UNITED NATIONS UNIVERSITY

UNU-WIDER

World Institute for Development Economics Research

Research Paper No. 2008/25

Analysing the Impact of Natural Hazards in Small Economies

The Caribbean Case

Martin Heger,[1] Alex Julca,[2] and Oliver Paddison[2]

March 2008

Abstract

This paper analyses the impact of natural disasters in the Caribbean. The economic impact of natural disasters in the region has been significant, resulting in widespread destruction of the productive economy. This paper presents the main macroeconomic impact of disasters, e.g., a deteriorating fiscal balance, a collapse of growth and a worsening external balance, as a consequence of damage resulting from the event. By making special reference to the small-island developing state nature of many countries in the region, valuable lessons of the impact of such disasters on the capital stock can be learnt, particularly as the interruption of production of goods and services can be particularly devastating in an environment where few large sectors (agriculture, tourism) dominate the economic landscape.

Keywords: natural disasters, Caribbean, diversification, trade and environment

JEL classification: Q54, O54, L25, F14

[1] University of Hawaii at Manoa, Department of Natural Resources and Environmental Management, email: mheger@hawaii.edu; [2] Development Policy and Analysis Division, UN-DESA, New York, emails: julca@un.org (A. Julca); paddison@un.org (O. Paddison)

This is a revised version of a paper originally prepared for the UNU-WIDER conference on Fragile States–Fragile Groups, directed by Mark McGillivray and Wim Naudé. The conference was jointly organized by UNU-WIDER and UN-DESA, with a financial contribution from the Finnish Ministry for Foreign Affairs.

UNU-WIDER gratefully acknowledges the contributions to its project on Fragility and Development from the Australian Agency for International Development (AusAID), the Finnish Ministry for Foreign Affairs, and the UK Department for International Development—DFID. Programme contributions are also received from the governments of Denmark (Royal Ministry of Foreign Affairs), Norway (Royal Ministry of Foreign Affairs) and Sweden (Swedish International Development Cooperation Agency—Sida).

ISSN 1810-2611 ISBN 978-92-9230-071-5

Acknowledgements

Comments and suggestions received from participants at the UNU-WIDER Conference on Fragile States – Fragile Groups: Tackling Economic and Social Vulnerability held in Helsinki, 16-17 June 2007, and from Esteban Perez, Ana Cortez, Richard Kozul-Wright and Rob Vos are greatly appreciated. The opinions expressed in this paper are those of the authors only. Usual disclaimers apply.

Acronyms

BPoA	Barbados Programme of Action
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CRED	Centre for Research on the Epidemiology of Disasters
SIDS	small island developing states

The World Institute for Development Economics Research (WIDER) was established by the United Nations University (UNU) as its first research and training centre and started work in Helsinki, Finland in 1985. The Institute undertakes applied research and policy analysis on structural changes affecting the developing and transitional economies, provides a forum for the advocacy of policies leading to robust, equitable and environmentally sustainable growth, and promotes capacity strengthening and training in the field of economic and social policy making. Work is carried out by staff researchers and visiting scholars in Helsinki and through networks of collaborating scholars and institutions around the world.

www.wider.unu.edu *publications@wider.unu.edu*

UNU World Institute for Development Economics Research (UNU-WIDER)
Katajanokanlaituri 6 B, 00160 Helsinki, Finland

Typescript prepared by Liisa Roponen at UNU-WIDER

1 Introduction

The Caribbean region is characterized by great diversity.[1] This manifests itself not only in the population size, ranging from less than 50,000 (St Kitts and Nevis), to close to nine million (the Dominican Republic), but also in the dispersion of income per capita, ranging from approximately US$500 (in Haiti) to over US$17,000 in the Bahamas. Similarly, alongside linguistic diversity, with Dutch, French, Spanish, English as well as Papiamento, Maroon and Creole being spoken in the region, there are also notable cultural influences stemming from Western Europe, North America as well as Africa and Asia.

Despite this diversity, by and large economies in the region face common challenges. For one, as small countries they must overcome many disadvantages resulting from their small island developing states (SIDS) nature. These include, for example, exhibiting a high degree of specialization owing to the narrow range of resources available to them as well as the inability to take advantage of economies of scale owing to small domestic and regional markets. They also include being overly dependent on international trade and thereby particularly vulnerable to global trade developments as well as coping with the pressures that high population density, despite having relatively small populations, exerts on the limited resource supply. These challenges are in fact well accepted and were in such acknowledged at, *inter alia*, the Global Conference on SIDS in Barbados in 1994, which resulted in the 'Barbados Programme of Action' (BPoA) and set forth procedures for governments, national, regional and international organizations to realize the sustainable development objectives that were defined in Agenda 21 of the Rio Declaration.[2]

A further common feature of particular relevance to the majority of Caribbean economies is that they are particularly vulnerable to natural and environmental disasters owing to their dependence on agriculture and tourism. This too is explicitly emphasized in the BPoA.[3] In this view, the concept of vulnerability needs, however, first to be placed into context and be properly defined, not only when dealing with SIDS and their susceptibility to suffering adverse impacts of natural hazards in particular, but also as there is no generally accepted, universal definition of *vulnerability*.[4]

---

1 In the context of this paper, 'the Caribbean' refers, unless otherwise noted, to the following island economies: Antigua and Barbuda, the Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Puerto Rico, St Lucia, St Kitts and Nevis, St Vincent and the Grenadines, Trinidad and Tobago. It also includes Suriname, Belize and Guyana which, whilst non-islands, are usually considered small-island developing states (SIDS) as they have 'island-like' features. Cuba was excluded from the sample due to the lack of available data. The same holds true for a number of islands that are non-independent (such as the US Virgin Islands, the British Virgin Islands, Martinique, the Netherlands Antilles, etc.), whilst Puerto Rico has been included owing to the general availability of data.

2 The problems and constraints of the BPoA have since been reviewed, see, for example, ECLAC (1997).

3 See United Nations (1994: 30).

4 The concept for *vulnerability* has often been defined according to needs and goals of respective authors. Thywissen (2006) presents 29 definitions of vulnerability that have been identified in the literature.

Typically, the concept of vulnerability to natural hazards relates to two factors. On the one hand, vulnerability is determined by the frequency (incidence) and severity (intensity) of natural hazards. The second factor relates to the ability to deal with the impact of natural hazards, be it either to withstand the potential negative consequences they may have on an affected region/country or to rapidly cope with the resulting damages. Vulnerability is therefore the outcome of the interaction between exogenous factors determined, e.g., by hydro-meteorological or geological characteristics which drive the incidence and intensity of hazards, and the ability of a country/region to deal with the impact, which is in turn a function of endogenous elements. For the aim of this paper, an appealing definition of vulnerability may therefore be that of the United Nations International Strategy for Disaster Reduction:

> The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards (UN-ISDR 2004).

Therefore, a high degree of vulnerability may be the result of a high incidence and intensity of natural hazards (i.e. physical and environmental factors), as it may equally be the result of a lower incidence and intensity coupled yet with a lower ability to deal with the impact (weaker social and economic factors). This recognition is important in so far important as it emphasizes the fact that vulnerability and poverty should not be conflated. Whilst there may be a link between vulnerability and poverty (or an alternative measure of wellbeing in general), it is neither true that all poor are necessarily vulnerable, nor that the non-poor are either invulnerable or less vulnerable.

Moreover, when relating the concept of vulnerability to SIDS, one must recognize that the ‘ability to bounce back’ from the negative impact of natural hazards is particularly hampered by the characteristics which define them as small-island developing states. In particular, due to their smallness, relating either to their geographic size, their population size or indeed their relatively undiversified economic structure, there is an important structural component inherent in the concept of *vulnerability* vis-à-vis SIDS. Hence, the low degree of resilience to natural hazards in the region results from the frequent occurrence of natural disasters, defined here as a *situation or event, which overwhelms local capacity, necessitating a request to national or international level for external assistance*.[5]

The impact of such disasters is often significant and has profound consequences for economies affected, as disasters can undo years of development. For instance, a particularly active hurricane season in 2004 caused damages amounting to approximately US$3.1 billion, which translated into significant proportions of GDP, ranging from approximately 10 per cent in Jamaica to more than 200 per cent in Grenada. Moreover, such monetary aggregates of the cost of damages only capture a small element of the actual impact of the event. What such figures do not convey is the impact on the economy and on society resulting, e.g., from the loss of human life, from the disruption of public services and the adverse impact thereof on human well-being (break-up of families due to migration, increased risk of disease, lack of access to health and education facilities, worsened public infrastructure available, etc.) and consequently from the impact of increased poverty owing to the loss of livelihoods, to name but a few

5 UN-ISDR (1992).

channels. Whilst damages and losses arising from natural hazards are in principal not the obstacle to development, it may well be that the impact of these damages and losses pose a principal stumbling stone for development of many SIDS: the repeated setback resulting from the destruction of economic and social capital through natural disasters perpetuates the poverty cycle and acts as a catalyst for turning natural hazards into natural disasters per se.

This paper aims to analyse the impact of natural disasters on SIDS, focussing on the Caribbean region in particular. Whilst all countries in the Caribbean region are particularly vulnerable to natural disasters, the aim is to identify factors that may mitigate their impact as this must be considered an important component of economic policy in the region to reduce vulnerability to natural hazards.

The paper is structured as follows: section 2 section presents a typology of countries in the Caribbean region, underling their differences in terms of economic structure as well as highlights their similarity vis-à-vis vulnerability to natural hazards. Section 3 presents an econometric analysis of natural disasters in the region whilst section 4 concludes.

2 Caribbean economies

The Caribbean is comprised of many diverse, small countries: the populations of countries referred to in this study range from 8.9 million inhabitants in the Dominican Republic to 48,000 in St Kitts and Nevis. Similarly, there is a large degree of variability in income in the region, with an income per capita of over US$17,000 in the Bahamas being more than twenty fold that of Haiti, at US$500.[6]

Moreover, this diversity is also reflected in the underlying economic structure of countries in the region: whilst most are constrained by the narrow resource base of their economies, single dominant sectors that have merged in these economies differ, thus resulting in a bipolar structure that distinguishes between *service-based* economies on the one hand (referring to Antigua and Barbuda, Grenada, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, the Bahamas, Barbados and the Dominican Republic) and *resource-based* economies such as Trinidad and Tobago (petroleum), Guyana (rice, timber, sugar and gold) and Suriname (rice, gold and diamonds) on the other hand. Moreover, whilst Jamaica can be considered bipolar, with a significant extraction sector as well as strong services, Dominica and Haiti are generally considered as agricultural economies owing to the relatively important agriculture sectors (contributing 18.6 per cent and 27.9 per cent of value-added respectively, see Table 1), despite having a dominant services sector (ECLAC 2006).

Nevertheless, despite these differences within the region, there are some important similarities that all countries share. For one, all Caribbean economies are very open, with the sum of import and export ratio (relative to GDP) exceeding 100 per cent for all Caribbean countries. Likewise, given their geographic constraints and the challenges

6 See footnote 1 for the list of countries covered in this paper.

Table 1
Population size, GDP and sectoral composition (as % of value-added) of economies

Country	Total population 2005	GDP per capita (current US$) 2005	Agriculture	Industry	Services, etc.	Manufact.
Antigua and Barbuda	82,786	10,578	3.69	20.29	76.02	2.14
Bahamas	323,063	17,497(a	n/a	n/a	n/a	n/a
Barbados	269,556	11,465	3.56	16.48	79.96	6.88
Belize	291,800	3,786	16.49	17.67	65.84	9.05
Dominica	72,000	3,938	18.69	23.98	57.33	8.08
Dominican Republic	8,894,907	3,317	11.67	29.61	58.72	15.47
Grenada	106,500	4,451	8.47	23.11	68.42	5.50
Guyana	751,218	1,048	31.31	26.97	41.73	9.64
Haiti(c	8,527,777	500	27.92	16.97	55.11	8.36
Jamaica	2,654,500	3,607	5.56	32.73	61.71	13.74
Puerto Rico	3,912,054	17,685(b				
St Kitts and Nevis	48,000	9,438	3.15	27.53	69.32	10.14
St Lucia(c	164,791	5,007	5.27	18.11	76.62	5.15
St Vincent and the Grenadines	119,051	3,612	8.16	24.64	67.20	5.48
Suriname	449,238	2,986	11.16	23.50	65.34	5.37
Trinidad and Tobago	1,305,236	11,000	1.06	55.05	43.89	6.92

Notes: (a 2992; (b 2001; (c Sectoral figures relate to 2003.
Source: World Bank (2006).

Table 2
Top five export commodities as percentage of overall exports, 1970-2005

Country	1970		2005		Single top commodity
Antigua and Barbuda	94.5	(1973)	91.7		69.9
The Bahamas	97.0	(1974)	72.9	(2001)	19.2
Barbados	73.5		62.9		31.6
Belize	78.1	(1972)	90.1		26.2
Dominica	95.0	(1977)	89.8		42.7
Dominican Republic	88.1	(1972)	60.8	(2001)	17.6
Guyana	93.1		82.3		29.1
Grenada	95.3	(1977)	72.1	(2004)	40.3
Haiti	78.8		80.6	(1977)	47.7
Jamaica	83.0	(1972)	88.3		63.6
Puerto Rico	n/a	n/a	n/a	n/a	n/a
St Kitts and Nevis	89.8	(1981)	97.6		87.2
St Lucia	85.0	(1973)	73.6		24.8
St Vincent and the Grenadines	95.2	(1976)	76.4		43.7
Suriname	97.1	(1974)	96.2		77.7
Trinidad and Tobago	89.3		92.1		45.7

Source: Own calculations based on UN ComTrade Database.

arising from their smallness, taking advantage of economies of scale is limited for the majority of countries. This in turn has translated into dependency on imports for the majority of goods consumed within countries as well as the emergence of a relatively limited export base. Moreover, increased specialization to compensate for lack of economies of scale and remain competitive in an increasingly global environment has contributed to high degrees of export concentration. In fact, only in five countries do the five main export goods/commodities account for less than three quarters of overall exports. In fact, in five countries they represent more than 90 per cent of overall exports (see Table 2). Moreover, this percentage has increased in five countries (Belize, Haiti, Jamaica, St Kitts and Nevis, Trinidad and Tobago) during recent years signalling greater specialization rather than diversification.[7] This lack of economic diversification represents one of the sources of the inherent structural vulnerability common to all SIDS, especially regarding vulnerability to natural hazards. To name but one channel, the impact of natural hazards on trade, in particular the reduction of exports owing to decreased production capability, and the increase in imports responding to reconstruction efforts, spills over to a worsening in the fiscal balance as many Caribbean countries derive a significant proportion of revenue from the taxation of international trade, exceeding more than 50 per cent of total tax revenue in most cases (see ECLAC 2006).[8] Natural hazards, therefore, particularly strain the ability of the public sector in reconstruction efforts and can potentially lead to higher debt stocks to overcome the shortfall in revenue and required increase in expenditure.[9]

In fact, all Caribbean economies are highly susceptible to natural hazards: whilst hydro-meteorological disasters such as hurricanes and wind storms are the most common natural hazards in the region, accounting for more than half of all natural disasters, there is a sizeable occurrence of flooding in the region, part of which is no doubt related to the after-effects of hurricanes and wind storms. In addition, the occurrence of disasters of geological origin (earthquakes and volcano eruptions) was not insignificant in the region over the last four decades (see Figure 1).

The high vulnerability of the region however owes both to a combination of high frequency of natural hazards as well as high intensity of natural hazards in the region. Figure 2 suggests that the occurrence of natural disasters is on an increasing trend; overall an average of six natural disasters occurred in the region per year over the period covering 1970 and 2006. Economies such as Haiti, the Dominican Republic and Jamaica, have experienced more natural disasters than many of the smaller economies (see Figure 3). However, being geographically larger, this outcome is not surprising. Taking the population size of each country into account, a rather different picture emerges. In this case, those countries registering the highest number of natural disasters relative to their populations are St Kitts and Nevis, Dominica and St Vincent and the Grenadines, which all experienced more than one natural disaster per 10,000 inhabitants

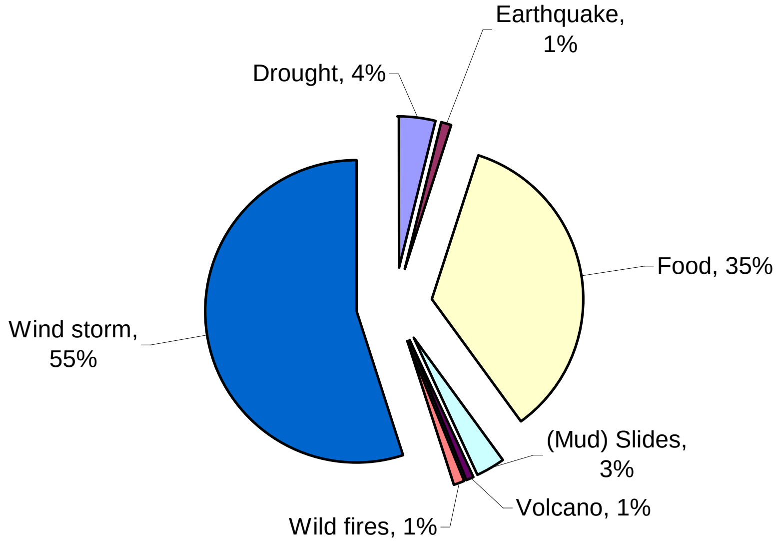
7 In fact, the importance for small economies in specializing in 'niche-markets' owes in many cases to the realization that competing in global markets without access to economies of scale is likely to fail (see Arjoon 1996 and Downes 2000). However, the extent to which this be detrimental in an environment prone to natural hazards must be questioned—one of the aims of this paper.

8 Although the actual deterioration in the trade balance may in fact be offset by positive effects on the capital account owing to reinsurance flows. Moreover, as Pelling, Özerdem and Barakat (2002) point out, any potential period of increasing import capacity should not be interpreted as a genuine economic upturn but rather must be recognized as temporary boom owing to the period of reconstruction.

9 This may well have contributed to the high indebtedness of some countries in the region; in fact 14 Caribbean countries, referring to a region as a whole, not only the sample considered here, rank amongst the world's 30 most indebted emerging market countries, with in fact seven ranking among the top ten (Sahay 2005).

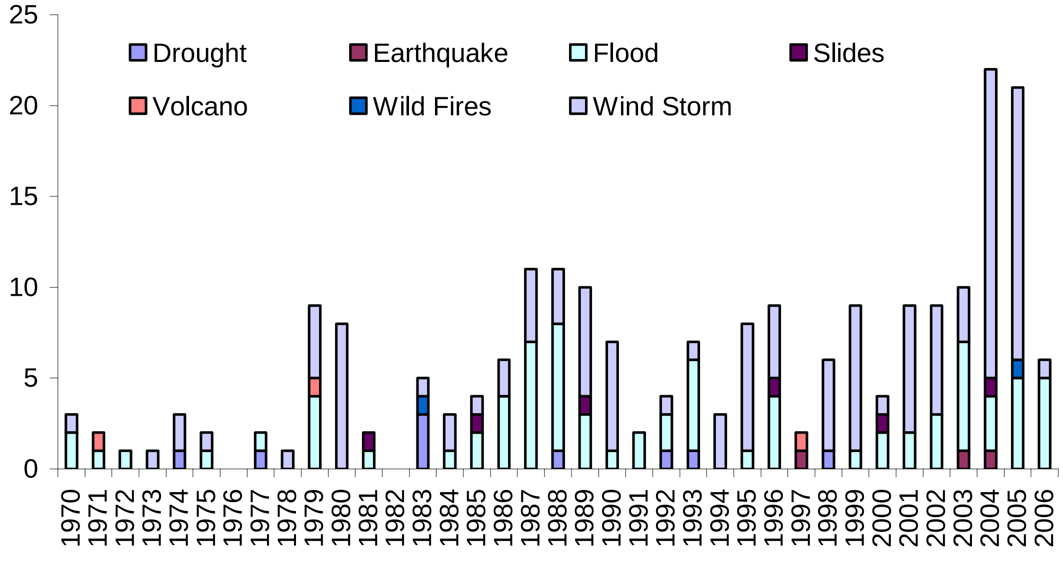
over the period 1970-2006, whilst the respective figures was less by a factor of more than 10 in the larger countries such as Haiti, the Dominican Republic, Trinidad and Tobago, and Suriname.[10]

Figure 1
Type of natural disasters, 1970-2006



Source: CRED (2007).

Figure 2
Frequency of natural disasters, 1970-2006



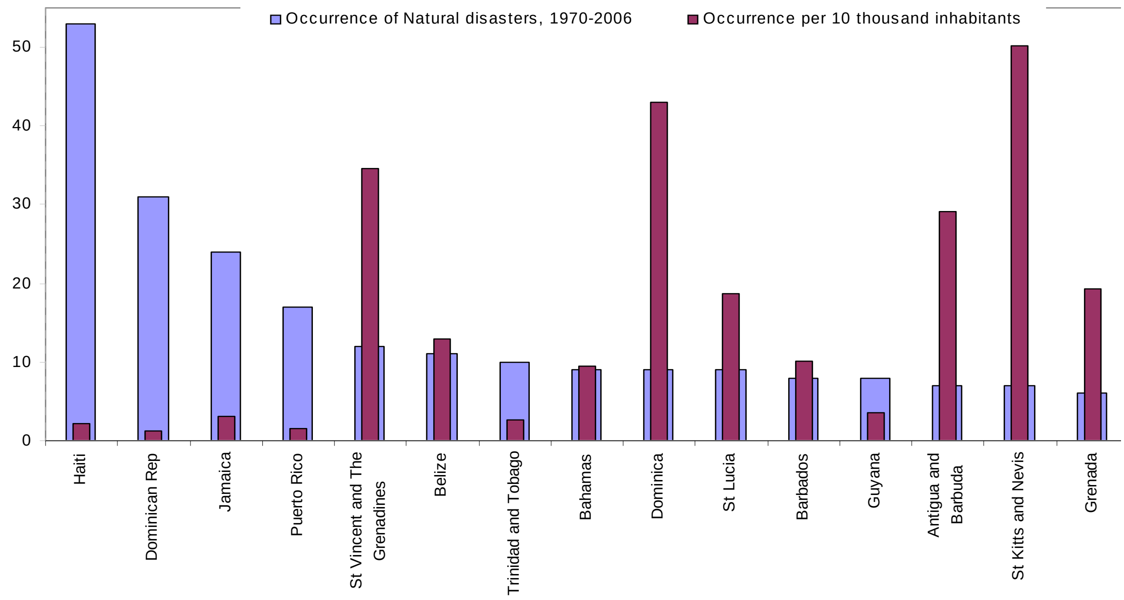
Source: CRED (2007).

---

10 This mirrors Rasmussen (2004), who finds that Eastern Caribbean countries are among the most disaster-prone in the world.

In addition to the high frequency of natural disaster, their high intensity is a key aspect in explaining the regions vulnerability to natural hazards. This, and the fact that the spatial concentration of economic activity in general, and production capacity in particular, is higher in smaller countries contributes to the significant damage that can occur: damages exceeded 50 per cent of GDP in individual countries have been observed in the region (see Table 3). Moreover, this impact is particular relevant as precisely smaller economies, owing to the lack of *hinterland*, are in general less likely to be able to recover rapidly from a natural disaster without external assistance. Whilst larger economies can spread the burden both over time as well as over space, thereby absorbing more ably the overall impact, coping strategies for smaller countries are more limited and reliance on post-disaster financing taking the form of grants and loans from external sources is likely to be more relevant.

Figure 3
Occurrence of natural disasters by country, 1970-2006



Source: CRED (2007) and UN (2005).

Table 3
Destructive impact of natural disaster in region

Country	Time	Event	Damages (% of GDP)
St Lucia	1988	Hurricane Gilbert	365
Grenada	2004	Hurricane Ivan	203
Dominica	1979	Hurricanes David and Fredrick	101
St Kitts and Nevis	1995	Hurricane Luis	85
St Lucia	1980	Hurricane Allen	66
Antigua and Barbuda	1995	Hurricane Luis	61
Guyana	2005	Floods	59

Source: Own calculations based on data from World Bank (2006) and EM-DAT.

2.1 The economic impact of natural hazards

Understanding the economic impact of natural hazards is important for implementing corrective policy action to lessen the hardship resulting from the natural hazard-turned-disaster. The impact of natural events on the economic fundamentals of economies essentially takes three forms: damages, indirect losses and secondary effects. As these have been well documented elsewhere (see ECLAC 2003), they are only briefly mentioned in the following.[11]

Damage and indirect losses

On the one hand natural hazards cause *damages* to assets and to productive capital, i.e., stocks of capital such as infrastructure. These damages usually occur right at the time of the hazard and will include items such as the damage (partial or total) sustained to physical assets such as buildings, machinery, infrastructure (roads, utility supply equipment, etc.). In addition to damages, the economy in general, and agents in particular, incur *indirect losses*. These refer to losses in *flows* of income resulting from the impact of the event and costs incurred such as teachers' salaries, repair of shelters used as emergency places for evacuation, and the like. Having to incur higher operational costs, such as higher transportation costs due to the damage sustained by roads and transport infrastructure, form part of the indirect losses as they are a direct consequence of the damage caused by the natural disaster. Moreover, shortfalls in harvests, for example, or in the provision of services resulting from the impact of the natural disaster also contribute towards the indirect losses. In short, *losses* incurred are a consequence of the impact of the event in general, and of the damage following the hazard, in particular.

The overall impact of a disaster varies depending on the nature thereof. As such, geological disasters such as earthquakes usually cause higher damage to assets, with

Table 4
Economic impact of 2004 hurricane season in the Caribbean

Country	US$ million
Bahamas	1,000
Barbados	5
Dominican Rep	297
Grenada	889
Haiti	22
Jamaica	895
St Lucia	0.5
St Vincent and the Grenadines	5
Trinidad and Tobago	1
Total	$3,114.5

Source: Own calculations based on data from World Bank (2006) and EM-DAT.

11 ECLAC has been working since the early 1970s on assessing the socioeconomic impact of natural disasters in Latin America and the Caribbean, with emphasis on macroeconomic indicators. It has undertaken numerous assessments of natural disasters within the Latin American and Caribbean region as well as outside the region as its methodology is recognized as a consistent, continuous and usable method for better recovery and reconstruction needs.

fewer indirect damages, particularly in economies based on agriculture. On the other hand, climatic disasters, such as severe wind storms, flooding or drought, usually have a more significant impact on indirect losses.

In any case, the total impact of disasters, as measured by the sum of indirect losses and damages, can be substantial. For instance, the 2004 hurricane season caused more than US$3 billion in damages in the countries considered in this sample (see Table 4).

Secondary effects

Damages and indirect losses on stocks and flows respectively in the economy resulting from natural disasters are reflected in changes in main economic variables, which are termed *secondary effects*.

Such secondary effects are a result of the impact of the natural event: (i) by affecting production and distribution channels of an economy and thus depressing the overall rate of growth of the economy; (ii) through the loss of aggregate income and employment and the spillovers on consumption profiles; (iii) through increased imports resulting from the need to purchase intermediate goods and raw materials for repairs; (iv) by increasing insurance flows, and (v) by lower government revenue.

Thus, the damages and indirect costs and impact spill over to the external balance (the balance of payments, the level of indebtedness) and the internal balance of the respective economy (inflation, growth and income, the fiscal balance, employment, etc.).

The analysis of the impact of natural disasters is often undertaken on a case-by-case basis to obtain financial assistance to mitigate the impact. In contrast, the aim of a more encompassing analysis of natural disasters spanning a larger set of countries is of interest to elicit overall patterns of impact and to derive policy recommendations based upon general observations that may not be identified on a case-by-case basis.

Several studies have taken a broader look at the impact of natural disasters. For instance, looking at 16 countries in Latin America and the Caribbean, Auffret (2003) finds that the impact of natural disasters in the region is, in fact, so significant that the volatility of consumption in the Caribbean is higher than in any other region in the world. Whilst this is due to the smallness of most countries in the region in general, and the impact of disasters thereon in particular, Auffret also finds that higher volatility is a result of significant decreases in investment and production shocks. This points to inadequate risk-management mechanisms available in the region.

Whilst this work focuses on consumption volatility, there has been some work on the impact of disasters on growth. However, there seems to be a certain degree of conflicting evidence in this case, in particular on long-term growth. In such, whilst Benson and Clay (2003) argue that the impact of natural disasters on long-term growth is negative, Skidmore and Toya (2002) in contrast argue that disasters may *positively* impact long-term growth as the effect of a natural disaster may be to reduce the return on physical capital and thereby increasing the relative return to human capital. Consequently, this may *induce* growth in general. In how far this result remains valid for the Caribbean region, however, is not clear. For one, there are only few Caribbean countries in Skidmore and Toya’s (2002) sample. Moreover, there is significant braindrain in the Caribbean which reduces the benefit of higher levels of human capital in the region and could hence potentially cast doubt on the applicability of their result to the Caribbean region.[12]

Taking a more comprehensive assessment of impacts for a larger group of economies in the Caribbean region (in this case, members of the Eastern Caribbean Currency Union, i.e. Antigua and Barbuda, Dominica, Grenada, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines—and two dependent territories of the United Kingdom, Anguilla and Montserrat), Rasmussen (2004) finds, for instance, that a short-term impact of disasters is an immediate contraction in output as well as a significant worsening of external balances, with a median increase in the current account deficit amounting to approximately 10.8 per cent of GDP. He also points to a worsening of the fiscal balance, resulting from higher expenditure and lower receipts, which is argued to contribute to an approximately cumulative increase in median public debt (measured as a percentage of debt) of 6.5 percentage points over three years.

Overall, we find that there is only limited work relating to the impact of natural disasters on international trade in general, and specifically relating to smaller economies. In a recent study, Gassebner, Keck and Teh (2006) investigate the impact of major disasters on international trade flows. Whilst the authors find that the democracy level and the area of the affected country are key forces in driving the impact of these events, their analysis, however, essentially excludes all smaller Caribbean countries due to their definition of a large-scale disaster.[13] In contrast, Easterly and Kraay (2000) do look at the issue of volatility of small states; the authors, however, question whether their vulnerability to external shocks such as those arising from the impact of natural disasters is due to more specialized trade patterns of smaller economies relative to larger economies. Rather, they suggest that the greater degree of openness is likely to be a more relevant source of the greater volatility of terms of trade shocks that these countries experience.

3 Analysis of natural disasters in the Caribbean

This section deals with and reports the assessed effects of natural catastrophes on economic performance and trade. First, the data along with the estimation procedure is documented, which is followed by a section dealing with conceptual issues, followed by the actual empirical estimations and completed by the presentation of its results and the emerging conclusions.

3.1 Data

The empirical analysis uses data from three sources. Data relating to the incidence of natural disasters, such as frequency, damage incurred, people affected (as measured by deaths, injured and affected in general) are drawn from the EM-DAT database compiled

[12] Docquier and Marfouk (2004) find that almost half of the 30 countries with the highest emigration rates are member states of the Caribbean region.

[13] Using the Munich Re Foundation's (2006) classification of disasters, only events that either kill or injure at least 1,000 persons respectively, cause at least US$1 billion in damages and/or affect at least 100,000 persons are considered.

by the Centre for Research on the Epidemiology of Disasters (CRED). This database compiles data pertaining to over 12,800 natural disasters from 1900 to the present from various sources (including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies) and is in such considered one of the principal databases for such information.[14]

We use a number of disaster variables in order to capture the various effects that are hypothesized to result from the impact of a disaster. By doing so, we expect to distinguish between different channels through which a disaster affects economic output. We also want to distinguish between distinct and latent effects, between *direct* and *indirect impacts* of environmental hazards. The variables of our choice after applying our transformations are:

- *Dummy disaster:* Indicates whether a country has been struck by a natural disaster during the year of observation;
- *Count disaster:* Nominal number of natural disasters per country and per year;
- *Deaths*: Number of persons that are either confirmed as dead, presumed to be dead, or are missing; taken relative to the entire population of the country;
- *Injured*: Number of people whose physical or psychological injuries are intense enough to require medical treatment; taken relative to the entire population of the country;
- *Homeless*: People needing immediate assistance for shelter; taken relative to the entire population of the country;
- *Affected*: People requiring immediate assistance during a not further identified period of emergency, which may in cases include displaced or evacuated people;
- *Damage*: Estimated costs resulting from a disaster. The estimated figures are expressed in US dollars[15] as a share of GDP and are taken from several institutions.

In our analysis we only focus on natural disasters, ignoring, for example, 'technological' disasters, although it has been argued (Gassebner, Keck and Teh 2006) that the medium to trigger the disaster might not be relevant for its particular form and hence a disaster can be regarded interchangeably, may it stem from a technological malfunction or an environmental crisis.[16] We believe, however, that there are distinctive differences, which is in fact confirmed by a Chow break point test.

---

[14] To be classified as a disaster, the occurrence of an event has to meet at least one of the following criteria: (i) at least 10 or more people must have been killed by the occurrence, (ii) at least 100 or more people must have been affected, been injured or made homeless, (iii) a state of emergence has been declared or (iv) an appeal for international assistance has been made. See www.em-dat.net/

[15] In case where the cost estimation was expressed in local currencies, CRED converted it into US dollars using the exchange rate of the day the disaster stroke.

[16] Natural disasters thus include the following: hurricanes, windstorms, earthquakes, droughts, epidemics, extreme temperature events, floods, famines, (mud) slides, waves, wildfires and volcanic eruptions.

Data used to calculate the Herfindahl-Hirschman index were drawn from the United Nations ComTrade database whereas economic indicators, which form our outcome variables, are taken from the *World Development Indicators* (WDI) of the World Bank's 2006 edition. Among them are mainly measures of economic performance and trade of interest. *GDP/capita* (purchasing power parity) expressed in the value of international dollar during the year 2000. *Imports* and *exports*, respectively, represent the percentage share of imports and exports relative to annual GDP. *Debt* measures total external debt in current US dollars relative to current GDP.

The social and demographic variables that we use later as either control or as intermediating variables are the following:

– *Agri1*: Agricultural raw material exports; as a share of the commodity exports as a whole;

– *Agri2*: The value added of agriculture, as a percentage of GDP;

– *Agri3*: Agricultural raw material imports; as a share of the commodity imports as a whole.

Our analysis covers 16 Caribbean states over the period 1970-2006: Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Dominican Republic, Guyana, Grenada, Haiti, Jamaica, Puerto Rico, Suriname, St Lucia, St Kitts and Nevis, St Vincent and the Grenadines and Trinidad and Tobago. There are no missing observations for the disaster variables and the economic explanatory variables are characterized by very few missing observations for the period selected. The summary statistic is presented in Table 5.

Table 5
Summary statistics, 1970-2005

Variable	Mean	Median	Maximum	Minimum	Std dev.	Obs
Disaster count	0.387037	0.000000	8.000000	0.000000	0.810540	540
Disaster damage	0.074560	0.000000	8.406819	0.000000	0.593624	540
Deaths	2.05E-05	0.000000	0.007369	0.000000	0.000320	540
Affected	0.015198	0.000000	1.217532	0.000000	0.092919	540
GDP/capita	7347.114	5527.646	24320.14	1471.451	4671.419	363
Import	62.46241	64.69657	107.1361	11.66411	20.05664	350
Export	50.96752	51.15314	96.22115	5.428159	17.16692	350
Debt	0.402827	0.347811	1.963396	0.029001	0.265132	316
Import specialization HHI-import	0.059568	0.029638	0.882359	0.000000	0.127842	378
Export specialization HHI-export	0.232584	0.203925	0.939320	0.000000	0.224830	398
Agriculture1	0.450039	0.197708	8.067529	0.000154	0.881221	289
Agriculture 2	10.43925	7.977932	39.12017	0.580730	8.249661	282
Agriculture 3	1.856724	1.937857	4.903169	0.069307	0.929998	278
Population density	233.7072	222.8690	626.8744	16.95744	137.7147	468

3.2 Conceptual issues

There are several conceptual issues that must be addressed in the paper. One emerges from the usual unit root considerations in such that we cannot simply regress natural disaster variables on trended variables such as GDP and other economic indicators. Hence, we experiment with a number of options to eliminate this potential bias, i.e., including year dummies, country-specific time trends and differentiated estimators.

Furthermore, it is not straightforward to believe that we can perfectly estimate economic output equations with natural disaster occurrences; hence we do not expect our regressions to yield a high R^2. We apply a time dimension to our analysis not only because we want to take advantage of a bigger dataset, but also because we want to experiment with different lag-structures as we believe that there will not only be immediate impacts of natural disasters, but that these manifest themselves through time.

We also worry about reverse causality, as we do consider it possible that an ever-growing GDP may trigger more natural disasters (see Figure 3) in absolute numbers as well as more destructive ones owing primarily to the environmental drawbacks that are associated with a growing economy.

3.3 Estimation and results

Following a simple OLS estimation (including a full set of fixed effects and country-specific linear time trends), we note that three variables remain as the variables of choice for our purpose of assessing the impacts of natural disasters on economic performance and trade: *disaster count*, *deaths* and *costs* (in order of importance).[17] We shall use the *cost* variable to illustrate the economic dimension of disasters, and use the *death* variable to capture the social dimension affecting society after a disastrous event.

As seen in Table 6, the F-statistic testing the joint significance for the collection of explanatory variables is reported to be significant at every level, which indicates that our disaster variables are capable of explaining a significant part of the variation occurring in a country, across time in GDP and trade. The R^2 indicates a range from 0.84-0.91, signalling a good overall fit.

It seems however that the impact of natural disasters cannot properly account for annual and cross-country deviations of external debt when considering the low R^2 of 0.04 to 0.05. Whilst most coefficients measuring the impact of natural disasters on debt are statistically insignificant, we do though find that the coefficients on total affected population (column (6)) and the dummy variable for disasters (column (5)) show a statistical significance at $\alpha = 0.01$ and $\alpha = 0.05$.[18] Thus, although the explanatory power is relatively low, signalling that other factors are the primary cause, natural disasters do contribute to the region's overall high level of indebtedness.

---

17 Use of a binary dummy variable signalling only the occurrence of a natural disaster contains too little information in order to have any explanatory power, see column (1). This result makes sense in such that one would expect *ceteris paribus* a country hit by a number of disasters during the same year to suffer more than one that was only hit once.

18 This contrasts to Noy (2007) who does not find any significant impact of the total affected population.

Table 6
Selection of proxy for natural disasters
(1970-2005, OLS estimation, included is a full set of fixed effects and country-specific linear time trends)

DV	GDP/capita		Trade (% of GDP)		External debt(%of GDP)	
Column	(1)	(2)	(3)	(4)	(5)	(6)
Disaster dummy	-252.7283 (219.2777)		3.617800 (2.276276)		0.068366* (0.032645)	
Disaster count		**-333.6497** **(120.1231)**		2.500857** (1.406526)		0.016716 (0.016343)
Disaster damages/capita	461843.1 (453085.0)	351292.2 (447848.8)	3.864680* (1.946553)	4.018298* (1.949024)	-0.010668 (0.028455)	-0.008814 (0.028729)
Disaster deaths/population	-4734286.0* (2290320.0)	-3952312.0** (2288550.0)	-28287.63 (43041.67)	-27286.98 (42802.77)	-155.1071 (489.9144)	-147.7331 (495.5273)
Affected/population	-18.08942 (1042.668)	77.60837 (1021.925)	-13.24902 (10.72164)	-13.29795 (10.68645)	**0.920962** **(0.346047)**	**1.030205** **(0.343049)**
Injured/population	62349.36 (76265.83)	50804.87 (75604.23)	705.9310 (996.6161)	707.1378 (993.8763)	-114.5837 (622.5016)	-183.8516 (625.3695)
Homeless/population	12533.04 (14586.19)	14022.72 (14432.90)	169.8997 (164.3981)	172.2395 (163.9787)	-5.079664 (5.238534)	-4.069379 (5.240666)
Obs	363	363	350	350	316	316
R^2	0.90	0.91	0.84	0.84	0.05	0.04
F-statistic:	61.28 (0.00)	62.61 (0.00)	29.05 (0.00)	29.12 (0.00)	2.76 (0.01)	2.18 (0.04)

Notes: Reported are coefficients with the related standard errors in parentheses;
p-values: bold values indicate a coefficient that is significant at 1 per cent level;
*, ** represent significance levels of 5 per cent and 10 per cent, respectively;
Unit of observation is a country-year.

The point of the above exercise is to identify the most appropriate measure for the respective outcome variable of interest. The main result drawn from this is that disasters do affect economic and trade activity significantly. Moreover, a disaster negatively affects GDP per capita not only through its mere incidence, but also through the impact on the victims that it causes (the *deaths* variable is significant in column (1) of Table 6.

As the *count* variable is the most significant explanatory variable, it will form the point of origin and core of our impact analysis, while the other two variables shall serve as auxiliary variables when analyzing the effects on GDP. The *cost/capita* variable will be our measure of choice when assessing the impacts on the trade variables (*export* and *import*) and the *total affected* variable will be our cardinal explanatory measure for *debt* as an outcome variable.

As shown in Table 6, all three indicators capture a different dimension and yield an overall good fit of the model.

3.3 Dynamic analysis

So far, the analysis has remained at a snapshot method of a moment in time. Clearly, given the nature of the data, we must however turn to dynamic inspection. Doing so, we include lagged versions of the explanatory variable to detect any persistent tendencies that may be present (see Table 7). Using panel data to estimate the time-varying independent variables, we correct for the unwanted but possible presence of time-constant omitted variables by using fixed effects estimation techniques and first differencing with which we eliminate time-constant explanatory variables. The orthogonality condition should have been regained after proper differentiating of the variables.

Column (1) in Table 7 confirms that losses from disasters occur mainly contemporaneously rather than with a lagged influence for economic performance. The results suggest that the growth rate of *GDP/capita* recovers in the three periods following the disaster. Whilst these results are not significant at common levels, they still indicate the pro-cyclical movement that a disaster triggers after its occurrence. In such, one cannot deny the impression that after a 23.7 percentage decline in GDP per capita in the period during which the disaster occurs, GDP per capita increases by approximately 11 per cent, 19 per cent and 13 per cent in three subsequent periods.

Interpretation of the results for e*xports* suggests counterintuitively that there is an increase in export performance relative to GDP as a consequence of a natural disaster during the transition period *t* followed by a decrease for the following two years. Here we point to the following issues: (i) this result may be accounted for by the argument that the relative export rate has to increase due to a decrease of GDP, following the impact, which is the denominator of the term. Also the negative lags in the ongoing periods can be explained through the subsequent recovery of the GDP along its growth path. (ii) Taking into consideration the rather broad frame of observation, which spreads a range of 365 days, the phenomenon of initial increase in export rates and subsequent decline can also be accredited for through the long-term production process under which the commodities to be exported are already in stocks and depots, but the future means of production are harmed.

Imports, on the other hand, react differently following the occurrence of a natural disaster in that they increase in the year of the impact as well as the following year whilst decrease two and three years after the impact respectively (column (3) of Table 7). This finding confirms that in response to a natural disaster, the import demand of countries increases, responding, for example, to the reconstruction needs.

As straightforward as the results from specification (3) were, as counterintuitive appear the ones from specification (4): external *debt* as a share to GDP decreases in the years following a natural disaster. This may however be explained though the flows of aid to countries and the subsequent relief of external debt that is granted in the course of reconstruction.

To verify that the results reported above are not the outcome of the selected estimation method, a different estimation strategy has been performed to verify the independence of results to the methodology. The results of the complementary GMM-dynamic panel data estimation are presented in Table 8. Indeed, the tendencies and phenomena detected in the OLS-regression appear to be invariant in the regression method.

Table 7
Impact of catastrophic events on selected economic variables
(1970-2005, OLS estimation, included is a full set of fixed effects and country-specific linear time trends)

DV	$\log[\partial(Gdp/Capita)]$ (1)	∂ Export (% GDP) (2)	∂ Imports (% GDP) (3)	Debt (% GDP) (4)
$Disaster_t$	-0.237284* (0.1003)	1.068430* (0.452537)	**1.986973** **(0.496953)**	0.098586 (0.106662)
$Disaster_{t-1}$	0.113277 (0.1197)	-1.042936** (0.587713)	1.140838** (0.652515)	-0.072417 (0.106638)
$Disaster_{t-2}$	0.191944 (0.1197)	-0.157006 (0.580136)	**-2.544528** **(0.655986)**	-0.218883* (0.106898)
$Disaster_{t-3}$	0.127803 (0.1195)		-0.486971 (0.641943)	-0.032804 (0.075465)
AR(1)	0.000279 (0.0001)	-0.142985* (0.056487)	**-0.252695** **(0.059081)**	
AR(2)	0.000349 (0.0002)	-0.126016* (0.055643)	**-0.195851** **(0.055904)**	
AR(3)	0.000171 (0.0001)		**-0.184758** **(0.056095)**	
Obs	212	306	228	294
R^2	0.50	0.08	0.21	0.21
F-statistic	3.7 (0.00)	1.5 (0.09)	3.93 (0.00)	1.47 (0.03)
DW	1.9	2.00	2.03	2.09

Notes: Reported are coefficients with the related standard errors in parentheses;

p-values: bold values indicate a coefficient that is significant at a 1 per cent level;

*, ** represent significance levels of 5 per cent and 10 per cent, respectively.

Unit of observation is a country-year.

Disaster (t) equals the count variable for specification (1), the damage/capita for specification (2) and affected/population for specification (4).

Specification(s) (1) uses the count variable, specifications (2) and (3) the damage variable and specification (4) the affected outcome variable.

Table 8
Robustness check: impact of catastrophic events on selected economic variables
(1970-2005, GMM-dynamic panel data estimation, included is a full set of country-specific linear time trends)

DV	$\log[\partial(Gdp/Capita)]$ (1)	∂ Export (% GDP) (2)	∂ Imports (% GDP) (3)
$Disaster_t$	-0.423094 (0.270139)	1.875635 (2.845387)	5.082306** (2.729389)
$Disaster_{t-1}$	0.275517 (0.156314)**	-1.102194** (0.609829)	0.643857 (0.787328)
$Disaster_{t-2}$	0.189963 (0.158197)	-0.189697 (0.595269)	**-2.783494** **(0.735378)**
$Disaster_{t-3}$	0.255220 (0.178293)		-0.708613 (0.724728)
AR(1)	-0.032378 (0.117877)	-0.128565 (0.075929)**	**-0.226451** **(0.067887)**
AR(2)	-0.036652 (0.125943)	-0.126688 (0.055941)*	**-0.205773** **(0.059606)**
AR(3)	-0.125913 (0.120714		**-0.195084** **(0.059587)**
Obs	104	306	228
R^2	0.43	0.07	0.09
DW	1.82	1.99	1.94

Notes: See Table 7.

3.4 Interaction terms

As Yang (2006) argues, there is an obvious presence of other factors that are important in determining the destructive power of a hurricane other than its mere destructive existence. Whilst we have so far fleshed out clear evidence that an individual disaster disrupts trade and economic performance, we now analyse the nuances of economies that may make the difference between a devastating natural catastrophe and one that can be disregarded in its factual harm. We therefore introduce intermediating factors: factors that we hypothesize to be decisive in affecting the degree of a disastrous event and which is in recognition of the findings of other authors.[19]

We presume that the presence of additional factors besides the sheer cost of damages are important elements that contribute to the impact of natural disasters on economic and trade performance of a Caribbean country. The heterogeneity in the effects of disaster damages could possibly be related to a number of physical factors of the respective affected country. We assume that the following regionally limited idiosyncrasies are powerful mediators and form a significant quantitative explanatory mark-up. Our strategy is to let the disaster impact measure of choice interact with some dimensions of heterogeneity. In particular, we hypothesize that the economic and human impacts and aftermaths of natural disasters will be affected by:

19 For example, Gassebner, Keck and Teh (2006) interact their disaster variable with the democracy rating of the selected country whilst Yang (2006) introduces, for example, a democracy index, alliance similarities and GDP as heterogeneous factors.

(1) *The population density of the island*. *Population density* (people per square kilometre). We intuitively assume that both the absolute number of people living in a selected area and the absolute size of the area they live in alter the degree of devastation. It should be quite different for e.g. the Dominican Republic to recover from a 'theoretically equally intense and targeted' hurricane than it is for the about 9 times smaller – in population terms – Grenada.

(2) *Trade diversification versus trade specialization*: A country that extensively exploits the channel of comparative advantage and specializes in the production of a single or a few goods should find it more difficult to recover from an event that affects the means of production. This implicitly assumes that the possibility to switch to an alternative means of production should be beneficial for that matter.

(3) *Low dependence on the agricultural sector versus high dependence*: We hypothesize that a country that is more reliant on the agriculture sector is more vulnerable to natural catastrophes.

(4) *Low dependence on tourism versus high dependence*: We hypothesize that an economy that is more reliant on tourism is more affected by a natural disaster due to the required reconstruction of amenities and features which customarily attract tourists. *Tourism 1* thus measures the number of arrivals on the island per given year, while *Tourism 2* measures the share of international tourism expenditure in current US dollars relative to GDP.

In Table 9, we scale our disaster measures with some characteristics that we believe might contribute to (or mitigate) the absolute impact magnitude of a disaster and present the coefficient estimates along with the standard errors of the *count-disaster* variable with the interlinked factors.[20] Table 9 confirms that the inclusion of the re-scaled disaster measures leaves only few variables virtually unchanged, indicating an insignificant interaction of that term, whilst in most cases an evident alteration of the coefficient estimates of origin is discernable.

Our agglomeration measure delivers the expected results: the more densely an island is populated, the larger will be the impact of natural disasters. If the majority of citizens are topographically concentrated in a few accumulation centres, GDP per capita will be decisively more strongly diminished after a natural disaster than would be the case if the population were more evenly distributed across the geological surface. Within this even distribution of people, however, there are discrepancies to be discerned. Given an equal distribution of people across the island, the destructive power of a hurricane increases with the number of people living in a hypothetical representative square kilometre. Moreover, taking a closer look at specification (1) reveals that the higher the concentration of citizens on an island-nation, the more devastating is the aftermath of a natural disaster.

Our indicator of agricultural dependency as well as the measures for trade specialization (i.e., the Hefindahl-Hirschman indices) also significantly adds explanatory power to the

---

[20] The disaster variables impact on the outcome variables might react in three different ways to the interaction with a demographic factor: either be magnified, decreased or remains unaltered.

disaster measure and alters the magnitude of the disastrous impact. Countries with more agriculture exports and with more value-added resulting from the agriculture sector will see higher imports following a natural disaster, as will those with a less diversified export and import structure.

Table 9
Interaction of impacts of storms with other variables
(IV estimation in the framework of a dynamic panel data (GMM)

DV	GDP/capita (1)	Export (% GDP) (2)	Import (% GDP) (3)
Count disaster, interaction with:			
Population density	-4.329121** (2.419870)	-0.028758 (0.022808)	0.034090 (0.024644)
Agriculture1	7778.758 (364.3078)	1.197294 (2.894839)	10.03226* (4.528472)
Agriculture2	8.172955 (44.32379)	-0.157585 (0.276425)	0.641525** (0.346308)
Agriculture 3	-73.55759 (156.0944)	0.316594 (0.801836)	0.489601 (0.867978)
Tourism1	0.000750 (0.000763)	-3.58E-06 (2.44E-05)	-5.30E-05 (0.000172)
Tourism2	-10189.24 (10461.06)	-166.3331 (151.3856)	45.67380 (119.2164)
Labour force (share of population)	-1.54E-10 (1.85E-10)	-3.86E-13 (5.67E-13)	-8.93E-13 (9.83E-13)
HHI export	-482291.2 (1293094.0)	10542.35** (6088.393)	**23119.02** **(7196.586)**
HHI import	-5389527.0 (15402207)	115690.3 (70370.45) a p value of 11%	**273822.9** **(84967.89)**
GDP/capita		-0.000256 (0.000726)	0.002188** (0.001135)
Import	-3.800920 (9.907336)		
Export	-4.265539 (14.96361)		

Notes: Reported are coefficients with the related standard errors in parentheses;
p-values: bold values indicate a coefficient that is significant at a 1 per cent level;
*, ** represent significance levels of 5 per cent and 10 per cent, respectively.
Unit of observation is a country-year.
Each square reports a single regression, including a set of control variables, which is not shown.

3.5 Subsamples

We split the dataset into subsamples to shed more light on the intermediating factors. Our decision-criterion for splitting the sample into two subsamples is the median of all the values.[21] Moreover, we consider the following three formal specifications to

[21] We do so merely to obtain two samples with a roughly even number of observations, rather than out of any theoretical consideration.

describe the outcome variables of *GDP per capita*, *export* and *import* to more intuitively conceptualize the connections that we are scrutinizing:

$$IMP_{nt} = \alpha + \beta Dis_{nt} + \delta ExpSpec_{nt} + \theta IMPSpec_{nt} + \sum_z \delta_z Agr_{z,n} + \phi_n + \varphi_t + \mu_{nt} \quad (1)$$

$$Exp_{nt} = \alpha + \beta Dis_{nt} + \delta ExpSpec_{nt} + \phi_n + \varphi_t + \mu_{nt} \quad (2)$$

$$GDP_{nt} = \alpha + \beta Dis_{nt} + \tau PopDens_{nt} + \phi_n + \varphi_t + \mu_{nt} \quad (3)$$

Where n denotes the country and t the time. Dis_{nt} is the natural disaster measure of choice. $ExpSpec_{nt}$ and $IMPSpec_{nt}$ are measures that capture export and import diversification/concentration of goods and services, respectively. We use the normalized Herfindahl-Hirschman index to indicate the extent to which a country is dependent on a specific or broad range of merchandise and services (imported or exported respectively). *Agr* is a vector of *z* auxiliary interacting variables. In total, there are three ways of expressing the values of agricultural imports and exports for the economy, all of which have been introduced and elaborated upon above.

ϕ_n and φ_t are included to mitigate institutional and cultural influences as well as global shocks that occur during any particular year; with ϕ_n being the country-fixed effect and φ_t being the year-fixed effect. The estimated country year-fixed effects are included for the sake of capturing shifts in the mean of the underlying distribution over time in each country. μ_{nt} captures the unobservable and is assumed to be random and not correlated with the observable explanatory variables. It is the remainder from the general error term ε_{nt} from which we extracted the country and period fixed effects.

The estimation results of specifications (1) to (3) are given in Table 10. Specification (1) tells us that the physical damages caused by a disaster increase imports to a country. Moreover, the higher a country's import specialization, the higher is its absolute import quantity.

After controlling for import and export concentration, the cost disaster variable no longer exerts a significant influence onto the relative export rate. Strangely, the degree of export specialization/concentration does not significantly alter the export rate (specification (2) in Table 10).

The most important finding of Table 10 is in specification (3) which tells us that an additional disaster—given that it fulfils the inclusion specifics introduced at the beginning—reduces GDP by 5 per cent. The negative coefficient estimate (significant at the 1 per cent level) for the population density measure indicates that the impacts of the disaster affect GDP even more with greater agglomeration of the population in the dedicated area.

The most interesting finding derived from Tables 11-13 is that the two subsamples are not homogenous for any specification; rather, the coefficient estimates for the explanatory variables differ markedly, in some cases more than in others. There seem to be discrepancies between the two ends of the distribution; this is potentially important for any forthcoming policy recommendations.

Table 10
Most precise model specifications for the different outcome variables
(1970-2005, OLS estimation, included is a full set of fixed effects and country-specific linear time trends)

DV	log(IMP_{nt}) (1)	(log) Exp_{nt} (2)	log(GDP_{nt}) (3)
Dis_{nt}	0.022656* (0.009754)	0.006756 (0.013239)	**-0.054838** **(0.015044)**
$ExpSpec_{nt}$	-0.206270** (0.112737)	-0.100916 (0.098818)	
$IMPSpec$	**2.615571** **(0.526762)**	**1.324386** **(0.226583)**	
$Agr_{1,n}$	-0.051929 (0.033883)		
$Agr_{2,n}$	0.004303 (0.004134)		
$Agr_{3,n}$	-0.003016 (0.021576)		
$PopDens_{nt}$			**-0.008272** **(0.000893)**
Obs	176	261	332
R^2	0.86	0.76	0.93
F-statistic	16.06 (0.00)	13.51 (0.00)	90.17 (0.00)

Notes: Reported are coefficients with the related standard errors in parentheses.
p-values: bold values indicate a coefficient that is significant at a 1 per cent level;
*, ** represent significance levels of 5 per cent and 10 per cent, respectively.
Unit of observation is a country-year.
Disaster (t) equals the count variable for specification (1), the damage/capita for specification (2) and affected/population for specification (4).
Disaster proxy used for specifications (1) and (2) damage; for specification (3) count.

If the point of origin of our analysis is a country characterized by a high diversity of its exports (hence reflecting on a broad set of production possibilities and possible substitutions between the different productive sectors), then neither will its exports, nor its imports, nor its GDP/capita be affected by natural disasters. In contrast, a country following the principles of Ricardian comparative advantage (and thus specializing in the production of very few goods) will see its imports significantly increase after the incidence of a natural disaster (α =0.10) and its GDP decrease with an α of 0.01 by 4 per cent per additional catastrophe. Thus emerges the clear finding that more diversified economies are less vulnerable to natural disasters.

Similar reasoning can be made vis-à-vis differences in the subsamples regarding import diversity versus import concentration. A country with a high import concentration (importing few different goods) suffers approximately a 5 per cent decrease in GDP/capita after a disastrous event, whilst its diverse counterpart is almost unaffected by the event. We can therefore conclude from the analysis that both import and export specialization is a disadvantage for countries in terms of resilience to negative external shocks taking the form of natural disasters.

Turning attention to the agriculture sector, we find that a low dependence on agriculture results in a significantly increasing reaction of imports to a natural disaster. This is also a very straightforward finding. It implies that the more a country depends on agriculture

Table 11

Differences in the impact of natural disasters on relative imports for specified subsamples

(1970-2005, OLS estimation, included is a full set of fixed effects and country-specific linear time trends)

	IMP_{nt}								
	Entire group	Import specialization	Import diversity	Export specialization	Export diversity	Strong dependence on agriculture	Low dependence on agriculture	High GDP	Low GDP
Column	(1)	(2)		(3)		(4)		(5)	
Dis_{nt}	**1.782518**	0.328334	2.519043*	1.662684**	0.496001	0.798639	2.031926**	0.349293	2.683170*
	(0.627050)	0.806694	(1.168361)	(0.909531	(1.115319)	(0.855328)	1.219592	(0.561017)	(1.295497)
$ExpSpec_{nt}$	-11.08252	-18.69065**	-9.873077			**-22.70135**	2.095644	-22.73149*	25.46858
	(7.132573)	11.10962	(18.45612)			**(7.555103)**	15.27577	(9.821525)	(16.11274)
$IMPSpec$	**130.9005**			**142.1372**	113.5847	7.292065	-88.13960	51.32984*	674.0343**
	(32.25845)			**(36.39469)**	(432.4929)	(13.34887)	71.94620	(25.40981)	(333.6434)
$Agr_{1,n}$	-3.537286**	-4.831484**	-3.055565	4.327093	-8.655379*			-6.424309*	-2.291452
	(2.115412)	(2.599765)	(6.120307)	(3.139519)	(3.585727)			(2.647093)	(3.851278)
$Agr_{2,n}$	0.086871	0.409717	-0.977988	-0.238106	1.091707			0.512994	-0.767878
	(0.263501)	(0.626078)	(0.684280)	(0.403471)	(1.315524)			(0.758739)	(0.749483)
Obs	176	102	74	122	54	116	113	88	71
R^2	0.83	0.89	0.82	0.86	0.92	0.86	0.9	0.95	0.88
F-statistic	13.07	11.30	4.06	12.93	4.26	9.00	12.61	18.06	6.68
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes: Reported are coefficients with the related standard errors in parentheses;

p-values: bold values indicate a coefficient that is significant at a 1 per cent level;

*, ** represent significance levels of 5 per cent and 10 per cent, respectively;

Unit of observation is a country-year;

Disaster (t) equals the count variable for specification (1), the damage/capita for specification (2) and affected/population for specification (4);

The samples are segregated into two groups based on their deviation from the mean;

A country whose reported measure lies below the mean value will be subcategorized into one group; the rest into the opposite group.

Table 12
Differences in the impact of natural disasters on relative exports for specified subsamples
(1970-2005, OLS estimation, included is a full set of fixed effects and country-specific linear time trends)

DV	Exp_{nt}						
	Entire group	Import specialization	Import diversity	Export specialization	Export diversity	High GDP	Low GDP
Column	(1)	(2)		(3)		(4)	
Dis_{nt}	0.779936 (0.642556)	-0.948764 (0.867287)	**3.062769** **(1.182862)**	1.383672 (0.897541)	-0.013060 (1.225742)	-0.932819 (0.788679)	2.452313* 1.092802
$ExpSpec_{nt}$	-2.687246 (4.796090)	-10.68146** (5.842663)	**44.65253** **(13.22806)**			16.34350* (6.224413)	**9.441739** **(10.02176)**
$IMPSpec$	**60.33304** **(10.99712)**			**64.32118** **(11.78468)**	27.02995 (161.5534)	**73.07471** **(14.14640)**	161.8078 (54.28426)
Obs	261	156	105	164	97	127	97
R^2	0.76	0.78	0.77	0.75	0.86	0.95	0.87
F-statistic	13.51 (0.00)	7.96 (0.00)	4.72 (0.00)	7.50 (0.00)	7.80 (0.00)	18.06 (0.00)	9.40 (0.00)

Notes: See notes to Table 11.

Table 13
Differences in the impact of natural disasters on relative imports for specified subsamples
(1970-2005, OLS estimation, included is a full set of fixed effects and country-specific linear time trends)

DV	log (GDP_{nt})								
	Entire group	High population density	Low population density	Import specialization	Import diversity	Export specialization	Export diversity	Strong dependence on agriculture	Low dependence on agriculture
Column	(1)	(2)		(3)		(4)		(5)	
Dis_{nt}	**-0.054838** **(0.015044)**	-0.023094 (0.015514)	-0.037204 (0.035735)	-0.046361** (0.024464)	-0.004771 (0.023195)	-0.040859 (0.028656)	-0.040859 (0.028656)	-0.019798 (0.026691)	-0.038572 (0.030404)
$PopDens_{nt}$	**-0.008272** **(0.000893)**								
Obs	332	173	159	147	90	154	94	122	97
R^2	0.93	0.96	0.94	0.95	0.99	0.94	0.97	0.96	0.97
F-statistic	90.17	86.36 (0.00)	54.72 (0.00)	51.2	121.50	42.91	45.28	43	44.26

Notes: See notes to Table 11.

as a means of generating collective revenue, the more it is predicted to import once a disaster hits. In this case, there seems however to be no significant difference between the GDP of the two categories detectable.

Following the above analysis one needs to assess what lessons can be learnt and what the implications for countries in the region are.

4 Conclusions

The Caribbean region is extremely vulnerable to natural disasters—some have argued that it is the most vulnerable region to such events even on a global scale. In such mitigating the impact of natural disasters is a particular relevant and important component of economic policy in the region.

Mitigation can, in principle, take two possible forms. It can either take place after the occurrence of a natural disaster (ex-post), or it can take place before with a view to decreasing the overall impact of any likely event.

Ex-post mitigation relies, to varying degrees, on post-disaster assistance taking the form of grants and loans from external donors. The process of securing and obtaining such funds is, however, time-consuming; moreover, it requires individual negotiation between partners, whose willingness to commit funds can be negatively affected by the occurrence of natural disasters and/or other emergencies elsewhere. Moreover, the process does not necessarily guarantee that required funds will be available when needed.[22]

Ex-ante mitigation in contrast takes a different approach in such that it seeks to create an environment that is less susceptible to negative impacts of natural disasters and that is at the same time more able to deal with them. It is in this line that our findings have important implications for the region. For one, we show that despite often referred to as a region as a whole, economies in the region are sufficiently diverse that in fact splitting our sample into two subsamples resulted into results that were not homogenous for any specification.

---

22 The drawbacks of having to rely on such mechanisms have been recognized. In fact, responding to the need for a more reliable mechanism to access funds for mitigation of damages arising from the impact of natural disasters, the World Bank launched in 2007 a Caribbean Catastrophe Risk Insurance Facility (CCRIF), a multi-country catastrophe insurance pool through which participating countries (18 to date) would have access to lower premia and which would provide immediate liquidity in the event of a natural disaster. The CCRIF as such represents an important step towards rapid mitigation of damages. However, as payments from the facility depend on the intensity of the respective natural event/disaster, rather than on the damage occurred, the extent to which they will be able to mitigate the damage incurred remains to be seen. Moreover, the CCRIF does not provide disaster insurance to the private sector in the region. It is however precisely the need to provide insurance to individual property owners that needs to be addressed in the region. For one, due to lack of economies of scale, domestic disaster insurance is either often unavailable, or unaffordable, precisely because domestic insurance markets are insufficiently developed, but also because providing coverage for large-scale systemic risks, rather than idiosyncratic risks, can often be prohibitively expensive to the provider.

Countries in the region have traditionally been focussed on monocultures. This manifested itself not only in the emergence of dominant primary agricultural sectors in the past (such as sugar and bananas), but has also been fostered in more recent times in particular owing to the credo that small economies must specialize in 'niche-markets' to compete in global markets and to compensate for the lack of economies of scale available to them (Arjoon 1996; Downes 2000). However, a negative consequence of this is, as outlined above, that a high degree of dependency on revenue from taxation of international trade now characterizes many economies in the region.

The results presented above reinforce the case for diversification as they show that countries with highly diversified exports will not see their exports, imports or GDP/capita be affected by natural disasters whereas specialized countries will see a surge in imports; hence, more diversified economies are less vulnerable to natural disasters. This is of particular importance to the smaller economies that were shown to be particularly vulnerable to natural disasters.

This said, the extent to which small countries can realistically diversify is still an issue that needs to be addressed and has not been done so in this paper. The notion of what constitutes an economy in the region will ultimately have to be revisited as the challenges confronting such small economies may be insurmountable on an individual basis. However, the region is making great strides towards greater economic integration, which could act as an impetus to creating a more viable setting.

Bibliography

Arjoon, S. (1996). 'Managing Risk and Uncertainty: The Use of Scenario Planning'. *Bulletin of Eastern Caribbean Affairs*, 21 (2): 1-10.

Auffret, P. (2003). 'High Consumption Volatility: The Impact of Natural Disasters'. WB Policy Research Working Paper 2962. Washington, DC: World Bank.

Benson, C., and E. Clay (2003). 'Economic and Financial Impacts of Natural Disasters: An Assessment of their Effects and Options for Mitigation'. London: Overseas Development Institute.

CRED (Centre for Research on the Epidemiology of Disasters) (2007). EM-DAT: The OFDA/CRED International Disaster Database. Brussels: Université Catholique de Louvain. Available at: www.em-dat.net.

Docquier, F., and A. Marfouk (2004). 'Measuring the International Mobility of Skilled Workers, 1990-2000'. WB Discussion Paper 19/8. Washington, DC: World Bank.

Downes, A. (2000). 'Long-term Planning: Institutional Action and Restructuring in the Caribbean'. ECLAC Serie Gestión pública N° 10. Santiago: ECLAC.

Easterly, W., and A. Kraay (2000). 'Small States, Small Problems? Income, Growth, and Volatility in Small States'. *World Development*, 28 (11): 2013-27.

ECLAC (1997). 'Way Forward. Review of the Implementation of the SIDS POA: Priorities for the Future'. Document LC/CAR/G.519. Port-of-Spain: ECLAC.

ECLAC (2003). ‘Handbook for Estimating the Socioeconomic and Environmental Effects of Disasters’. Document LC/MEX/G.5 and LC/L.1874. Port-of-Spain: ECLAC.

ECLAC (2005). ‘The 2004 Hurricanes in the Caribbean and the Tsunami in the Indian Ocean. Lessons and Policy Challenges for Development and Disaster Reduction’. Serie estudios y perspectivas 35. Available online.

ECLAC (2006). ‘Fiscal Policy and Tax Reform in the Caribbean’. Document LC/CAR/L.94. Port-of-Spain: ECLAC.

ECLAC (various). ‘Disaster Assessments for Central America and the Caribbean’. Port-of-Spain: ECLAC.

Gassebner, M., A. Keck, and R. Teh (2006). ‘The Impact of Disasters on International Trade’. WTO Staff Working Paper ERSD-2006-04. Geneva: World Trade Organization.

Munich Re Foundation (2006). ‘Annual Review: Natural Catastrophes in 2005’. Topics Geo. Available at: www.munichre.org/publications/302-04772_eg.pfd .

Noy, I. (2007). ‘The Macroeconomic Consequences of Disasters’. Manoa: University of Hawaii. Mimeo.

Pelling, M., A. Özerdem, and S. Barakat (2002). ‘The Macroeconomic Impact of Disasters’. *Progress in Development Studies,* 2 (4): 283-305.

Rasmussen, T. (2004). ‘Macroeconomic Implications of Natural Disasters in the Caribbean’. IMF Working Paper WP 04/224. Washington, DC: IMF.

Sahay, R. (2005). ‘Stabilization, Debt, and Fiscal Policy in the Caribbean’. IMF Working Paper WP/05/26. Washington, DC: IMF.

Skidmore, M., and H. Toya (2002). ‘Do Natural Disasters Promote Long-run Growth?’. *Economic Inquiry*, 40 (4): 664-87.

Tandon, A., and R. Hasan (2005). ‘Highlighting Poverty as Vulnerability: The 2005 Earthquake in Pakistan’. Asian Development Bank-ERD Policy Brief, Series 40. Manila: ADB.

Thywissen, K. (2006). ‘Core Terminology of Disaster Reduction: A Comparative Glossary’. In J. Birkmann (ed.), *Measuring Vulnerability to Natural Hazards.* Tokyo: United Nations University Press.

UN-ISDR (UN International Strategy for Disaster Risk Reduction) (1992). *International Agreed Glossary of Basic Terms Related to Disaster Management*. Geneva: UN-ISDR.

UN-ISDR (2004). ‘Living with Risk: A Global Review of Disaster Reduction Initiatives’. Geneva: UN-ISDR.

United Nations (1994). ‘Report of the Global Conference on the Sustainable Development of Small Island Developing States’ Available at: www.sidsnet.org/docshare/other/BPOA.pdf.

United Nations (2005). *World Population Prospects*: *The 2004 Revision.* New York: UN.

United Nations (nd). COMTRADE Database. Available at: www://comtrade.un.org/

World Bank (2006). *World Development Indicator*s, *2006*. Washington, DC: World Bank.

World Travel and Tourism Council (WTTC) (2004). 'The Caribbean: The Impact of Travel and Tourism on Jobs and the Economy'. Available at: www.wttc.travel/bin/pdf/original_pdf_file/caribbean2004.pdf .

Yang, D. (2006). 'Coping with Disaster: The Impact of Hurricanes on International Financial Flows, 1970-2002'. NBER Working Paper 12794. Cambridge, MA: National Bureau of Economic Research.