COMPARATIVE SUSCEPTIBILITY TO NATURAL DISASTERS IN THE CARIBBEAN

by

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CARIBBEAN DEVELOPMENT BANK

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ABSTRACT

Natural disasters can have catastrophic impacts. These may be economic, social and environmental. Damage to infrastructure can severely impede economic activity. Social impacts can include loss of life, injury, ill health, homelessness and disruption of communities. Environmental damage can range from the felling of trees to the reshaping of entire landscapes. It is claimed, for instance, that "from 1960 to 1989, hurricanes in the Greater Caribbean Basin resulted in the deaths of 28,000 people, disrupted the lives of 6 million people and destroyed property worth U.S. $16 billion," (Pulwarty and Riebsame, 1997, p.194; attributed to OAS, 1991).

Measuring the comparative susceptibility of countries to natural disasters can serve to draw attention to the issue, to identify sectors of the economy or society that are particularly at risk, and to assist in planning to mitigate the effects of future events. In addition, a wider international comparison may serve to highlight the particular vulnerability to natural disasters of small island states such as those of the Caribbean.

A convincing comparison between countries will need to quantify susceptibility to disasters. This will inevitably be based, at least in part, on the historical incidence of events and their magnitude. The most commonly recorded impacts of natural disasters are the number of deaths, the number of injuries, the number of people made homeless, the total number of people "affected" and the monetary cost of damage caused. The value of these measures for comparing impacts and hence susceptibility between countries is considered. The key problem with each of the measures stems from the quality of the data. In many instances, data are simply not available. Data are often, of necessity, very rough estimates. These estimates lack consistency over time and between countries. It is not considered, therefore, that a sufficiently accurate comparison can be made of countries' susceptibility to natural disasters using these measures of impact.

A comparison between regions of the world is carried out in terms of numbers of disasters experienced, persons affected, and the number of deaths resulting. The use of recent data, between 1993 and 1997, and pooling within regions may serve to balance some of the inaccuracies identified in the underlying data. The results suggest that the Caribbean experiences a relatively high number of natural disaster events. The number of people affected by disasters, however, is comparatively low, although the number of deaths that result is high.

Various sources of data on natural disaster impacts are used to rank selected Caribbean countries, in an effort to identify those countries that are most susceptible. Concerns with the underlying data suggest that any ranking should be treated cautiously. However, the results from different studies and sources of data differ tremendously, making anything other than broad qualitative statements impossible.

Economic impacts of natural disasters can be considered directly by assessing changes in economic variables associated with the occurrence of natural disasters. A methodology that measures impact in terms of growth rate of economic variables before and after disasters is applied to a set of 21 of the most severe storms and hurricanes experienced in the Caribbean between 1974 and 1996. General patterns can be identified in some variables, such as GDP, exports, imports and tourist arrivals. However, such patterns mask huge variations in the behaviour of variables between different disaster episodes. The large number of anomalous results confirms that this approach is unsuitable for comparing relative susceptibility of countries to natural disasters.

The study concludes that it is not feasible, based on the data employed, to rank countries according to their relative susceptibility to natural disasters. Ideally, a comparative analysis would be based on probabilities of future events, and their impact, and not simply on limited historical information.

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INTRODUCTION

Natural disasters can have catastrophic impacts. These may be economic, social and environmental. Damage to infrastructure can severely impede economic activity; social impacts can include loss of life, injury, ill health, homelessness and disruption of communities; and environmental damage can range from the felling of trees to the reshaping of entire landscapes. It is claimed, for instance, that from 1960 to 1989, hurricanes in the Greater Caribbean Basin resulted in the deaths of 28,000 people, disrupted the lives of 6 million people and destroyed property worth U.S. $16 billion, (Pulwarty and Riebsame, 1997, p.194; attributed to OAS, 1991).

Measuring the comparative susceptibility of countries to natural disasters can serve to draw attention to the issue, to identify sectors of the economy or society that are particularly at risk, and to assist in planning to mitigate the effects of future events. Interest in comparing countries' susceptibility to natural disasters has been fuelled in recent years by the call by small island developing states (SIDS) for their relative vulnerability to be acknowledged by international agencies and donor institutions. SIDS are often located in areas prone to events such as hurricanes (or typhoons) and volcanic activity. The inevitable concentration of their economic activity in the coastal zone makes them particularly prone to storm surges and tsunamis. And when a natural catastrophe occurs, the impact is invariably of national proportions for such small states. This point is emphasised in the following quote in a report by the United Nations Conference on Trade and Development:

> *"Island developing economies are often particularly exposed to natural hazards for fundamental reasons of geography. Given the small size of individual islands and of island developing countries generally, the often overwhelming proportional impact of disasters in these countries justifies special concern by the international community."* UNCTAD (1983, p.33)

ALTERNATIVE MEASURES FOR ASSESSING SUSCEPTIBILITY TO NATURAL DISASTERS

A convincing comparison between countries will need to quantify susceptibility to disasters. This will inevitably be based, at least in part, on the historical incidence of events and their magnitude. However, there are considerable shortcomings in the available data, particularly with regard to assessing the magnitude of past disasters. Perhaps the most fundamental of these is the lack of data over a long time scale. This is important since a short time scale will miss many less frequent but perhaps more powerful events. For instance, according to OAS/USAID (1991), Montserrat was witness to only one major volcanic eruption during the past 10,000 years, and yet has been decimated by volcanic activity since 1995.

A number of measures are available with which to measure comparative susceptibility to natural disasters. The most straightforward is simply the historical frequency of disasters. However, this ignores the relative impact of each event. Measures of impact include the number of persons affected, the number of deaths, damage costs, and macro-economic impacts. These are considered in turn.

(i) The number of natural disaster events[1]

The data available on the number of natural disaster events are more reliable, consistent and span a far greater time period than for any of the other measures. This is a major advantage. However, the inability to differentiate between different types of event and their severity renders this measure of limited use for detailed analysis.

Another drawback of this measure is that it ignores social factors relating to vulnerability or the degree of mitigation. It is generally recognised that factors such as poverty and environmental degradation may increase local vulnerability (see, for instance, UNDRO, 1986; Kreimer and Munasinghe, 1991). As noted in CRED (1997, p.7), "natural disasters concern the interaction of natural hazards and socio-economic systems rather than natural hazards *per se*." An alternative definition of natural catastrophes such as hurricanes, proposed by Gibbs (1995, p.244), is not 'natural disasters' but, "natural events which sometimes lead to man-made disasters."

The number of natural disaster events historically experienced in a country could be considered as a measure of inherent susceptibility in the absence of mitigation, but does not accurately portray current vulnerability to natural disasters. Considering the number of events in relation to population size (or land area) serves to indicate the proportional impact. However, some events can affect a considerable proportion of even a larger country, so that adjustment for population size might understate the relative impact for large countries.

(ii) Persons affected by natural disasters

The measure of number of persons affected can provide an indication of the extent of disasters and their effect on human activity. It encapsulates measures of the number injured and homeless. The data on the number of people affected, however, are not consistent, nor are they available for all disaster episodes. The most comprehensive source is the data-set produced by the Center for Research on the Epidemiology of Disaster (CRED), in Belgium: the EM-DAT database. Notably, for the 4,039 events worldwide recorded in the EM-DAT database between January, 1990 and July, 1998, figures for the number of people 'affected' (including those injured or made homeless) are available for only 2,190 (or 54%).

It is probable that periods earlier than 1990-1998 will have even poorer coverage in avaiable data-sets. As the IFRC (1996, p.121) notes, reported figures show the aggregrate number of victims increasing over time, but this "does not necessarily mean that human impact is increasing, but may simply be a reflection of better reporting."

[1] Definitions of a disaster event vary. The Office of U.S. Foreign Disaster Assistance includes the following: a) disasters warranting a U.S. government emergency response; b) earthquakes and volcanoes with at least six persons killed, or at least 25 total killed and injured, or at least 1,000 homeless or affected, or at least US$1mn damage; c) weather disasters, excluding drought, with at least 50 killed and injured, or at least 1,000 homeless or affected, or at least US$1mn damage; and d) droughts where "the number of people affected is substantial" (USOFDA. 1993). In terms of the EM-DAT database, "a disaster is a situation or event which overwhelms local capacity, necessitating a request to the national or international level for external assistance" (CRED, year unknown, p.5).

Quality of monitoring is also likely to vary between countries. This will bias the results, with those countries with better measurement capability being more likely – all other things being equal – to register greater impact. As the International Federation for Red Cross and Red Crescent Societies notes, "defining 'persons affected' is extremely difficult, and figures will always rely on estimates, as there are many different standards" (IFRC, 1994, p.143).

Doubts surrounding this measure call into question previous studies that have sought to utilise EM-DAT data on the number of people affected to compare the relative vulnerability of countries to natural disasters.

(iii) Deaths due to natural disasters

The number of deaths gives an idea of the severity of disasters, and can be taken as an indication of the overall impact of a disaster. The data are likely to be more reliable than on the number of persons affected, but even these data can be uncertain[2]. In the EM-DAT database, 74% of the events recorded between 1990 and July, 1998 had reported mortalities.

The number of deaths will be considerably affected by a country's ability to defend against the effects of disaster. This will be influenced, of course, by the susceptibility of the population to natural hazards, and the extent and efficacy of mitigatory measures in place. For instance, the IRFC (1995) notes that, "Poor countries or countries containing large proportions of their population living below the poverty line ... suffer high disaster-casualty rates."

A major drawback of this measure is that many disasters which might have far-reaching economic consequences may result in few if any casualties, so that economic impact will be underestimated. On the other hand, a localised tragedy might result in a relatively high death toll but limited economic consequences, thereby over-stating the overall impact. Moreover, the number of deaths may represent an increasingly poor proxy for overall impact, since it has been found that as development advances, damages can increase dramatically even as related deaths decline (Diaz and Pulwarty, 1997a).

(iv) Damage costs

Although the initial damage does not represent the full range of economic consequences, it can be taken as a proxy for overall impact. The primary drawback of this measure is limited data. As the Programme of Disaster Preparedness of the European Community Humanitarian Office notes in its assessment of the Caribbean, "it is even more difficult to establish the effect of natural disasters on the region's economic activities than it is to gauge their effect on the population" (DIPECHO, 1999).

The majority of disasters in the recent past do not have estimates of damage costs, and the number of estimates declines further back in time. Those estimates that do exist can be highly subjective. In the EM-DAT data-set, only 26% of worldwide disasters between 1990 and July, 1998 have a cost estimate associated with them. This is consistent with the IFRC (1995) finding in its 'World Disasters Report, 1995', when comparing the average estimated damage by natural disasters across regions for 1989-1993. It was found that, "only some 24 per cent of those disasters recorded have a financial loss figure associated with them" (IFRC, 1995, taken from the IFRC internet site).

An additional concern with employing damage costs as a measure of impact is that it will inevitably place a higher value on damage to more costly assets. It will therefore understate relative losses endured by the poorer in society, who may have few, if any, valuable assets. And it is often the poor who are most hard hit by natural disasters (D'Ercole and Pigeon, 1998). One means of estimating damage costs is through analysis of insurance claims. However, this will omit the possibly large number of private buildings and property that are not insured, as well as uninsured public infrastructure that can suffer extensive damage.

(v) Macro-economic impacts

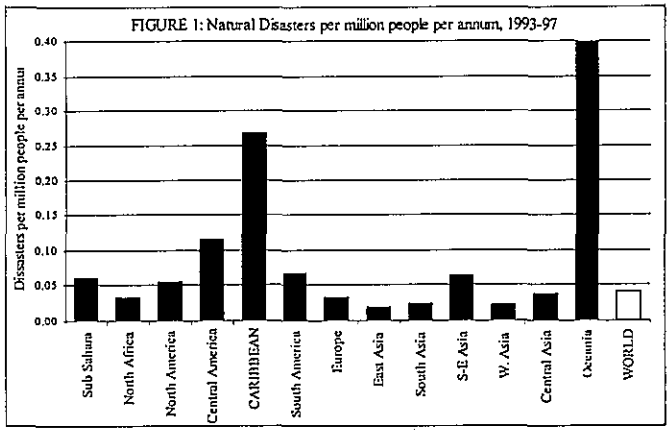
Natural disasters can have a significant impact upon the broad economy, especially in small states where a single event can affect a large proportion of the country. In a study of the effects of Hurricane Gilbert on Jamaica, Brown (1994) emphasises the impact on inflation, the trade balance and tourism. An approach to providing comparative quantitative estimates of effects on such variables was applied by Pantin (1997). The difference between average growth rates in seven key variables in the three years prior to a disaster and the three years following a disaster is interpreted as the impact of the disaster. A number of problems arise with this procedure. For instance, it is assumed that any changes are the result of the natural disaster; and averaging the post-disaster period can disguise significant decreases in growth (followed by large increases). This procedure is discussed in more detail below in relation to the Caribbean.

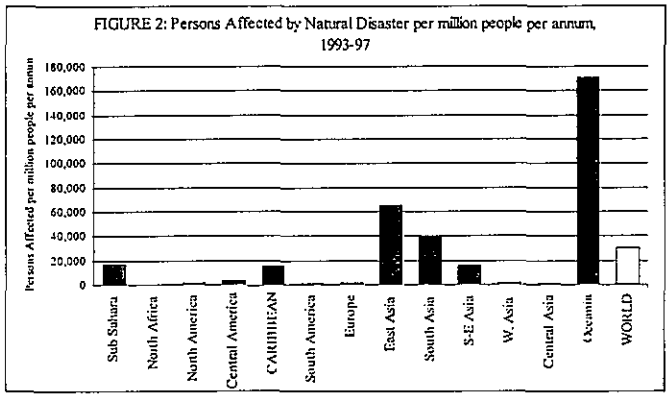
AN INTER-REGIONAL SYNOPSIS

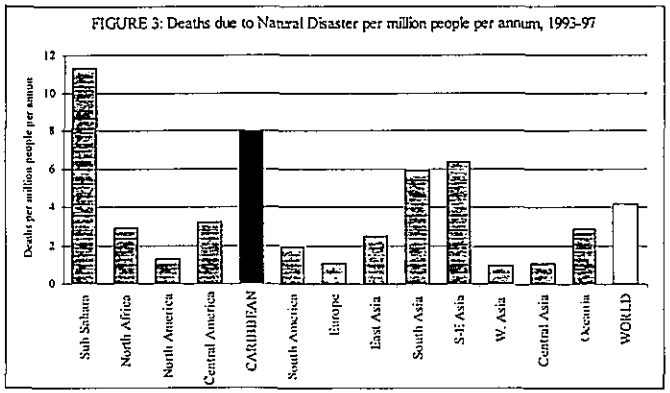
It is of note that the detailed CRED/CIFEG (1997, p.131) report states that "no country [in Central America and the Caribbean] has a risk level which could be defined as low." CRED publishes EM-DAT data by region on its internet site, for the period 1993 to 1997. Such pooling of data across countries may compensate for the use of a limited 5-year time span. Combining these data with estimates of regional population (by suitably adjusting regional population data in UNCTAD (1995) to match the CRED regional groupings) provides an indication of the recent relative impact of natural disasters around the world. As Figure 1 shows, the two regions experiencing the most disasters per capita were Oceania (islands of the Pacific, Australia and New Zealand) and the Caribbean (which refers to islands of the Wider Caribbean, thereby excluding Belize, Guyana and Suriname). These two regions contain the majority of SIDS. When considering the relative number of people affected, as illustrated in Figure 2, Oceania is by far the highest, with South and East Asia the next most affected. The pattern changes if the number of deaths due to natural disasters is considered, as in Figure 3. It is Sub-Saharan Africa which is most severely afflicted, followed by the Caribbean and then south eastern Asia. Notably, Oceania ranks relatively low by this measure.

The number of deaths may better represent the level of impact of disasters. It will partly reflect the extent of disaster mitigation, which may explain the relatively poor ranking of Sub-Saharan Africa and positive ranking of Oceania by this measure.

[2] The number of deaths associated with a disaster is often far from certain. For instance, Kelman (1998, p.110) notes that reported fatalities ranged from 19 to more than 30 persons as a result of the 25 June, 1997, pyroclastic flow from Montserrat's Soufriere Hills. Estimates of deaths due to the eruption of Mount Pinatubo in the Phillipines in 1991 ranged from "approximately 200" to "nearly 500" (Kelman, 1998, p.100). Moreover, many of the deaths that occurred in the Phillipines were a combination to two simultaneous natural events, the volcanic eruption and Typhoon Yunya (Kelman, 1998, p.100), complicating the issue of allocating the number of deaths attributable to each disaster.







These three graphs raise some interesting points with regard to assessing vulnerability to natural disasters. The measure employed, whether the number of disasters, the number of people affected or the number of deaths which result, can clearly lead to a vastly different ranking. This suggests careful consideration of which measure is to be used.

NATURAL DISASTERS IN THE CARIBBEAN

An attempt has been made to rank a number of Caribbean countries according to historical susceptibility to natural disasters based on the measures discussed above.

Numbers Affected

Perhaps the most applicable data is employed in Wells (1997), using the EM-DAT database, to assess the cumulative number of people affected as a proportion of the population for the period 1970-1996. The study includes 11 Caribbean countries, with their relative ranking illustrated in Column 7 of Table 1A. Antigua and Barbuda ranks as by far the most vulnerable (Bahamas and Grenada are ignored since figures are based on inappropriate approximations rather than EM-DAT data[3]). This is followed by Dominica, and then Jamaica, St. Lucia, Guyana and St. Vincent and the Grenadines. Based on Wells' analysis, Belize and St. Kitts and Nevis appear relatively non-vulnerable, and Barbados, Trinidad and Tobago and Suriname appear barely so at all. The same results are used in the Commonwealth Secretariat study of economic vulnerability (Easter, 1998).

Data on the number of people affected by *all* disasters (with both natural and human 'triggers') from IFRC (1994), for 1968-1992, when converted to a percentage of the population, largely concur with Wells' study. As can be seen from Column 8 of Table 1A, Dominica and Antigua and Barbuda rank as the most vulnerable, followed by Jamaica and St. Lucia. Among the least vulnerable are Trinidad and Tobago, Grenada, Suriname and Barbados.

Damage Costs

The analysis in Briguglio (1995) is based on UNDRO (1990) information on damage costs as a proportion of a country's GDP, between 1970 and 1989. Damage costs alone will not represent the full extent of economic impact, but perhaps a more serious drawback of this approach is the lack of available data. Nonetheless, the results of the UNDRO study (as reported in UNEP, 1994) concur to a large extent with results based on numbers affected, as Column 9 of Table 1A shows. Dominica, St. Lucia and Jamaica rank among the most vulnerable, followed by Antigua and Barbuda, St. Vincent and the Grenadines, St. Kitts and Nevis and Belize. A notable addition to this sample is the inclusion of Montserrat, which ranks as by far the most vulnerable, based solely on the devastating impact of Hurricane Hugo in 1989.

[3] Wells (1997) employs dubious approximations. The index for the Bahamas is based on Haiti's proportion of population affected, making it the most vulnerable of all CARICOM countries. However, direct association between one of the richer countries and one of the poorest countries in the world, with widely different characteristics and mitigation capacities, seems inappropriate. Grenada is approximated by a 'neighbouring country', taken to be Antigua and Barbuda. However, Grenada is at the southern, and less storm-prone, end of the Lesser Antilles chain, while Antigua and Barbuda lies at the northern end.

TABLE 1A: Caribbean Country Ranking According to Natural Disaster Activity Based on Various Sources

Proportion of 1993 population (or of GDP)																	
1		2		3		4		5		6		7		8		9	
						Pantin		Pantin				Wells		IFRC		UNEP	
CRED		OAS		OFDA		(UNDRO/UNEP)		(EMDAT)		EMDAT		(EMDAT)		ALL disasters		(UNDRO)	
1900-96		1889-1989		1900-92		1970-92		1970-96		1990-98		1970-96		1968-92		1970-89	
Events		Events		Events		Events		Events		Deaths		Affected		Affected		$ costs	
ANG	1200	BVI	278	ANG	200	MON	364	MON	136	MON	383.6	*BAH*	*491.3*	DOM	507.0	MON	1200
MON	455	ANG	200	MON	182	DOM	183	SKN	45	BEL	14.2	ANT	430.8	ANT	461.5	DOM	141
BVI	167	MON	182	SKN	95	SKN	95	DOM	44	ANT	4.1	DOM	262.0	JAM	249.2	STL	81
SKN	167	SKN	167	ANT	77	SVG	82	SVG	28	SVG	3.6	*GRE*	*228.3*	STL	210.1	JAM	64
DOM	155	TCI	154	SVG	73	STL	65	ANT	23	BAH	2.0	JAM	130.9	SVG	156.9	ANT	38
TCI	154	DOM	141	DOM	56	BEL	44	BVI	22	DOM	1.9	STL	92.9	GUY	133.1	SVG	36
ANT	108	SVG	118	BVI	56	JAM	9	STL	19	TT	0.5	GUY	85.2	TT	15.6	SKN	28
SVG	100	ANT	108	STL	43	*TT*		BEL	9	JAM	0.4	SVG	74.8	GRE	8.7	BEL	7
STL	79	STL	65	BAH	30	*SUR*		JAM	3	*ANG*		BEL	28.2	SUR	4.4	*ANG*	
BAH	49	BDS	38	BEL	29	*GUY*		*ANG*		*BDS*		SKN	21.4	BDS	0.3	*BAH*	
GRE	43	BAH	30	GRE	11	*GRE*		*BAH*		*BVI*		BDS	0.5	*ANG*		*BDS*	
BEL	34	GRE	22	JAM	9	*CAY*		*BDS*		*CAY*		TT	0.1	*BAH*		*BVI*	
BDS	27	BEL	10	BDS	8	*BVI*		*CAY*		*GRE*		SUR	0.0	*BEL*		*CAY*	
JAM	16	JAM	8	SUR	2	*BDS*		*GRE*		*GUY*		*ANG*		*BVI*		*GRE*	
TT	7	TT	5	TT	2	*BAH*		*GUY*		*SKN*		*BVI*		*CAY*		*GUY*	
CAY		SUR	2	GUY	1	*ANT*		*SUR*		*STL*		*CAY*		*MON*		*SUR*	
GUY		GUY	1	*CAY*		*ANG*		*TT*		*SUR*		*MON*		*SKN*		*TT*	
SUR		*CAY*		*TCI*		*TCI*		*TCI*		*TCI*		*TCI*		*TCI*		*TCI*	

TABLE 1B: Caribbean Country Ranking According to Natural Disaster Activity Based on Various Sources

Absolute number of events (annual average)													
10		11		12		13		14		15		16	
						Pantin		Pantin					
CRED		OAS		OFDA		(UNDRO/UNEP)		(EMDAT)		*'CRED'*		*'CRED'*	
1900-96		1889-1989		1900-92		1970-92		1970-96		*'predicted'*		*'predicted'*	
Events		Events		Events		Events		Events		*Events*		*Event % popn*	
JAM	0.40	JAM	0.21	JAM	0.24	JAM	0.22	JAM	0.81	*JAM*	*21*	*MON*	*181.8*
BAH	0.13	SVG	0.14	BAH	0.09	DOM	0.13	DOM	0.31	*DOM*	*20*	*ANG*	*150.0*
ANG	0.12	BDS	0.11	SVG	0.09	BEL	0.09	SVG	0.31	*MON*	*20*	*TCI*	*107.7*
DOM	0.11	DOM	0.11	BEL	0.06	STL	0.09	STL	0.27	*SKN*	*20*	*BVI*	*83.3*
STL	0.11	STL	0.10	STL	0.06	SVG	0.09	BEL	0.19	*ANT*	*19*	*CAY*	*65.5*
SVG	0.11	BAH	0.09	ANT	0.05	MON	0.04	SKN	0.19	*CAY*	*19*	*SKN*	*47.6*
TT	0.09	ANT	0.08	DOM	0.04	SKN	0.04	ANT	0.15	*STL*	*16*	*ANT*	*29.2*
ANT	0.07	SKN	0.08	SKN	0.04	*ANG*		MON	0.15	*ANG*	*15*	*DOM*	*28.2*
BDS	0.07	TT	0.08	TT	0.03	*ANT*		BVI	0.04	*BVI*	*15*	*STL*	*11.5*
BEL	0.07	BVI	0.05	ANG	0.02	*BAH*		*ANG*		*BAH*	*14*	*SVG*	*10.9*
SKN	0.07	ANG	0.02	BDS	0.02	*BDS*		*BAH*		*TCI*	*14*	*GRE*	*8.7*
MON	0.05	BEL	0.02	MON	0.02	*BVI*		*BDS*		*SVG*	*12*	*BAH*	*5.2*
GRE	0.04	GRE	0.02	BVI	0.01	*CAY*		*CAY*		*BDS*	*11*	*BDS*	*4.2*
BVI	0.03	MON	0.02	GRE	0.01	*GRE*		*GRE*		*GRE*	*8*	*BEL*	*2.9*
TCI	0.02	TCI	0.02	GUY	0.01	*GUY*		*GUY*		*BEL*	*6*	*JAM*	*0.9*
CAY		GUY	0.01	SUR	0.01	*SUR*		*SUR*		*TT*	*3*	*SUR*	*0.2*
GUY		SUR	0.01	*CAY*		*TT*		*TT*		*GUY*	*1*	*TT*	*0.2*
SUR		*CAY*		*TCI*		*TCI*		*TCI*		*SUR*	*1*	*GUY*	*0.1*

Number of Disasters

Details on the number of major natural disasters in 15 Caribbean countries between 1900 and 1996, from the EM-DAT database, are taken from CRED/CIFEG (1997, p.32). Initially, the severity and relative impact of each event is assumed to be equal - a highly unlikely assumption - and the total number for each country between 1900 and 1996 is adjusted for population size. This suggests that Anguilla and Montserrat are the most susceptible, followed by the British Virgin Islands (BVI), St. Kitts and Nevis, Dominica and Turks and Caicos Islands (TCI). This is illustrated in Column 1 of Table 1A.

A database covering a similarly long period, 1889-1989, reported in OAS (1997) gives very similar results, with the addition of Suriname and Guyana ranked as least vulnerable. See Column 2 of Table 1A. However, it also brings to light certain anomalies. For instance, Barbados is attributed with a relatively high number of events, most notably seven hurricanes, in comparison with most of the islands of the Lesser Antilles. Most of these small islands are further north than Barbados and are generally considered more prone to hurricanes. They are also of volcanic origin. However, the majority of these islands have only between one and three hurricanes recorded for the period. The BVI is reported as having suffered five hurricanes, compared to its directly adjacent neighbour, the USVI, with sixteen.

Another data-set covering a long period is provided in USOFDA (1993). Once again, the figures and ranks are similar but not identical to the other long-term data-sets. Notable is the relatively low ranking of BVI and high ranking of Antigua and Barbuda.

More recent data on the number of events are used by Pantin (1997), from UNDRO/UNEP for the period 1970 to 1992, and from EMDAT for the period 1970-1996 (Columns 4 and 5 of Table 1A). These data, when adjusted for population size, largely concur with the longer-term studies except that Montserrat ranks as the most vulnerable.

As noted above, a primary drawback of utilising data on the number of natural disasters stems from the lack of measures of severity for each event. The simple adjustment of dividing through by population size leads to a ranking which is predominantly a reflection of population size, with smaller countries almost inevitably ranking as more vulnerable. Given the large potential extent of impacts resulting from natural catastrophes such as hurricanes, earthquakes and volcanic eruptions, in comparison to the relatively small size of countries under consideration, adjusting the number of events for size of population (or land area) seems particularly inappropriate. For instance, an event equivalent to that which might impact upon the whole of an island with population of 10,000 could just as well affect an island of 100,000 or even 1 million (mn). As an example, Hurricane Gilbert, in 1988, travelled the full length of Jamaica and is reported as having adversely affected 810,000 of Jamaica's 2.4 mn inhabitants (OFDA, 1993).

If the number of events is considered independently of population size or land area, it is clear (from Columns 10 to 14 of Table 1B) that Jamaica, the largest country within CARICOM, witnessed the most events during the past 100 years or, more recently, over the past 25 years. Other than this, however, there are marked differences in the ranks deriving from different sources. For the longer, 100-year, time period, CRED/CIFEG (1997) ranks Anguilla particularly high and Antigua and Barbuda low; OAS (1997) ranks Barbados and BVI relatively high and Bahamas low; and OFDA (1993) ranks Belize high and Dominica low. In more recent times, based on Pantin's more limited set of data from UNDRO/UNEP and EMDAT, Dominica has witnessed a high number of events, while Montserrat and BVI have not. This illustrates the major drawback of assessing vulnerability based on just the number of events, independent of the extent of impact, since Montserrat's two events, Hurricane Hugo and the eruption of the Soufriere Hills Volcano, have had devastating impacts.

It is clear from a glance at Tables 1A and 1B that definitions and estimates of natural disasters differ significantly between sources, even for the relatively straightforward measure of the number of events each country has experienced.

Overview of Comparing Natural Disasters in the Caribbean

The CRED/CIFEG (1997, p.131) report suggests that Jamaica and St. Vincent and the Grenadines are particularly at risk within the Caribbean with regard to natural disasters. The emphasis on St. Vincent and the Grenadines does not seem to concur with the evidence this century. However, it might reflect longer-term evidence. For instance, according to OAS/USAID (1991), St. Vincent and the Grenadines has experienced 210 volcanic eruptions in the past 10,000 years, as compared to the next highest, Dominica and St. Kitts and Nevis, each having experienced only four.

The measure employed, of course, affects the outcome. A very different ranking results from employing the number of disasters, or the number adjusted for population size. If the number of persons affected by each disaster is considered, then yet another ranking is derived.

The time period included in the study is equally as important as the measure used. A shorter time period will obviously place greater emphasis on the events that occurred during that period. A longer time period is preferable, given the long return-periods associated with major events. Data are extremely limited, particularly for estimates of disaster impacts. However, ignoring more distant events may lead to inaccurate results. The rationale for choosing a time period in the comparative studies to date has been data availability. It is apparent that the longer the period the better, but research has had to make do with what is available. It is probable that this has resulted in misleading results[4].

Since the ultimate aim of this analysis of historical frequency of natural disasters is to estimate relative susceptibility to future episodes, a very rough assessment of the probability of suffering a disaster has been carried out. Figure 16, a 'Map of Potentially Threatening Phenomena', in CRED/CIFEG (1997, p.26) is used to estimate the potential for each country to experience natural disasters. Given the nature of the information provided, hurricane potential ranges from zero to sixteen, based on frequency of hurricanes over the course of the century; earthquake exposure is ranked from 1 (low exposure) to 4 (very high exposure); potential volcanic activity is a binary zero-one variable; and proneness to flooding is a binary variable for which only Jamaica receives a value of one. There is no consideration of proneness to drought. The values are simply added together, and the results are in Column 16 of Table 1B. The ranking is similar to other measures, although Montserrat ranks particularly high, and TCI is also relatively high. In contrast, St. Lucia, Bahamas, St. Vincent and the Grenadines and Belize rank relatively low. A ranking of predicted exposure adjusted for population size degenerates into an

[4] For instance, restricting the time period to post-1970 is of particular concern in the case of the Caribbean, where hurricanes are the predominant form of natural catastrophe. The evidence suggests that "the period of the 1930s to 1950s saw a high level of hurricane activity in the western Atlantic ... Subsequent decades experienced a slowdown from the level of tropical storm activity ... In recent years, there have been indications that the recent period of relatively low Atlantic tropical cyclone activity may be ending," (Diaz and Pulwarty, 1997b, p.285). Recent historical evidence, therefore, may be a poor predictor of future activity.

inverse ranking of population size due to inadequate differentiation between the values of predicted exposure.

Estimating predicted exposure to natural catastrophe is what is required in a comparative study of susceptibility to natural disasters, but the approach utilised here is exceedingly rough and of little direct use. However, a more sophisticated methodology could be developed.

In summary, evidence on historical exposure to natural disasters, as outlined in Table 1, leads to an inconclusive ranking of countries according to historical susceptibility to natural disasters. However, a very general pattern can be discerned when considering events or numbers affected adjusted for size.

Despite the difficulties associated with comparing natural disaster susceptibility, a broad ranking of Caribbean countries can be discerned. The limited, and at times conflicting, evidence suggests that Montserrat and Anguilla are the most affected by natural disasters, relative to country size. Also highly affected are Dominica and St. Kitts and Nevis. It seems that BVI would be in this group based on number of events experienced, but that effective mitigation reduces the extent to which it is affected. The next group consists of Antigua and Barbuda, Jamaica, St. Lucia, and St. Vincent and the Grenadines. Moderately affected countries include Bahamas, Barbados, Belize and Grenada. Less affected countries are Guyana, Suriname and Trinidad and Tobago. The data on Cayman Islands and TCI are sparse, but would suggest they are highly susceptible, perhaps on a par with a country such as Antigua and Barbuda.

This is a qualitative and unreliable assessment. The information that has been analysed is incomplete and inconsistent. There certainly does not appear to be sufficiently comprehensive or robust data to allow the derivation of a quantified index of susceptibility to natural disasters in the Caribbean.

MACROECONOMIC IMPACTS

Macroeconomic impacts of natural disasters are considered by Pantin (1997) in terms of changes in seven possible economic indicators between the three years prior to an event and the three years following the event. This work draws on previous studies such as Albala-Bertrand (1993). The indicators are the rates of change in GDP, merchandise exports, merchandise imports, exchange rate, rate of inflation, external debt and gross domestic investment. The averages of the rates of change in these variables before and after each event are calculated. These differences are then averaged to form a single difference figure for each country for each measure. These are then further averaged for each country to derive a single index of macro-economic change.

It is then proposed by Pantin, that this macro-economic index be combined with indices of population affected and of geographic vulnerability (defined as length of coastline and area of cropland). This represents a complex procedure, for which little justification is made.

A number of problems are associated with this procedure:

1. Combining the seven economic indicators (or any combination of these) implies that they are equally weighted in terms of their economic significance.

2. The economic data series required for such an analysis are available for a restricted historical period only, thereby limiting the time span that can be considered.

3. The particular methodology employed by Pantin (1997) is, unfortunately, prone to suggest that small states are more vulnerable. This stems from taking the *average,* over the period, of differences in the rate of change for each economic variable before and after natural disasters. This ignores the fact that larger countries, under the same conditions, are likely to suffer from a greater number of events. Note that, in considering percentage changes in variables, the difference in scale between countries is already accounted for. So that, for instance, a similar event experienced by a larger economy is likely to have a smaller impact on percentage growth in GDP (although a greater absolute economic impact). However, if it experiences more of these relatively smaller impacts, the net result might be similar to the few, but proportionally larger, impacts experienced by a small country. It is the *cumulative* impacts over the period that should, therefore, be measured. By assessing the *average* impact, undue prominence is afforded to the relatively few events experienced by small countries, while the fact that larger countries may experience more, perhaps less devastating, events, is ignored. A summation of impacts over time, of course, will make the results even more sensitive to the time period under consideration. In addition to the omission of major events that may have occurred before or after the chosen period - which is common to all historical analyses - the extent to which cumulative impacts are captured will necessarily depend upon the time period analysed.

4. A more fundamental problem is the unlikely assumption that there are no other influences on the macro-economy during the seven-year period analysed for each disaster. This suggests not only stable external and domestic political and economic environments, but also that no other natural disasters occur during those seven years.

5. A further problem arises with averaging annual changes in each variable. The recovery from an initial negative impact can lead to high rates of growth in proceeding years. The average of these negative and positive growth rates will reduce the apparent impact. What is being measured is a combination of negative impact *and* subsequent recovery. Or, where there is a delay in the impact, the average will include the initial unaffected rate of growth.

6. It could happen that the differential timing of impacts within a country could dampen the apparent overall effect. For instance, in St. Lucia in 1982, two years after Hurricane Andrew hit the island, growth in cruise ship passenger arrivals rebounded from a previous drop of -68% back up to +79%. In the same year, merchandise exports recorded zero growth and GDP growth fell from 4.8% to 2.1%. Direct comparison across sectors in each year, therefore, may be of limited value when each sector can react very differently.

7. It also appears that by omitting the actual year of the disaster from the analysis, Pantin misses some significant immediate impacts. For instance, the 5% decline in tourist arrivals, and 44% decline in merchandise exports, in Montserrat in 1989, the year that Hurricane Hugo hit. Or, the 12% decline in Jamaica's tourist arrivals in 1988, when Hurricane Gilbert swept through the island, which was followed by growth rates of between 10% and 20% in the following three years (and it these latter years that will be picked up in Pantin's methodology).

The Economic Impacts of Natural Disasters in the Caribbean

An assessment of economic impacts of natural disasters is carried out for the Caribbean. The analysis is based on 21 major natural disasters that occurred in the Caribbean Development Bank's Borrowing Member Countries (BMCs) between 1970 and 1997. All of these events were

hurricanes or severe tropical storms. Montserrat's recent volcanic eruptions have not been included in the analysis due to the lack of a subsequent period with which to compare. Events in Montserrat are considered separately. The disasters occurred mostly in September, although they range from August through to November, and are listed in the Appendix. A problem here, as with Pantin's work, arises in choosing which disasters to include. Those with a low impact will reduce the average effect and lead to non-disaster factors exerting greater influence on the results. The events selected in the present study are those associated with a significant degree of impact according to various sources.

Variations before and after the onset of these disasters were measured for rates of growth of the following economic variables:

- Gross domestic product
- Consumer prices
- Exports of goods
- Imports of goods
- Balance of trade[5]
- Net foreign assets
- Long-stay tourist arrivals
- Cruise ship passenger arrivals
- External debt
- Government current expenditure (in real terms)
- Government capital expenditure (in real terms)

The following results are produced, from averaging across the 21 events, comparing the three years prior to the event with up to three years following the event:

Gross domestic product

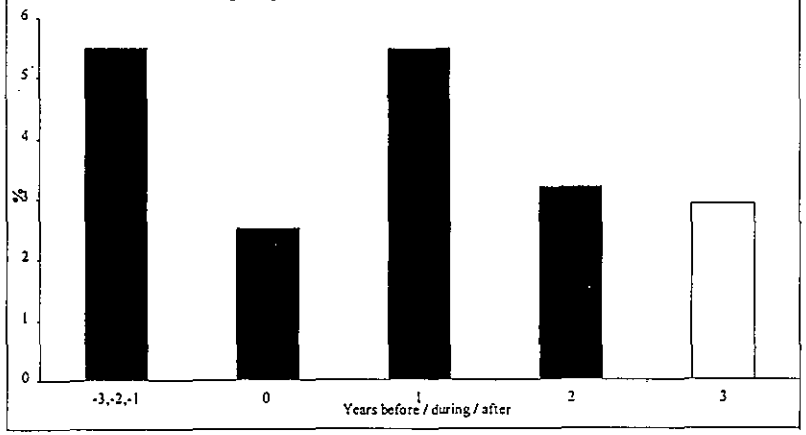
Gross domestic product growth is found to slow during the year of the event, by -3.0% on average. This is likely to be associated with reduced productivity resulting from damage to infrastructure and plant, loss of agricultural output, and reduced tourism arrivals in the main winter season. There is frequently a considerable rise in GDP growth (of around 3.0%) in the year immediately following the event, assisted by a surge in construction and rehabilitation activity, often financed from external sources. There tends to be a slowdown in the second year following the event (in the order of -2.5%) as the temporary boost in economic activity subsides, with the rate being maintained in the third year. This pattern is illustrated in Figure 4.

Consumer Prices

There is no significant pattern observable in the response of consumer prices to natural disasters. This is partly due to the somewhat volatile behaviour of prices in many Caribbean economies during the 1970's and 80's. The average rate of inflation for countries before disasters was 8%, and the average fluctuated between 6.5% and 9% subsequently. Even at the level of the individual disaster episode, rates of inflation rarely show much recognisable response.

[5] The difficulty with assessing the impact on a 'balance' item, such as the Balance of Trade or fiscal deficit/surplus is that these often fluctuate around zero and can be relatively small numbers. Rates of growth can therefore be extreme, in the hundreds or even thousands of percent. For instance, a change from 0.2 mn to 2.2 mn is an increase of 1000%, but may not represent a significant impact. On the other hand, analysing changes in absolute values rather than growth rates tends to attribute most weight to those countries with larger balances, rather than those suffering the greatest impact.

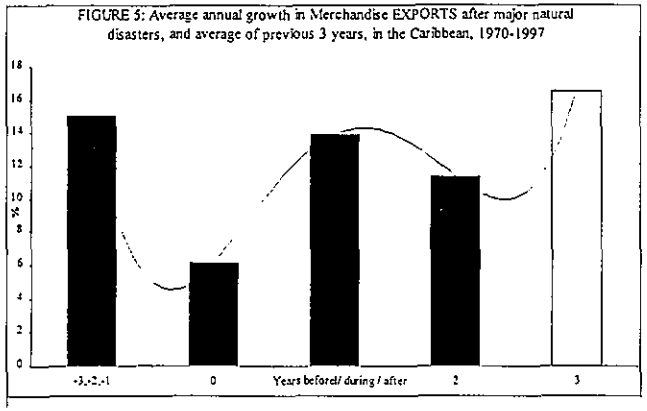
FIGURE 4: Average annual GDP growth rate after major natural disasters, and average of previous 3 years, in the Caribbean, 1970-1997



Merchandise Exports

Exports of goods suffer a reduction in the rate of growth of 9.0%, on average, during the year of the disaster. The growth rate largely returns towards its previous level in the year following the disaster, maintaining that growth in subsequent years. This is illustrated in Figure 5. There are exceptions to this pattern. For instance, sugar exporting countries such as Barbados and St. Kitts and Nevis have tended to suffer a greater loss in exports in the following year, since the sugar harvest is complete for the year in which the disaster occurs.

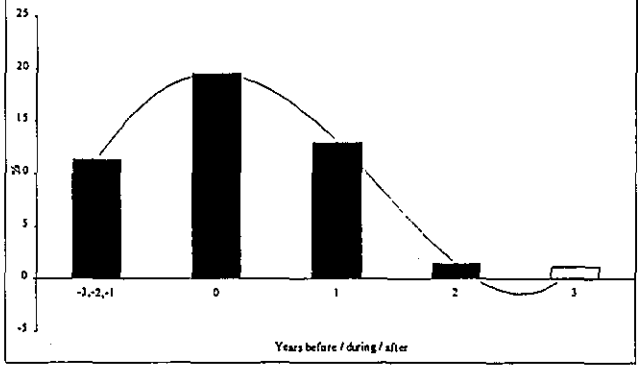
FIGURE 5: Average annual growth in Merchandise EXPORTS after major natural disasters, and average of previous 3 years, in the Caribbean, 1970-1997



Merchandise Imports

Imports of goods tend to witness a considerable increase in growth during the year of the disaster, of 8.2% on average. This is presumably associated with meeting consumption requirements not met by the reduced local supply, and imports for rehabilitation. Growth rates tend to fall to around their prior level in the subsequent year, and fall by another 11.5%, on average, in the second year following the disaster. There is little further change in growth rate in the third year. This pattern is illustrated in Figure 6. These dramatic declines in import growth are likely to be a consequence, at least in part, of reduced economic activity and disposable income.

FIGURE 6: Average annual growth in Merchandise IMPORTS after major natural disasters, and average of previous 3 years, in the Caribbean, 1970-1997



Balance of Trade

Balance of trade changes represent the combined effects of shifts in exports and imports. In the year of the disaster, with decreased exports and increased imports, there is a considerable drop in the growth rate of the balance of trade. This huge deterioration generally improves somewhat in the first year, resulting in approximate balance in the second and third years, with exports recovered and imports depressed. A quantified assessment of balance of trade changes is not attempted, since measurement of changes in a 'balance' item is complex and can give deceiving results (see previous footnote).

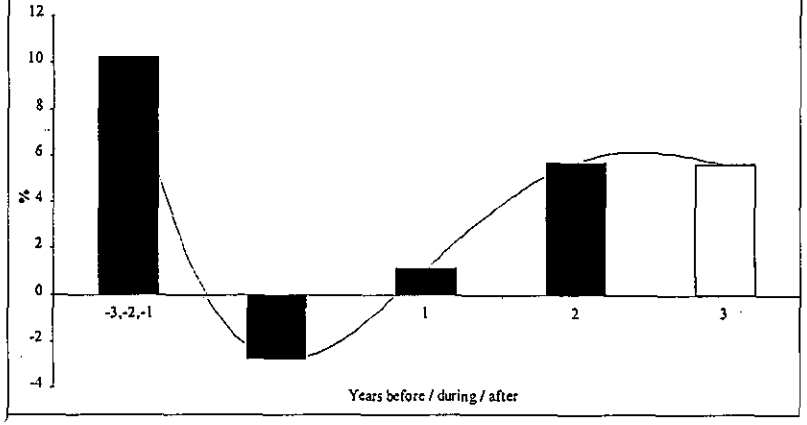
Net Foreign Assets

Net foreign assets (NFA) tend to fluctuate around zero, and thus suffer from the problems identified above for measuring changes in 'balances'. Nonetheless, analysis of growth rates and absolute levels confirms that NFA generally rise considerably during the year of the disaster. This is presumably associated with relief funds and possibly re-insurance payments. The rate of growth slows dramatically in the two years following the disaster.

Long-stay Tourist Arrivals

Long-stay tourist arrivals commonly slump during the year of the disaster, with a loss of potential visitors during the high, winter season, leading to an average drop in the growth rate of around 13%, with numbers falling in absolute terms by 2.8% on average. There is a tendency for growth in visitor numbers to pick up slowly in subsequent years, but this follows a very significant initial drop and, on average, does not reach previous rates of growth even after three years. This pattern is illustrated in Figure 7.

FIGURE 7: Average annual growth in TOURIST ARRIVALS after major natural disasters, and average of previous 3 years, in the Caribbean, 1970-1997



Cruise Ship Passenger Arrivals

Cruise ship passenger arrivals show an average drop in growth during the year of the disaster from the three years prior. However, cruise ship passenger arrivals are often volatile, making it difficult to distinguish any genuine impact of natural disasters. Quantified measures of impact, therefore, are not attempted.

External Debt

External debt growth rates average 17.6% in the years leading up to disasters, rising to 20.6% during the year of the disaster, and dropping to around 13.5% in subsequent years. The initial rise may be attributable to emergency loans provided for disaster recovery. However, external debt tends not to grow at a constant rate, due to the 'lumpiness' of loan approvals and disbursements, making increases due to natural disaster impacts difficult to isolate.

Government Expenditure

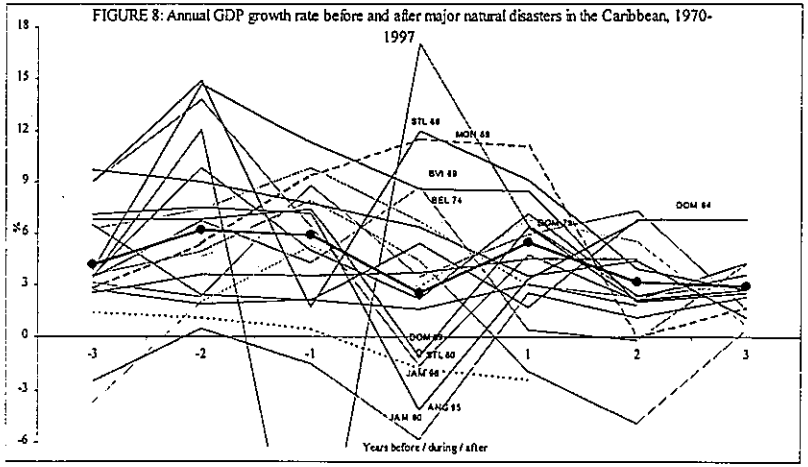
There is little relationship discernible between natural disasters and government expenditure. There is a tendency for more rapid growth in capital expenditure during the year of the disaster, declining in the three years thereafter. However, the growth rate of capital expenditure tends to fluctuate widely between all years, reducing the significance of the results. Growth of current government expenditure is also volatile, but it seems that growth rises somewhat in the year of the disaster and the year after, declining in the subsequent year.

Summary of macro-economic impacts

The degree to which the broad patterns outlined above mask huge differences between each event is illustrated in Figure 8. This Figure shows the rate of growth in GDP for the three years preceding each disaster, for the year of the event, and for each of the three years after the

event. The extent to which individual cases differ from the regional average is very apparent. This is explained by many factors, including the differential delay in impact in different countries, and other events unrelated to the natural disaster that lead to anomalous rates of growth in the variables.

FIGURE 8: Annual GDP growth rate before and after major natural disasters in the Caribbean, 1970-1997



There are many anomalies in the data series, which lead to counter-intuitive results. By running counter to the norm, these anomalies reduce the apparent average impact of natural disasters. Just some examples of such anomalies include:

(i) Massive increases in merchandise exports (of nearly 50%) in Antigua and Barbuda following Hurricane Hugo in 1989, despite registering almost no immediate negative impact.

(ii) A 174% increase in external debt in Antigua and Barbuda three years *before* Hurricane Hugo.

(iii) An increase in the Bahamas NFA of 163% the year before Hurricane Andrew in 1992. This was accompanied by a 55% increase in external debt and 9% fall in long-stay tourist arrivals.

(iv) Increased cruise ship passenger arrivals in BVI during the years of Hurricane Hugo (1989) and Hurricane Luis (1995), of 87% and 48%. This was attributable to cruise ships being re-directed from other more badly damaged destinations. In both instances, arrivals fell two years later (by 17% and 34%) as other destinations re-opened.

Such anomalous results highlight the futility of assuming that all other factors – internal and external – remain unchanged during the period leading up to and following each natural disaster. Each event needs to be considered separately, and the circumstances surrounding macroeconomic changes have to be analysed in depth.

A broad overview of the macro-economic implications of natural disasters based on the above methodology can reveal interesting patterns. However, these need to be treated with caution. Even for the very limited sample of eleven Caribbean countries and twenty-one events, widely differing responses to disasters are observed. The results illustrate that this approach is not suitable for comparing countries' relative susceptibility to natural disasters.

Montserrat

The recent devastating volcanic activity at Montserrat's Souffriere Hills deserves special mention. Even as the country was recovering from the severe impacts of Hurricane Hugo in 1989, the already dampened rates of economic growth (of between 0% and 2% in 1992 to 1994) collapsed to -7.6% and –21.4% in 1995 and 1996. With evacuation of much of the island, including the capital, Plymouth, in 1997, this slumped to –26.5%. These dramatic declines highlight the massive impacts - to all aspects of life, including the economy - that natural disasters can have, and the vulnerability of the entire economies of small island states.

However, even as economic growth declined, merchandise exports increased dramatically in 1995 and 1996 (by 317% and 94%) thanks to partial milling and export of rice from Guyana en-route to the European Union via the lucrative "Dependent Territories Route". This illustrates the difficulty of direct comparison between separate events, without analysis of other factors that influence economic variables. In the seven-year window that is the focus for analysis, other parameters do *not* remain unchanged. Some effects that influence the results will not be attributable to the natural disaster.

CONCLUSION

Assessing vulnerability to natural disasters boils down to predicting the likelihood of events occurring in the future, and of the extent of their impact. This is a notoriously difficult exercise. It is based largely on historical frequencies, of events and of their magnitude. The lack of historical data, over a sufficiently long time period and on the impact upon human activity, makes this prediction extremely difficult.

Attempts that have been made in the past to compare vulnerability to natural disasters have made use of the data that are available. These data, however, are insufficient for carrying out such an exercise. This study has sought to replicate some of the previous approaches for a smaller set of Caribbean countries. Utilising a smaller set allows detailed analysis between countries and of individual natural disaster events and their impact.

Comparing data on the number of events experienced by each country in absolute terms, or in relation to population size, gives very different results. Where all the countries under consideration are small, and can be affected throughout by a single event, the rationale for adjusting for size is relatively weak. If the analysis were to be extended to a world sample, adjusting for size would be very important to estimate the comparative impact at the national level. Measuring susceptibility based on the number of people affected also results in a different ranking. Primary concerns with this approach derive from the lack of data and incompatibility of data over time and between countries.

A different approach to comparing susceptibility is to measure changes in macro-economic variables, which are attributed to natural disasters. A number of drawbacks of this approach are highlighted. Broad patterns can be discerned in macro-economic variables following natural disasters, but the large number of results that do not conform to these patterns suggests that this approach is not suitable for inter-country comparisons.

A number of broad conclusions can be drawn from the study. Firstly, the Wider Caribbean region experiences a relatively high number of natural disasters. Secondly, some countries within the Caribbean can be identified as being particularly susceptible. Thirdly, a quantitative comparison of countries' susceptibility, whether based on the number of disasters experienced, human impacts or economic ramifications, is not feasible based on the available data. For this purpose, a detailed mapping exercise to determine the potential for countries to experience shocks, and the likely impact, would be useful.

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APPENDIX: Events Included In The Analysis

	ANG	ANT	BAH	BDS	BEL	BVI	DOM	JAM	MON	SKN	STL	SVG
1970												
1971												
1972												
1973												
1974					Fifi							
1975												
1976												
1977												
1978												
1979							David					
1980				Allen				Allen			Allen	Allen
1981												
1982												
1983												
1984							Klaus					
1985												
1986												
1987												Emily
1988								Gilbert			Gilbert	
1989		Hugo				Hugo	Hugo		Hugo	Hugo		
1990												
1991												
1992			Andre									
1993												
1994												
1995	Luis					Luis	Luis		*Volcan*	Luis		
1996								Storm	*Volcan*			
1997									*Volcan*			