Barbuda and St. Lucia, and 23 percent for Grenada (World Bank, 2022). Fuel imports as a percent of total merchandise imports is 17 percent for St. Lucia, 16 percent for Grenada, and 11 percent for St. Vincent and the Grenadines (World Bank 2022).

At the same time, high dependence on international trade makes Eastern Caribbean economies highly vulnerable to external shocks, the most frequent being hurricanes given that these countries are located in the Atlantic hurricane belt (Noy, 2009; Heger et al., 2008; and Benson and Clay, 2004). The economic and social destructive effects of tropical storms in the region have been considerable (Heger et al., 2008; Rasmussen, 2004; and Crowards, 2000). The Eastern Caribbean is said to be the most disaster-prone territory in the world on account of the large number of hurricanes experienced; according to Rasmussen (2004: 3), "since 1970 a natural disaster inflicting damage equivalent to more than 2 percent of the affected country's GDP can be expected roughly every 2.5 years." The region has also been affected by damaging successive storms over short periods of time. Tropical Storm Erika and Hurricane Maria struck Dominica in 2015 and 2017 causing damage estimated at 90 percent and 226 percent of GDP, respectively, (WTO, 2018), while Hurricane Maria destroyed 100 percent of the agriculture sector in Dominica (CARDI, 2017). Hurricanes have also disrupted trade in these countries. When Hurricane Ivan struck Grenada in 2004, exports fell by 60 percent and imports by 65 percent in the months following (World Bank, 2005). Hurricane Tomas in St. Vincent and the Grenadines reduced exports by 25.3 percent (ECLAC, 2011).

## 3. Literature Review

### *3.1. Direct and Indirect Impact of Natural Disasters on International Trade*

There are various transmission channels through which natural disasters can directly and indirectly affect international trade with both negative and positive consequences. Disasters can directly destroy human and physical capital through death and injury and destruction of transport infrastructure such as ports, container terminals, roads or railway connections, storage facilities, and communication infrastructure, thereby disrupting international trade (Osberghaus, 2019; Oh, 2017; Gassebner et al., 2006; and Oh, 2010). Disasters can also directly reduce production, particularly in agriculture, and they can even affect manufacturing facilities, consequently reducing the supply of tradable goods (Mohan, 2016; Mohan, 2017; and Mohan and Strobl, 2013).

With regard to indirect effects, as a result of the fall in production from a disaster strike, income may decline, which reduces private spending and investments as well as tax revenues, which in turn reduces government spending and may thus reduce imports (Osberghaus, 2019; Parsons, 2016; and Auffret, 2003). Natural disasters may also increase the cost of trade, as traders may need to use longer routes or alternative ports and airports to reach markets and pay higher insurance premiums as insurers seek to cover increased risk. A rise in the cost of traded goods may consequently lead to price increases, causing a decrease in demand for exports and imports (Parsons, 2016, and Oh, 2010). Additionally, natural disasters can reduce optimism, thereby reducing persons' willingness to engage in economic activities such as consumption, production, and investment, which can indirectly affect trade (Oh, 2010).

On the other hand, trade may increase following a natural catastrophe. Imports may rise as a result of large inflows of international aid, including food supplies and medicine and the accompanying clean-up, relief, and reconstruction activities (WTO, 2018). Reconstruction efforts of damaged infrastructure in the affected country often require large amounts of imported construction materials and technology. Exports can also increase in the aftermath of a natural disaster as governments in seeking to rebuild may implement policies that can increase exports and reduce prices in order to obtain foreign currency (WTO, 2018).

### *3.2. Mediating Role of Exchange Rates in Natural Disasters and International Trade*

The exchange rate is an important transmission mechanism of natural disaster shocks, especially in SIDS given their small open economies and reliance on agricultural exports (Strobl and Kablan, 2017). The transmission mechanism of natural disasters to exchange rates often occurs through fiscal policy (Bénétrix and Lane, 2013). After natural disasters, governments see their costs increase as they face relief, clean-up and reconstruction expenses and the decline in economic activity results in lower tax revenues. If governments adopt an expansionary fiscal policy this will lead to an increase in aggregate demand, which affects real money demand, and interest rates will increase, which will result in an exchange rate appreciation. In the context of a floating exchange rate, there will be an appreciation of the exchange rate, while in the case of a fixed exchange rate, only the REER will appreciate (Edwards and Levy Yeyati, 2005). Similarly, an increase in imports and a decrease in exports due to a natural disaster will result in a deficit in the current account, which in turn will lead to a depreciation of the exchange rate in a flexible exchange rate framework (Du and Zhu, 2001).

There is also a relationship between REER and openness. Countries that are more exposed to trade tend to have a more stable REER. Gantman and Dabós (2018) provide empirical support that trade openness is associated with a depreciation of the REER. Strobl and Kablan (2017) investigated the response of the REER to tropical storms in SIDS, including those in the Caribbean, and found that under flexible exchange rate regimes there is a real exchange rate appreciation up to two months after a storm, while a fixed exchange rate almost completely buffers an appreciation.

### *3.3. International Studies on Natural Disasters and International Trade*

There is a paucity of literature on the economic impact of natural disasters on international trade. These studies generally indicate that disasters can have a negative or positive impact on trade, although SIDS appear to be more negatively affected. In a review of the literature on disasters, climate, and international trade, Osberghaus (2019) shows that there is large diversity in terms of motivations, data sets, and methodologies used, along with results. Generally, the results show that increases in average temperature seem to have a detrimental effect on exports, mainly on manufactured and agricultural products, while imports seem to be less affected by temperature changes. The effects of natural disasters on trade are more ambiguous, although it may be concluded that exports are negatively affected, whereas imports may decrease, increase, or remain unaffected. Additionally, SIDS with low institutional quality and political freedom seem to face more severe effects on trade resulting from natural disasters.

Gassebner et al. (2010) examine the impact of major natural disasters on import and export flows using a gravity model for 170 countries from 1962 to 2004. The results show that natural disasters reduce imports on average by 0.2 percent and exports by 0.1 percent, while the less democratic and smaller a country the greater the loss. Also using a gravity model, Oh and Reuveny (2010) examine the impact of climatic disasters together with political risk on bilateral trade for 116 countries from 1985 to 2003. The results suggest that an increase in climatic disasters or political risk, for either importer or exporter countries, reduces their bilateral trade. Countries that experience a decline in political risk see a smaller decrease in their trade flows when hit by natural disasters, while countries hit by natural disasters see an increasingly larger decline in their trade when their political risk increases. Meng et al. (2015) study China's bilateral trade flows using a gravity model from 1980 to 2012 and determined that natural disasters have a positive impact on exports but no significant impact on imports, while trading partner countries' natural disasters reduce Chinese imports and exports. They also show that development level and land area of the partner countries are important in determining the intensity of natural disaster impacts on China's bilateral trade.

Da Silva and Cernat (2012) focus on the impact of natural disasters in developing countries' exports using a gravity model. The results suggest that exports of small developing countries decline by 22 percent over three years, while large developing countries are not affected. The study recommends that small countries should focus on measures dedicated either to reducing their export vulnerability to disasters before they occur or minimizing the negative export impact of disasters when they occur. Xu et al. (2019) examine the impact of natural disasters on trade in services using a gravity model over the period 1995-2012 for 191 reporter and 193 partner countries and conclude that natural disasters lead to a decline in services exports by as much as 2 to 3 percent of the affected country but have ambiguous effects on its services imports.

Furthermore, capital-intensive service sectors including transport and communications are most affected where negative impacts can last for up to five years after a disaster. Additionally, the negative impact of natural disasters on services trade is larger than that on merchandise trade.

*3.4. Caribbean Studies on Natural Disasters and International Trade*

Looking at studies for Caribbean SIDS, Crowards (2000), in an assessment of the macroeconomic impact of 21 major tropical storms and hurricanes over the period 1970-1997, shows that exports decrease by 10 percent during the year of a disaster, following which it largely return towards its previous level in the subsequent year following. Agricultural exports were more severely affected, however, and in some cases they were completely wiped out. Imports increase by 8.5 percent during the year of a storm, with further decreases by up to 11.5 percent in the year following. In another study of the Caribbean, Heger et al. (2008) used the Emergency Events Database (EM-DAT) with time series and dynamic panel data analysis on 16 islands from 1970 to 2006. They find that in the year a disaster occurs, exports decrease and imports increase. Additionally, countries with highly diversified exports will not see their exports or imports severely affected by natural disasters.

Auffret (2003) analyzes the impact of catastrophic events on 16 Caribbean and Latin American countries over a period of three decades (1970-1999). The findings indicate that these events lead to a decline in investment and output and higher volatility in consumption, which can negatively affect imports. Rasmussen (2004) focuses on the macroeconomic impact of natural disasters in Eastern Caribbean SIDS. The results show an immediate contraction in output and a worsening of fiscal balances, and given the dependence of imports on GDP, a disaster can reduce imports if it causes the level of aggregate economic activity to contract. This, however, requires the natural disaster to be sufficiently large or the affected economy to be relatively small, and the larger the share of trade in the affected country the larger the trade impacts.

Mohan (2016) uses historical hurricane tracks data to evaluate the impact of hurricanes on agriculture exports in Caribbean SIDS for the period 1961–2009. The results illustrate that hurricanes have a negative impact on agriculture exports, with the smaller Eastern Caribbean islands being more negatively affected. Furthermore, different agricultural exports are affected differently by hurricanes, and there is substantial product heterogeneity in resilience to hurricanes. The results also suggest that increased diversification within agriculture exports may increase resilience to hurricanes in the region. In another study, Mohan (2017) investigates the impact of hurricanes on banana exports, using a documented case study of Hurricanes David and Frederick, which struck Dominica in 1979, and a synthetic control estimator, which entailed creating a comparable control group using other Caribbean SIDS. The findings show that hurricanes had an immediate and sizeable negative impact on banana exports in Dominica in the year of the strike which lasted up to two years thereafter.

## 4. Data and Methodology

### *4.1. Trade and REER Data*

The source of trade data is the Eastern Caribbean Central Bank (ECCB) Dashboard-Data databank. These data are free and available to the public, and they can be downloaded from the ECCB website.[1] The databank provides monthly data on exports, imports and net exports of goods for the eight members (Anguilla, Antigua and Barbuda, Dominica, Grenada, Montserrat, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines) of the Eastern Caribbean Currency Union since 2000. Similarly, the databank provides monthly values of the REER for all members since 2000.[2] For the purposes of this study, the sample period is restricted to 2000-2019 in consideration of the likely structural break in the data since the outbreak of the COVID-19 pandemic.

### *4.2. Tropical Storm Damages Data*

To proxy tropical storm damage, a tropical storm destruction index is constructed which explicitly models the physical characteristics of a storm and also takes into account ex ante population exposure to damage. More precisely, tropical storms are tracked through time and space, and a wind field model proposed by Boose et al. (2004) is applied to derive local wind experienced within Eastern Caribbean countries. The wind field model measures wind direction and wind speed relative to the earth's surface of any location relative to the eye of a hurricane, using as inputs the information on the maximum wind speed, traveling speed, traveling direction and whether the storm made landfall. The output is then for each storm at each chosen point in time a measure of

[1] https://www.eccb-centralbank.org/statistics/dashboard-datas/

[2] The REER is based on the trade-weighted average of the consumer price indices of the country's main trading partners relative to that of the domestic currency. A decline in the REER implies a depreciation, while an increase implies an appreciation.

locally experienced wind speed. Given a storm track the model provides for each point in time of a storm's lifespan the wind speed experienced at any location on land.

The wind field model requires tropical storm track data as inputs. Ideally, one would like to use these data to identify all potentially damaging storms that may have affected localities in the Eastern Caribbean. More precisely, for each storm one would like to know if they approached or made landfall with sufficient strength to cause damage. For these the paper uses the National Hurricane Centre Hurricane database (HURDAT), which provides hurricane track data on all known storms in the North Atlantic Ocean Basin since 1850. It provides six-hourly reports of storm positions and maximum wind speeds of all known tropical cyclones in the North Atlantic Basin. For each storm the database provides information on the time and location of the storm eye and the maximum wind speed for every six-hour interval of the storm's lifespan. The study linearly interpolates these data to hourly positions.

As noted by Emanuel (2011), both the monetary losses of tropical storms and the power dissipation of these storms tend to rise roughly as the cube of the maximum observed wind speed rises. Consequently, he proposed a simplified power dissipation index that can serve to measure the potential destructiveness of tropical storms, which proxies the fraction of property damaged as a function of wind speed, *V*:

$$f_{ijk} = \frac{v_{ijk}^3}{1+v_{ijk}^3}*100 \qquad (1)$$

with

$$v_{ijk} = \frac{MAX\,[(V_{ijk} - V_{thresh}),0]}{V_{half} - V_{thresh}} \qquad (2)$$

where $V_{ikt}$ is the maximum wind experienced at point $k$ in country $i$ due to storm $j$, $V_{thresh}$ is the threshold below which no damage occurs, and $V_{half}$ is the threshold at which half of the property is damaged. Given the maximum wind speed, the functional form in (2) will depend on the choice of parameters $V_{thresh}$ and $V_{half}$. Emanuel (2011) notes that for $V_{thresh}$ there is unlikely to be any damage for winds below 92 km/h, and this cut-off point is also used here. Similarly, for $V_{half}$ the paper follows Emanuel (2011) and uses 203 km/h, but also experiments with a value of 278 km/h.

Since populations within countries are unlikely to be geographically distributed homogenously, one needs to take account not only of the local wind speed experienced but also of differences in exposure when generating a countr- wide proxy of destruction. The country-level potential destruction proxy is thus:

$$DAMAGE_{it} = \Sigma_{k\epsilon t}\Sigma_{k=1}^{N} w_{jkt-1} f_{jkt} \quad (3)$$

where $w_{ikt-1}$ is the share of population at point *i* in month *t-1* in island *k*. The population weight used is *t-1* rather than *t* in order to ensure that the weights are not influenced by the tropical storm shocks and thus potentially endogenous.

To determine local population exposure, i.e., the inputs into calculating the weights *w* in (3), the paper resorts to the gridded population database Gridded Population of the World (GWP) Version 4, which provides population estimates globally at the 30 arc-second resolution. Since these are only available at 5-year intervals since 1995 the study interpolates them to create grid cell-level monthly series.

### *4.3. Econometric Model*

The total net impact of tropical storm damages on export, imports and net exports is estimated with a linear panel fixed effects estimator as follows:

$$log(trade_{it}) = \alpha + \sum_{l=0}^{L} \beta_{t-l}\, DAMAGE_{i,t-l} + \delta_t + \mu_i + \varepsilon_{it} \quad (4)$$

where *trade* will alternatively take the value of exports, imports or net exports and *DAMAGE* is the constructed tropical storm damage indicator. $\mu$ and $\delta$ are island and year and month-specific indicators, respectively, while the *i* and *t* are island and month subscripts. The regression error terms are clustered at the country level. One should note that, given the positive skewness of the data and a possible large number of zeros, the dependent variable is logged.[3] The $\beta$'s are the main coefficients of interest and capture contemporary and potentially lagged total net monthly effect of tropical storms on trade.

The paper also disentangles the role of REER in the net impact of tropical storms by using mediation analysis in the spirit of Acharya et al. (2016). Equation (4) is thus re-estimated including the REER as the mediator of the effect of tropical storm damage on trade flows:

$$log(trade_{it}) = \alpha + \sum_{l=0}^{L} \beta_{t-l}\, DAMAGE_{i,t-l} + \sum_{l=0}^{L} \pi_{t-l} REER_{i,t-l} + \delta_t + \mu_i + \varepsilon_{it} \quad (5)$$

3 log(x+1) transformation is used to deal with zero values.

One can purge the indirect effect of tropical storm damage through *REER* from the trade dependent variables as follows:

$$log(\widehat{trade})_{it} = log(trade)_{it} - \sum_{l=0}^{L} \widehat{\pi_{t-l}} REER_{i,t-l} \quad (6)$$

Estimating:

$$log(\widehat{trade}_{it}) = \alpha + \sum_{l=0}^{L} \theta_{t-l}\, DAMAGE_{i,t-l} + \delta_t + \mu_i + \varepsilon_{it} \quad (7)$$

allows one to then disentangle the average treatment effect (ATE), i.e., the $\beta$'s, into the average direct effect (ADE), i.e., the $\theta$'s, of *DAMAGE* on trade flows and its average indirect effect (AIE), the $\pi$'s through the *REER*. One should note that since (6) and (7) include statistically estimated variables, standard errors for the ATE, ADE, and AIE are generated using 500 bootstrapped samples clustered at the country $i$ level.

Combining the trade and hurricane damage data provides a nearly balanced monthly panel covering the period 2000-2019 for the 8 Eastern Caribbean countries. Table 1 lists the descriptive statistics of the variables used in the study. As can be seen, the monthly export data have a mean of US$ 1.891 million, whereas the monthly import data have a much larger mean of US$ 4.602 million. The country therefore imports about 70 percent more than it exports. There is considerable variation in the export and import data, with both distributions being highly skewed. A particular country in a given month could export no product or very close to zero product, with another country exporting as much as US$ 9.945 million. Imports similarly show that a country in a given month could import as little as US$0.003 million in product or as much as US$ 72.826 million. A logarithmic transformation was applied to the trade variables to create more normalized variables for the econometric analysis. The average monthly REER rate is 95.695, with minimum and maximum values of 81.15 and 115.5, respectively. In terms of hurricane damage, on average there is 0.002 (DAMAGE 203) and 0.001 (DAMAGE 278) hurricane wind destruction each month in the Eastern Caribbean, with the most damaging events being 0.678 (DAMAGE 203) and 0.311 (DAMAGE 278), which correspond to Hurricane Irma in 2017.

**Table 1. Descriptive Statistics**

| Variable | Definition | Obs | Mean | Std. dev | Min | Max |
|---|---|---|---|---|---|---|
| Exports | Exports (real US$ million) | 1,812 | 1.891 | 1.716 | 0 | 9.945 |
| Imports | Imports (real US$ million) | 1,812 | 4.602 | 5.539 | 0.003 | 72.826 |
| Net exports | Net exports (real US$ million) | 1,812 | 18.27 | 18.71 | -34.87 | 121.57 |
| Log Exports | Log exports (real US$ million) | 1,812 | 0.888 | 0.598 | 0 | 2.393 |
| Log Imports | Log imports (real US$ million) | 1,812 | 1.404 | 0.771 | 0.003 | 4.302 |
| Log Net exports | Log net exports (real US$ million) | 1,572 | 2.871 | 0.877 | 0.584 | 4.808 |
| DAMAGE 203 | Hurricane wind index 203 km/h cut off | 1,920 | 0.002 | .0307 | 0 | 0.678 |
| DAMAGE 278 | Hurricane wind index 278 km/h cut off | 1,920 | 0.001 | .0127 | 0 | 0.311 |
| REER | Real Effective Exchange Rate | 1,800 | 95.695 | 7.544 | 81.150 | 115.500 |

*Source:* Author's calculation.

## 5. Results

Table 2 shows the panel regression results for the impact of tropical storms on exports using the wind damage destruction index DAMAGE 203. Column (1) shows that hurricanes had a negative impact on exports in the Eastern Caribbean, with the hurricane destruction index having a negative and significant coefficient. Lagged effects were then taken into account. Columns (2), (3) and (4) show that hurricanes had a negative significant impact on exports one, two, and three months after a strike. For an average damaging tropical storm, the cumulative effect over four months translates into a 20 percent decrease in exports.[4] Columns (5), (6), and (7) and (8) add the REER into the regression. The coefficient for the REER is positive and significant in Column (5), indicating that an appreciation of the exchange rate positively affects exports in the month of a strike. The effect is very small, however, as for every 1 percent increase in the REER exports increase by just 0.007 percent. When lags of the REER are added in Columns (6), (7), and (8) the REER coefficients become insignificant except for three months following a strike, in which case exports increase by a small amount of 0.012 percent. The coefficients for the hurricane destruction index are again negative and significant, demonstrating that tropical storms had a negative impact on exports in the month of an event and up to three months after. Table 3 displays the results for the impact of hurricanes on exports using DAMAGE 278 as the damage destruction index. The estimated coefficients again show that hurricanes had a negative impact on exports in the month of their

[4] If we consider the average (non-zero) value of DAMAGE 203 (0.118) then the coefficients (-0.579, -0.322, -0.514 and -0.294) implies that an average destructive tropical storm decreases monthly exports by 20 percent, that is (0.118*(-1.709)).

occurrence as well as one, two and three months thereafter, with the REER having a positive and significant impact in the year of a strike, becoming insignificant when lagged effects were added except for three months after a strike.

These results strongly suggest that exports do not benefit from hurricanes in Eastern Caribbean SIDS but are instead negatively affected, with wider negative macroeconomic impacts on the trade balance, foreign exchange reserves, income, and employment. Da Silva and Cernat (2012) and Gassebner et al. (2006) similarly found that natural disasters negatively affect exports in small developing countries but may not necessarily have a negative impact in large developing countries. Using a gravity model, Da Silva and Cernat (2012) model show that annual exports declined by 22 percent in SIDS following natural disaster events.

The decrease in exports in Eastern Caribbean SIDS may be caused by direct production losses, especially in agriculture and destruction of productive capital as well as infrastructure damages. In 2004, Hurricane Ivan destroyed 90 percent of forest vegetation in Grenada and resulted in loss of topsoil and nutrients important for agriculture production. In addition, 85 percent of the island's nutmeg crop—a top export—was lost, as well as 60 percent of its cocoa trees (World Bank, 2005). Similarly, in 2010, Hurricane Tomas caused major damage to St. Vincent and the Grenadines, reducing the productive sector by 54 percent. Twenty-seven percent of the infrastructure sector was also impacted, with telecommunications, electricity and the road network being affected, which can indirectly reduce exports (ECLAC, 2011).

**Table 2. Impact of Hurricanes on Exports of Goods (wind index DAMAGE 203)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| DAMAGE 203 | -0.515*** | -0.531*** | -0.560*** | -0.579*** | -0.523*** | -0.547*** | -0.583*** | -0.610*** |
| | (0.175) | (0.175) | (0.175) | (0.176) | (0.172) | (0.173) | (0.173) | (0.173) |
| DAMAGE 203 lag1 | | -0.272 | -0.303** | -0.322** | | -0.281 | -0.327* | -0.348** |
| | | (0.175) | (0.176) | (0.176) | | (0.174) | (0.174) | (0.174) |
| DAMAGE 203 lag2 | | | -0.494*** | -0.514*** | | | -0.496*** | -0.533*** |
| | | | (0.175) | (0.176) | | | (0.174) | (0.174) |
| DAMAGE 203 lag3 | | | | -0.294* | | | | -0.279 |
| | | | | (0.176) | | | | (0.174) |
| REER | | | | | 0.00702*** | 0.00210 | 0.00226 | 0.000836 |
| | | | | | (0.00144) | (0.00589) | (0.00588) | (0.00590) |
| REER lag1 | | | | | | 0.00514 | -0.00387 | -0.00246 |
| | | | | | | (0.00589) | (0.00810) | (0.00811) |
| REER lag2 | | | | | | | 0.00929 | -0.00239 |
| | | | | | | | (0.00590) | (0.00811) |
| REER lag3 | | | | | | | | 0.0121** |
| | | | | | | | | (0.00580) |
| Observations | 1,812 | 1,811 | 1,810 | 1,809 | 1,692 | 1,690 | 1,688 | 1,686 |
| R-squared | 0.195 | 0.195 | 0.199 | 0.199 | 0.175 | 0.176 | 0.181 | 0.185 |
| Number of id | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |

*Notes:* (a) *** and ** 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators. (c) regression error terms clustered at country level.

**Table 3. Impact of Hurricanes on Exports of Goods (wind index DAMAGE 278)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| DAMAGE 278 | -1.249*** | -1.294*** | -1.364*** | -1.406*** | -1.272*** | -1.334*** | -1.419*** | -1.479*** |
| | (0.422) | (0.423) | (0.423) | (0.423) | (0.416) | (0.416) | (0.416) | (0.416) |
| DAMAGE 278 lag1 | | -0.802** | -0.876** | -0.919** | | -0.825** | -0.933** | -0.980** |
| | | (0.423) | (0.423) | (0.423) | | (0.418) | (0.418) | (0.418) |
| DAMAGE 278 lag2 | | | -1.253*** | -1.298*** | | | -1.262*** | -1.343*** |
| | | | (0.423) | (0.423) | | | (0.417) | (0.418) |
| DAMAGE 278 lag3 | | | | -0.706** | | | | -0.682 |
| | | | | (0.423) | | | | (0.418) |
| REER | | | | | 0.00702*** | 0.00219 | 0.00230 | 0.000899 |
| | | | | | (0.00144) | (0.00587) | (0.00587) | (0.00589) |
| REER lag1 | | | | | | 0.00504 | -0.00415 | -0.00281 |
| | | | | | | (0.00587) | (0.00807) | (0.00808) |
| REER lag2 | | | | | | | 0.00953 | -0.00219 |
| | | | | | | | (0.00588) | (0.00809) |
| REER lag3 | | | | | | | | 0.0121** |
| | | | | | | | | (0.00578) |
| Observations | 1,812 | 1,811 | 1,810 | 1,809 | 1,692 | 1,690 | 1,688 | 1,686 |
| R-squared | 0.195 | 0.196 | 0.200 | 0.200 | 0.175 | 0.177 | 0.183 | 0.186 |
| Number of id | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

Table 4 illustrates the regression results for the impact of tropical storms on imports. Column (1) shows the coefficients using DAMAGE 203, which is negative and significant, suggesting that hurricanes cause imports to decline in Eastern SIDS in the month of their occurrence. Columns (2), (3), and (4) include lagged effects which are insignificant. The results therefore show that the average non-zero hurricane strike is associated with an 11 percent decrease in imports in the month of a strike.[5] Columns (5), (6), (7) and (8) show the results for DAMAGE 203 along with the REER ,which again shows that hurricanes adversely affect imports, while the REER has a positive and significant effect in the month of a strike (for every 1 percent increase in the REER imports increase by 0.015 percent) and becomes insignificant once lags were added except for three months later (where imports increase by 0.02 percent). Table 5 presents the estimated coefficients using DAMAGE 278, which confirms the initial finding that hurricanes decrease imports in the month of their happening, with the REER having a small positive impact in the month of a strike and month 3 after a strike.

The absence of an increase in imports in the months following a hurricane hit in the Eastern Caribbean indicates that consumption smoothing from an increase in imports to replace domestic production did not immediately take place. Similarly, the immediate import of relief supplies,

[5] If we consider the average (non-zero) value of DAMAGE 203 (0.118) then the coefficient (-0.928) implies that an average destructive tropical storm decreases monthly imports by 11 percent (0.118*(-0.928)).

reconstruction goods and capital did not take place. Reports show that Hurricane Maria in 2017 destroyed 100 percent of Dominica's crops. Since 25 percent of the workforce depends on agriculture, their food security and livelihoods were compromised, as imports were also negatively affected (United Nations, 2017). The port in Grenada, in contrast, recovered only one month after being struck by Hurricane Ivan, which then allowed for the increased traffic volume of relief and reconstruction material (World Bank, 2005).

**Table 4. Impact of Hurricanes on Imports of Goods (wind index DAMAGE 203)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| DAMAGE 203 | -0.928*** | -0.944*** | -0.955*** | -0.968*** | -0.929*** | -0.967*** | -0.989*** | -1.017*** |
| | (0.291) | (0.292) | (0.292) | (0.293) | (0.294) | (0.295) | (0.295) | (0.296) |
| DAMAGE 203 lag1 | | -0.258 | -0.271 | -0.283 | | -0.254 | -0.289 | -0.307 |
| | | (0.292) | (0.293) | (0.293) | | (0.296) | (0.297) | (0.298) |
| DAMAGE 203 lag2 | | | -0.198 | -0.211 | | | -0.202 | -0.245 |
| | | | (0.292) | (0.293) | | | (0.297) | (0.298) |
| DAMAGE 203 lag3 | | | | -0.197 | | | | -0.174 |
| | | | | (0.293) | | | | (0.298) |
| REER | | | | | 0.015*** | 0.0002 | 5.46e-05 | -0.002 |
| | | | | | (0.002) | (0.010) | (0.010) | (0.010) |
| REER lag1 | | | | | | 0.016 | 0.001 | 0.003 |
| | | | | | | (0.010) | (0.014) | (0.014) |
| REER lag2 | | | | | | | 0.015 | -0.006 |
| | | | | | | | (0.010) | (0.014) |
| REER lag3 | | | | | | | | 0.022** |
| | | | | | | | | (0.009) |
| Observations | 1,812 | 1,811 | 1,810 | 1,809 | 1,692 | 1,690 | 1,688 | 1,686 |
| R-squared | 0.228 | 0.227 | 0.227 | 0.226 | 0.230 | 0.231 | 0.231 | 0.233 |
| Number of id | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |

*Notes:* (a) *** and ** 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

**Table 5. Impact of Hurricanes on Imports of Goods (wind index DAMAGE 278)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| DAMAGE 278 | -2.366*** | -2.403*** | -2.430*** | -2.455*** | -2.376*** | -2.460*** | -2.510*** | -2.566*** |
| | (0.702) | (0.703) | (0.705) | (0.706) | (0.708) | (0.710) | (0.711) | (0.712) |
| DAMAGE 278 lag1 | | -0.645 | -0.674 | -0.700 | | -0.638 | -0.717 | -0.755 |
| | | (0.703) | (0.705) | (0.706) | | (0.713) | (0.715) | (0.715) |
| DAMAGE 278 lag2 | | | -0.489 | -0.515 | | | -0.498 | -0.591 |
| | | | (0.705) | (0.706) | | | (0.714) | (0.715) |
| DAMAGE 278 lag3 | | | | -0.421 | | | | -0.379 |
| | | | | (0.706) | | | | (0.716) |
| REER | | | | | 0.016*** | 0.0002 | -4.39e-05 | -0.002 |
| | | | | | (0.002) | (0.010) | (0.010) | (0.010) |
| REER lag1 | | | | | | 0.016 | 0.0015 | 0.003 |
| | | | | | | (0.010) | (0.014) | (0.014) |
| REER lag2 | | | | | | | 0.015 | -0.006 |
| | | | | | | | (0.010) | (0.014) |
| REER lag3 | | | | | | | | 0.022** |
| | | | | | | | | (0.009) |
| Observations | 1,812 | 1,811 | 1,810 | 1,809 | 1,692 | 1,690 | 1,688 | 1,686 |
| R-squared | 0.228 | 0.228 | 0.227 | 0.227 | 0.230 | 0.231 | 0.232 | 0.233 |
| Number of id | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |

*Notes:* (a) *** and ** 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

Tables 6 illustrates the regression results for the impact of tropical storms on net exports using DAMAGE 203. Column (1) shows that the coefficient for the impact of tropical storms on net exports is significant and positive in the month of a strike.[6] The coefficient value suggests that the average non-zero hurricane strike is associated with a 15 percent decrease in net exports in the month of a strike. Columns (2), (3), and (4) show that lagged impacts are insignificant. Column (5) shows the results for DAMAGE 203 along with the REER, which shows that hurricanes adversely affect net exports in the month of a strike, while the REER has a positive and significant effect in the month of a strike (for every 1 percent increase in the REER net exports increase by 0.015 percent). Columns (6), (7) and (8) show the results when lags are added for the REER. Table 7 presents the estimated coefficients using DAMAGE 278, which confirms the initial finding that hurricanes decrease net exports in the month of their occurrence, with the REER having a small positive impact in the month of a strike and then three months after.

**Table 6. Impact of Hurricanes on Net Exports of Goods (wind index DAMAGE 203)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| DAMAGE 203 | -0.802*** | -0.825*** | -0.828*** | -0.831*** | -0.839*** | -0.847*** | -0.844*** | -0.836*** |
| | (0.168) | (0.168) | (0.168) | (0.168) | (0.163) | (0.163) | (0.163) | (0.163) |
| DAMAGE 203 lag1 | | -0.437*** | -0.440*** | -0.443*** | | -0.473*** | -0.462*** | -0.462*** |
| | | (0.168) | (0.168) | (0.168) | | (0.164) | (0.164) | (0.164) |
| DAMAGE 203 lag2 | | | -0.0449 | -0.0482 | | | -0.0862 | -0.0703 |
| | | | (0.168) | (0.168) | | | (0.164) | (0.164) |
| DAMAGE 203 lag3 | | | | -0.0557 | | | | -0.0979 |
| | | | | (0.168) | | | | (0.164) |
| REER | | | | | -0.015*** | -0.002 | -0.001 | -0.001 |
| | | | | | (0.002) | (0.005) | (0.005) | (0.005) |
| REER lag1 | | | | | | -0.014*** | -0.003 | -0.004 |
| | | | | | | (0.005) | (0.007) | (0.00711) |
| REER lag2 | | | | | | | -0.012** | 0.002 |
| | | | | | | | (0.005) | (0.007) |
| REER lag3 | | | | | | | | -0.015*** |
| | | | | | | | | (0.005) |
| Observations | 1,572 | 1,572 | 1,572 | 1,572 | 1,452 | 1,451 | 1,450 | 1,449 |
| R-squared | 0.721 | 0.723 | 0.723 | 0.723 | 0.728 | 0.731 | 0.732 | 0.733 |
| Number of id | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |

*Notes:* (a) *** and ** 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

[6] If we consider the average (non-zero) value of DAMAGE 203 (0.118) then the coefficient (-0.825 and -0.437) implies that an average destructive tropical storm decreases monthly net exports by 15 percent (0.118*(-1.262)).

**Table 7. Impact of Hurricanes on Net Exports of Goods (wind index DAMAGE 278)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| DAMAGE 278 | -1.873*** | -1.924*** | -1.928*** | -1.930*** | -1.956*** | -1.971*** | -1.964*** | -1.939*** |
| | (0.416) | (0.416) | (0.417) | (0.418) | (0.405) | (0.404) | (0.404) | (0.404) |
| DAMAGE 278 lag1 | | -1.012** | -1.016** | -1.018** | | -1.092*** | -1.063*** | -1.058*** |
| | | (0.416) | (0.417) | (0.418) | | (0.406) | (0.407) | (0.406) |
| DAMAGE 278 lag2 | | | -0.0725 | -0.0743 | | | -0.172 | -0.129 |
| | | | (0.417) | (0.418) | | | (0.406) | (0.406) |
| DAMAGE 278 lag3 | | | | -0.0324 | | | | -0.133 |
| | | | | (0.418) | | | | (0.407) |
| REER | | | | | -0.015*** | -0.002 | -0.002 | -0.001 |
| | | | | | (0.002) | (0.005) | (0.005) | (0.005) |
| REER lag1 | | | | | | -0.014*** | -0.003 | -0.003 |
| | | | | | | (0.005) | (0.007) | (0.007) |
| REER lag2 | | | | | | | -0.012** | 0.002 |
| | | | | | | | (0.005) | (0.007) |
| REER lag3 | | | | | | | | -0.015*** |
| | | | | | | | | (0.005) |
| Observations | 1,572 | 1,572 | 1,572 | 1,572 | 1,452 | 1,451 | 1,450 | 1,449 |
| R-squared | 0.721 | 0.722 | 0.722 | 0.722 | 0.728 | 0.730 | 0.731 | 0.732 |
| Number of id | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

Tables 8, 9, and 10 show the results for the mediation analysis, which seeks to determine the mediating role of the REER with regard to the impact of hurricanes on exports, imports, and net exports. As seen in Table 8, when the DAMAGE 203 destruction index is used, for exports the average treatment effect is -1.766 and significant while the average direct treatment effect is -1.769 and insignificant. The average mediation treatment effect is 0.003 and insignificant. Accordingly, the REER plays no mediating role in explaining the impact of tropical storm damage on exports. More precisely, the observed average negative treatment effect of damages on exporting activity does not work through the REER. The corresponding values using DAMAGE 278 and exports give the same results. Examining the results for imports and net exports, one draws a similar conclusion for these, that is, tropical storms do not reduce imports and net exports through possible indirect impacts on the REER.[7] That the REER does not play a mediating role may result from the fixed exchange rate regimes of Eastern Caribbean SIDS. There is evidence in the literature that a fixed exchange rate can almost completely buffer an appreciation of the REER following external shocks, including tropical storms (Strobl and Kablan, 2017, and Bénétrix and Lane, 2013).

[7] Using data from the Caribbean Tourism Organization, monthly tourist arrivals was tried as a mediator, but no effect was found. Monthly inflation rate data from the ECCB, though limited, were also tried as a mediator but likewise showed no effect.

**Table 8. Mediation Analysis, Exports of Goods**

| | Estimate | 95% Bootstrapped CI |
|---|---|---|
| *DAMAGE 203* | | |
| Average treatment effect (ATE) | -1.766** | [-3.475, -0.057] |
| Average direct treatment effect (ACDE) | -1.769 | [-3.574, 0.035] |
| Average mediation treatment effect (AME) | 0.003 | [-0.212, 0.219] |
| *DAMAGE 278* | | |
| Average Treatment effect (ATE) | -4.472** | [-8.521, -0.423] |
| Average direct treatment effect (ACDE) | -4.483** | [-8.344, -.622] |
| Average mediation treatment effect (AME) | 0.011 | [-0.454, 0.477] |

*Notes:* (a) *** and ** indicate 1 and 5 percent significance levels, respectively. (b) Standard errors generated using 500 bootstrapped samples clustered at the country level.

**Table 9. Mediation Analysis, Imports of Goods**

| | Estimate | 95% Bootstrapped CI |
|---|---|---|
| *DAMAGE 203* | | |
| Average Treatment effect (ATE) | -1.730*** | [-2.458, -1.001] |
| Average direct treatment effect (ACDE) | -1.701*** | [-2.529, -0.874] |
| Average mediation treatment effect (AME) | -0.028 | [-0.134, 0.077] |
| *DAMAGE 278* | | |
| Average Treatment effect (ATE) | -4.159*** | [-5.961, -2.357] |
| Average direct treatment effect (ACDE) | -4.102*** | [-6.084, -2.121] |
| Average mediation treatment effect (AME) | -0.057 | [-0.319, 0.205] |

*Notes:* (a) *** and ** indicate 1 and 5 percent significance levels, respectively. (b) Standard errors generated using 500 bootstrapped samples clustered at the country level.

**Table 10. Mediation Analysis, Net Exports**

| | Estimate | 95% Bootstrapped CI |
|---|---|---|
| *DAMAGE 203* | | |
| Average Treatment effect (ATE) | -0.800*** | [-1.151, -0.449] |
| Average direct treatment effect (ACDE) | -0.839** | [-1.285,-0.392] |
| Average mediation treatment effect (AME) | 0.038 | [-0.014, 0.091] |
| *DAMAGE 278* | | |
| Average Treatment effect (ATE) | -1.868*** | [-2.693, -1.043] |
| Average direct treatment effect (ACDE) | -1.956*** | [-3.131, -0.782] |
| Average mediation treatment effect (AME) | 0.088 | [-.061, 0.237] |

*Notes:* (a) *** and ** indicate 1 and 5 percent significance levels, respectively. (b) Standard errors generated using 500 bootstrapped samples clustered at the country level.

It is also interesting to consider results using quarterly data for exports are shown in Table A1 using DAMAGE 203 and Table A2 using DAMAGE 278 in the Appendix. The majority of the results are insignificant, except there was a negative and significant coefficient for exports in the quarter after a strike for DAMAGE 278. The results for imports are shown in Tables A3 and A4 in the Appendix, which again illustrate insignificant results when quarterly data were used. Tables A5 to A8 in the Appendix give the results using annual data, which likewise show insignificant results. These results indicate that lower-frequency data such as quarterly and annual give mostly insignificant results for hurricane damages and international trade and that hurricane damages to exports and imports are more immediate and are better captured by high-frequency monthly data.

While it is possible that hurricane shocks could result in trade spillovers from one island to another, the lack of bilateral data makes this outcome difficult to measure. Tables A9 and A10 in the Appendix gives the top 5 export and import partners, respectively, and the share of exports and imports for countries under study to attempt an indirect assessment. The main export partner for most Eastern Caribbean SIDS is the United States, but France in the case of Montserrat, and the United Arab Emirates for Antigua and Barbuda. Other key export partners include other Caribbean countries outside of the Eastern Caribbean, namely Guyana, Trinidad and Tobago, and Barbados. Similarly, the main import partner for Eastern Caribbean countries is the United States, followed by Trinidad and Tobago, with other key import partners being China and the United Kingdom.

As a robustness check falsification tests were used. Specifically, the Fisherian randomization inference test was used following Heß (2017). The p-values for the treatment variable DAMAGE 203 and DAMAGE 278 for exports and imports are low and very similar to the regression values estimated in the initial regressions.[8]

## 6. Discussion

The Caribbean may see an increase in the frequency and intensity of hurricanes and similar weather events because of climate change, with an increase in destruction and economic costs, particularly in the absence of appropriate mitigation and adaptation measures. This in turn would have large

[8] The p-values are based on 2,000 draws from the distribution of the treatment effect estimate under the null hypothesis of no effect. The p-value for DAMAGE 203 and DAMAGE 278 for exports is 0.000. The p-value for DAMAGE 203 for imports is 0.01 and for DAMAGE 278 the p-value is 0.007.

macroeconomic spillover effects given the importance of international trade to the local economies of Eastern Caribbean countries.

The observed fall in exports in the month of a hurricane and up to three months after means a reduction in income, employment and tax revenues to help fund post-disaster recovery. Similarly, a fall in imports in the month of a strike suggests a fall in goods for consumption smoothing, clean-up and reconstruction, thereby impacting lives and livelihoods, hampering recovery efforts, and hindering efforts to build long-term resilience.

International trade, however, can act as a shock absorber for natural disasters. Imports from unaffected places help to curb supply shortages in countries that are affected by natural disaster strikes and allow for urgently needed clean-up and reconstruction materials including food, medicines, building material and equipment which are critical in any post-disaster recovery. In the wake of a disaster, exports become even more important to sustain income and jobs and to earn foreign exchange needed to pay for imports.

Trade, however, does not take place automatically. Wilkinson and Stevens (2020) state that tariff and non-tariff barriers and economic and administrative barriers can impinge on relief and recovery efforts following a natural disaster. In addition, during the disaster response phase import systems can experience a sudden surge in the volume of relief supplies, and inefficient customs clearance procedures can lead to perishable goods such as food being held up in ports for months and going to waste. For instance, container traffic into the damaged port of Roseau in Dominica following Hurricane Maria increased from an average of 80 containers per week to a peak of 300 containers, which the country could not deal with (WTO, 2018). Given these challenges, an open, rules-based trading system can support resilience in the face of natural disasters since there is evidence that countries with an open and competitive market are better prepared for a disaster, better able to respond when it strikes, and able to recover more quickly in the aftermath (WTO, 2018). Additionally, trade facilitation can act as a tool to disaster response, recovery, and resilience since it can help facilitate important humanitarian relief goods get to where they are needed when disaster strikes (Wilkinson and Stevens, 2020).

Research by the World Bank shows that a common complaint by the humanitarian community is that a country's customs procedures can delay disaster response, leaving life-saving goods stuck at borders, while standards conformity procedures and certification processes for medicines can slow the delivery of much-needed relief items (World Bank, 2015b). The study documents the case of Nepal after a devasting earthquake in April 2015. The country struggled to cope with an import surge of assistance that arrived after the disaster and found it difficult to distinguish relief assistance from normal commercial transactions. By bringing together agencies responsible for trade clearance and humanitarian actors and making use of a single window system, Nepal was able to streamline processes and reduce clearance times to 15-20 minutes (World Bank, 2015b). In another example from the study, the Philippines implemented a one-stop shop, simplified customs clearance procedures and duty-free/tax-free entry for relief items as part of its disaster contingency measures, given that the country has to cope with 10 to 20 typhoons annually (World Bank, 2015b). These measures can similarly be adopted by Eastern Caribbean SIDS to facilitate trade when hurricanes occur.

In addition, ex ante and/or ex post international trade and trade policy can and should play a role in dealing with extreme weather events in the case of Eastern Caribbean countries and small island economies more generally. For example, the World Trade Organization's Trade Facilitation Agreement (TFA) can act as a catalyst for reform of customs and other border clearance systems to reduce clearing times (WTO, 2018). Implementing the TFA can reduce trade complexity and support both relief and recovery efforts following a natural disaster by facilitating the release and clearance of goods, promoting border agency cooperation, providing for the establishment of a single window and enhancing customs cooperation (Wilkinson and Stevens, 2020). The need for such measures is illustrated by the experience of The Bahamas following Hurricane Dorian in September 2019, when the country struggled to distinguish relief assistance from unsolicited bilateral donations and normal commercial transactions. Following these complications, The Bahamas planned to incorporate a TFA to embed resilience into its regulatory framework and thus improve natural disaster response and recovery.

Trade policy that reduces pressure is also important to provide clearer and more streamlined trading procedures, reflecting international best practices for the swift release of critical goods. An immediate response could involve offering special preferences to lower the cost of imports when disasters strike to aid the recovery process. Technical and financial assistance could also be offered to facilitate an expansion of exports during times of disasters, and diversified supply chain networks could also be built (WTO, 2018). This might prove particularly important for Caribbean SIDS; they have a narrow range of exports in agriculture, which are particularly vulnerable to disasters, and a narrow range of export markets, which often include other Caribbean islands also impacted by the same natural disaster. The economic impacts of natural disaster can further be reduced by creating a diversified export base (i.e., including value-added, processed agricultural products) and finding trade partners outside the region.

It is also necessary to go beyond providing temporary relief when natural disasters occur and begin addressing climate change as an underlying cause of those disasters. While it is important for governments to take action on climate change to reduce greenhouse gas emission (i.e., mitigation), climate adaptation is also needed to lessen the impact of natural disasters. Oh (2010) suggest that countries could construct levees to protect ports and other transportation infrastructures from storms and floods; they could also stockpile goods and relocate industrial facilities producing for export to less vulnerable areas. It is also important for governments to implement measures to support recovery in the agriculture sector. Additionally, specialized international insurance programs can be developed, such as the Caribbean Catastrophe Risk Insurance Facility. Such measures are particularly important for Eastern Caribbean SIDS, which face limited fiscal space and domestic finance for climate adaptation and mitigation at the same time as the high-income status of the majority of these countries makes access to international finance challenging (Mohan, 2022, and Mohan and Strobl, 2021).

# Appendix

### Table A1. Impact of Hurricanes on Exports of Goods, Quarter (wind index DAMAGE 203)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| DAMAGE 203 | -0.520 | -0.653 | -0.655 | -0.658 |
| | (0.396) | (0.402) | (0.403) | (0.403) |
| DAMAGE 203 lag1 | | -0.716 | -0.717 | -0.716 |
| | | (0.402) | (0.403) | (0.403) |
| DAMAGE 203 lag2 | | | 0.100 | 0.0324 |
| | | | (0.396) | (0.403) |
| DAMAGE 203 lag3 | | | | -0.358 |
| | | | | (0.403) |
| Observations | 640 | 639 | 638 | 637 |
| R-squared | 0.133 | 0.137 | 0.137 | 0.137 |
| Number of id | 8 | 8 | 8 | 8 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

### Table A2. Impact of Hurricanes on Exports of Goods, Quarter (wind index DAMAGE 278)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| DAMAGE 278 | -1.430 | -1.776 | -1.778 | -1.787 |
| | (0.952) | (0.966) | (0.967) | (0.968) |
| DAMAGE 278 lag1 | | -1.939** | -1.940** | -1.940** |
| | | (0.966) | (0.967) | (0.968) |
| DAMAGE 278 lag2 | | | 0.120 | -0.0511 |
| | | | (0.952) | (0.968) |
| DAMAGE 278 lag3 | | | | -0.949 |
| | | | | (0.968) |
| Observations | 640 | 639 | 638 | 637 |
| R-squared | 0.134 | 0.139 | 0.139 | 0.139 |
| Number of id | 8 | 8 | 8 | 8 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

### Table A3. Impact of Hurricanes on Imports of Goods, Quarter (wind index DAMAGE 203)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| findex_203_max | -0.242 | -0.235 | -0.236 | -0.235 |
| | (0.387) | (0.395) | (0.395) | (0.396) |
| findex_203_max_lag1 | | 0.0360 | 0.0361 | 0.0353 |
| | | (0.395) | (0.395) | (0.396) |
| findex_203_max_lag2 | | | 0.121 | 0.165 |
| | | | (0.389) | (0.396) |
| findex_203_max_lag3 | | | | 0.237 |
| | | | | (0.396) |
| Observations | 640 | 639 | 638 | 637 |
| R-squared | 0.345 | 0.345 | 0.344 | 0.343 |
| Number of id | 8 | 8 | 8 | 8 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

**Table A4. Impact of Hurricanes on Imports of Goods, Quarter (wind index DAMAGE 278)**

| Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| DAMAGE 278 | -0.619 | -0.590 | -0.591 | -0.587 |
| | (0.933) | (0.949) | (0.951) | (0.952) |
| DAMAGE 278 lag1 | | 0.157 | 0.157 | 0.155 |
| | | (0.949) | (0.951) | (0.952) |
| DAMAGE 278 lag2 | | | 0.397 | 0.513 |
| | | | (0.936) | (0.952) |
| DAMAGE 278 lag3 | | | | 0.646 |
| | | | | (0.952) |
| Observations | 640 | 639 | 638 | 637 |
| R-squared | 0.345 | 0.345 | 0.344 | 0.343 |
| Number of id | 8 | 8 | 8 | 8 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

**Table A5. Impact of Hurricanes on Exports of Goods, Annual (wind index DAMAGE 203)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| DAMAGE 203 | -0.569 | -0.618 | -0.634 | -0.621 |
| | (0.643) | (0.647) | (0.651) | (0.653) |
| DAMAGE 203 lag1 | | -0.393 | -0.402 | -0.408 |
| | | (0.647) | (0.652) | (0.654) |
| DAMAGE 203 lag2 | | | 0.271 | 0.288 |
| | | | (0.651) | (0.654) |
| DAMAGE 203 lag3 | | | | 0.868 |
| | | | | (0.695) |
| Observations | 160 | 159 | 158 | 157 |
| R-squared | 0.177 | 0.178 | 0.175 | 0.182 |
| Number of id | 8 | 8 | 8 | 8 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

**Table A6. Impact of Hurricanes on Exports of Goods, Annual (wind index DAMAGE 278)**

| Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| DAMAGE 278 | -1.768 | -1.894 | -1.925 | -1.883 |
| | (1.513) | (1.521) | (1.532) | (1.536) |
| DAMAGE 278 lag1 | | -1.184 | -1.210 | -1.177 |
| | | (1.521) | (1.533) | (1.537) |
| DAMAGE 278 lag2 | | | | 0.267 |
| | | | | (0.652) |
| DAMAGE 278 lag3 | | | | 2.084 |
| | | | | (1.624) |
| Observations | 160 | 159 | 158 | 157 |
| R-squared | 0.181 | 0.183 | 0.180 | 0.188 |
| Number of id | 8 | 8 | 8 | 8 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

## Table A7. Impact of Hurricanes on Imports of Goods, Annual (wind index DAMAGE 203)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| DAMAGE 203 | 0.107 | 0.126 | 0.132 | 0.113 |
| | (0.595) | (0.601) | (0.605) | (0.609) |
| DAMAGE 203 lag1 | | 0.403 | 0.420 | 0.395 |
| | | (0.601) | (0.606) | (0.610) |
| DAMAGE 203 lag2 | | | 0.429 | 0.411 |
| | | | (0.605) | (0.609) |
| DAMAGE 203 lag3 | | | | 0.245 |
| | | | | (0.647) |
| Observations | 160 | 159 | 158 | 157 |
| R-squared | 0.346 | 0.345 | 0.342 | 0.335 |
| Number of id | 8 | 8 | 8 | 8 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

## Table A8. Impact of Hurricanes on Imports of Goods, Annual (wind index DAMAGE 278)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| DAMAGE 278 | 0.187 | 0.241 | 0.285 | 0.253 |
| | (1.404) | (1.415) | (1.424) | (1.434) |
| DAMAGE 278 lag1 | | 1.123 | 1.178 | 1.141 |
| | | (1.415) | (1.425) | (1.434) |
| DAMAGE 278 lag2 | | | 1.242 | 1.213 |
| | | | (1.424) | (1.434) |
| DAMAGE 278 lag3 | | | | 0.759 |
| | | | | (1.516) |
| Observations | 160 | 159 | 158 | 157 |
| R-squared | 0.345 | 0.346 | 0.344 | 0.338 |
| Number of id | 8 | 8 | 8 | 8 |

*Notes:* (a) ∗∗∗ and ∗∗ 1 and 5 percent significance levels, respectively; (b) all regressions include year and month dummy indicators; (c) regression error terms clustered at country level.

## Table A9. Eastern Caribbean SIDS Major Export Partners

| Country | Export Partner | Export Partner Share (%) |
|---|---|---|
| Anguilla | Guyana | 38.26 |
| | Netherlands Antilles | 37.51 |
| | United States | 17.01 |
| | United Kingdom | 1.85 |
| | France | 1.21 |
| Antigua and Barbuda | United Arab Emirates | 52.75 |
| | United States | 9.8 |
| | Netherlands | 7.62 |
| | Saint Maarten (Dutch part) | 6 |
| | St Lucia | 3.16 |
| Dominica | Trinidad and Tobago | 18.76 |
| | Jamaica | 16.23 |
| | St. Kitts and Nevis | 14.34 |
| | Guyana | 9.52 |
| | France | 8.77 |
| Grenada | United States | 20.63 |
| | Trinidad and Tobago | 7.7 |
| | St. Vincent and the Grenadines | 6.88 |
| | United Kingdom | 3.25 |
| | Barbados | 2.78 |
| Montserrat | France | 43.4 |
| | Antigua and Barbuda | 25.38 |
| | British Virgin Islands | 8.08 |
| | United States | 5.35 |
| | Anguilla | 4.57 |
| St Kitts and Nevis | United States | 68.68 |
| | St. Lucia | 6.82 |
| | Trinidad and Tobago | 6.53 |
| | Antigua and Barbuda | 2.81 |
| | Dominica | 2.11 |
| St Lucia | United States | 33.88 |
| | Barbados | 10.68 |
| | Trinidad and Tobago | 8.31 |
| | United Kingdom | 7.97 |
| | Dominica | 7.35 |
| St Vincent and the Grenadines | Barbados | 18.17 |
| | Dominica | 14.61 |
| | St. Lucia | 12.2 |
| | Antigua and Barbuda | 11.4 |
| | United States | 10.67 |

*Source:* Author’s compilation based on World Bank World Integrated Trade Solution.

## Table A10. Eastern Caribbean SIDS Major Import Partners

| Country | Import Partner | Import Partner Share (%) |
|---|---|---|
| Anguilla | United States | 59.42 |
| | Trinidad and Tobago | 14.47 |
| | Netherlands Antilles | 7.55 |
| | Canada | 2.1 |
| | Guyana | 1.99 |
| Antigua and Barbuda | United States | 50.67 |
| | China | 7.39 |
| | Japan | 4.41 |
| | Trinidad and Tobago | 4 |
| | Curaçao | 3.25 |
| Dominica | United States | 36.76 |
| | Trinidad and Tobago | 16.99 |
| | United Kingdom | 3.96 |
| | China | 2.42 |
| | Japan | 2.37 |
| Grenada | United States | 37.61 |
| | Trinidad and Tobago | 19.19 |
| | Cayman Islands | 7.2 |
| | Barbados | 4.82 |
| | United Kingdom | 4.04 |
| Montserrat | United States | 67.79 |
| | United Kingdom | 6.65 |
| | Trinidad and Tobago | 6.19 |
| | Japan | 2.57 |
| | China | 1.85 |
| St Kitts and Nevis | United States | 67.05 |
| | Trinidad and Tobago | 4.41 |
| | Canada | 2.68 |
| | Japan | 2.66 |
| | China | 2.56 |
| St Lucia | United States | 42.74 |
| | Trinidad and Tobago | 16.03 |
| | China | 5.42 |
| | United Kingdom | 4.77 |
| | Japan | 3.48 |
| St Vincent and the Grenadines | United  States | 40.69 |
| | Trinidad and Tobago | 15.22 |
| | United Kingdom | 6.77 |
| | China | 6.23 |
| | Japan | 2.4 |

*Source:* Author's compilation based on World Bank World Integrated Trade Solution.

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