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REPORT

Time's Bitter Flood

Trends in the number of reported natural disasters

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Contents

Executive Summary

This report analyses the number of reported disasters in those regions where the majority of the world's poor and vulnerable people live: sub-Saharan Africa, South and South-East Asia, and Latin America and the Caribbean. It presents analysis of the trends in the number of reported disasters, assesses what country-level factors influence the reported number of disasters, and compares the findings with independent published studies.

There is an upwards trend in the number of reported disasters. This is chiefly driven by a steep rise in reported floods in all regions and, to a lesser extent, storms in Africa and the Americas. When weather-related disasters are analysed separately, the average rate of increase is 4.1 per cent per year for the sample of countries which have a first disaster reported from 1980 (a rise of 233 per cent over 30 years), and 4.9 per cent per year for countries whose first report was from 1990 or before (159 per cent over 20 years). The rise in the number of reported disasters, and of floods in particular, is broadly supported by independent data.

An increase in the number of people exposed to disasters (approximated by population growth) partly explains the trend, but not fully. It is unlikely that reporting bias fully explains the trend either: the methodology used was designed to minimise reporting bias, and both of the methods used to evaluate any remaining reporting bias reduced, but critically did not eliminate, the rise in reported disasters. Although it was not possible to estimate directly, it is therefore possible that an increase in the number of hazards is responsible for some of the increase in reported disasters, even if only a small part. This is consistent with the reported increase in extreme weather events across many parts of the world. The implications of a continuing and steep rise in the numbers of disasters for the millions of vulnerable people living in developing countries are stark.

At a country level, the number of reported disasters is greater in more populous countries. This is partly explained by how disasters are defined but, more interestingly, population is also a first-order approximation of the number of people exposed to disasters. This is important because the populations in most developing countries are set to increase in the coming decades, which implies that there will be more disasters and more humanitarian assistance needed. Conversely, countries with higher 'bureaucratic quality' (a measure of effective governance) seem to have a lower number of disasters reported, presumably because a responsible state with functioning services is willing and able to put in place measures such as Disaster Risk Reduction (DRR) that can prevent a hazard becoming a disaster. This suggests that strengthening governance, and government institutions, could to some extent counteract any future rise in the number of disasters. Unsurprisingly, more democratic countries or those with a freer press report more disasters than those that are less democratic or lack press freedom.

1. Introduction

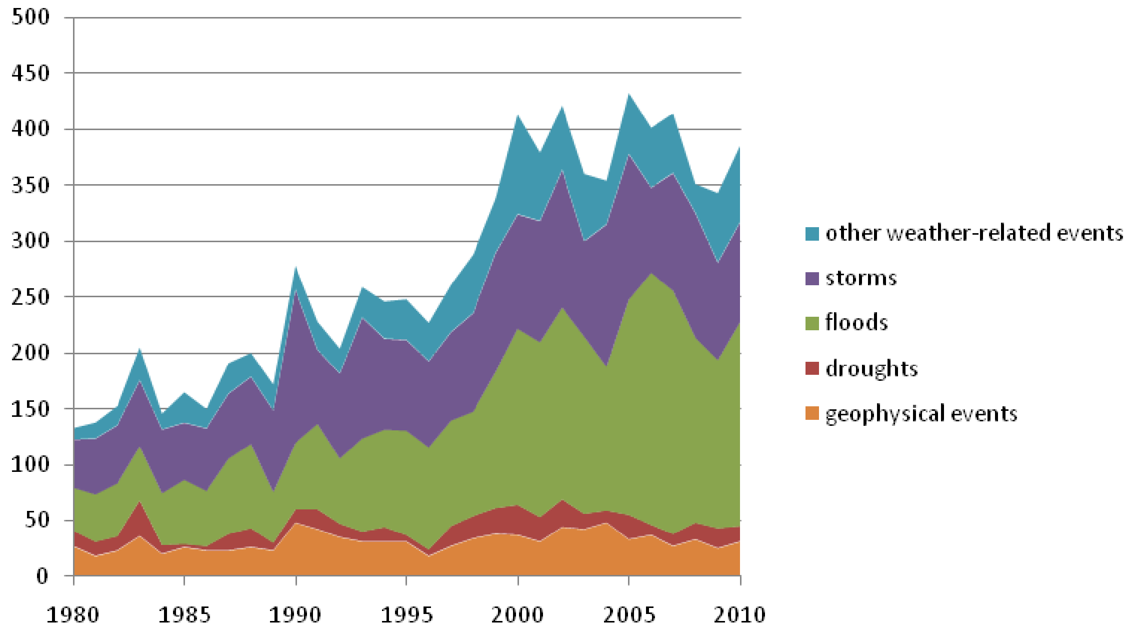
'Time's bitter flood will rise

Your beauty perish and be lost.'

W.B. Yeats

The number of natural disasters reported globally has increased considerably over the past three decades: 133 disasters were reported in 1980, whereas in recent years it has become the norm for over 350 disasters to be reported annually. Yet not all types of disaster are increasingly reported: the number of geophysical events and droughts has remained more or less stable over time, while there has been a sharp increase in the number of reported floods and storms and, to a lesser extent, in the number of other weather-related events such as wildfires and extreme temperatures (Figure 1).

Figure 1: Number of reported disasters



Note: 'Other weather-related events' are wildfires, extreme temperatures, and wet mass movements; geophysical events include earthquakes, volcanic eruptions, and dry mass movements. Source: CRED (2011).

There are three main factors that can, individually or in combination, explain this increase:

1. Increase in hazards:1 anthropogenic climate change could have led to more intense and/or more frequent disasters over time;
2. Increased exposure: if more people are exposed to hazards due to increasing vulnerability or population growth then disasters will become more frequent over time. Note that a hazard only becomes a disaster when it coincides with vulnerable people;
3. Changes in reporting: the data is for reported disasters, and so advances in information technology, increased awareness, and higher levels of press freedom in some countries mean that the number of countries covered by the EM-DAT database has increased over time. For the same reasons, it is also likely that the proportion of disasters reported in each country has risen.

The aims of this background paper are firstly to analyse trends in the number of reported disasters, secondly to assess what country-level factors influence the reported number of disasters, and finally to make some comparison of the findings with independent published studies. The analysis presented here uses data from the EM-DAT database (Emergency Events Database), which is maintained by the Centre for Research on the Epidemiology of Disasters (CRED). Disasters are entered into EM-DAT when at least one of the following criteria has been fulfilled: ten or more people reported killed; 100 people reported affected (i.e. requiring immediate assistance in a period of emergency); declaration of a state of emergency; or a call for international assistance.[2] The main sources for reported events are UN agencies, but information also comes from national governments, insurance organisations, and the media. In the broader discussions, the UN International Strategy for Disaster Reduction (UNISDR) definition of disasters is used: 'A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.'[3]

This report summarises two background papers produced by independent experts: (1) an analysis of the EM-DAT data by Fabian Barthel (London School of Economics); and (2) a desk review of the published literature on trends in weather-related hazards and natural disasters by Victoria Johnson (new economics foundation).

2. Trends in Reported Disasters

2.1 Brief note on the trend analysis

The EM-DAT database is widely used, partly because of its global coverage and partly because it is freely available. Like all other disaster databases, EM-DAT suffers from certain biases, which have been minimised in the following analyses (see Annex 1). The following analyses are for the major developing regions of South Asia, South-East Asia, sub-Saharan Africa, and Latin America and the Caribbean.

Two samples of countries from these regions were analysed. The first contains the 41 countries that have reported continuously since 1980 ('sample1980' – see Annex 2). Restricting the analysis to countries that have reported since 1980 removes the potential reporting bias of an increasing number of countries reporting over time. For the Americas and Asia, countries in this sample account for more than 80 per cent of the regional population, and can be considered broadly representative of these regions, though for Africa the coverage is far less (see Annex 3).

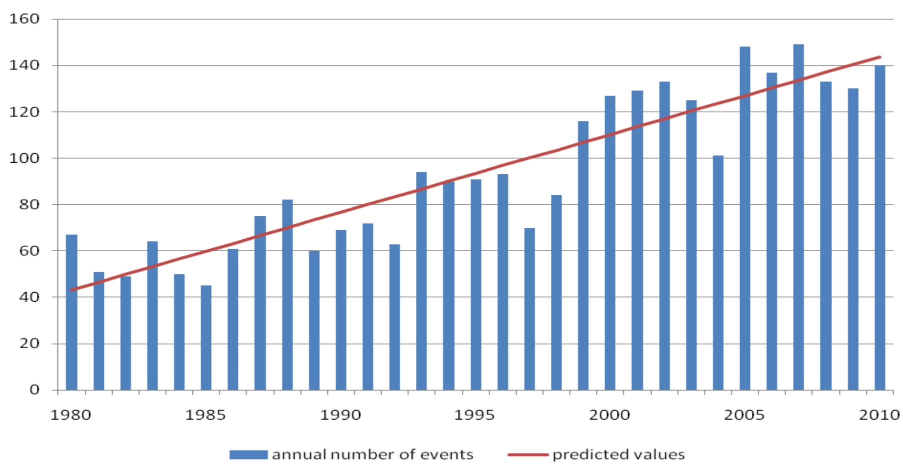
This is compared with a second sample of countries, those that reported their first disaster in 1990 or earlier ('sample1990'). This sample contains 101 countries (Annex 2) and reaches full or nearly full coverage in all regions (Annex 3). With a reduced time period, the assumption is that this second sample provides less time for the second type of reporting bias (countries reporting a higher proportion of disasters over time) to operate. However, in purely statistical terms, the reduced time period gives less certainty over the nature of any trend.

Trends in the number of reported disasters are tested by linear regression. A trend is statistically significant if the null hypothesis that the slope of the regression is equal to zero can be rejected at the 10 per cent level or lower.[4] Full details of the analytical method are available on request.[5]

2.2 Trends in reported natural disasters

There is a highly statistically significant increase in the number of reported disasters in the countries analysed since 1980 (Figure 2). In the 1980s, there were around 60 reported natural disasters each year in these countries, whereas it is now commonplace for 130 or more to be reported in recent years. This is equivalent to an extra 3.5 disasters happening every year.

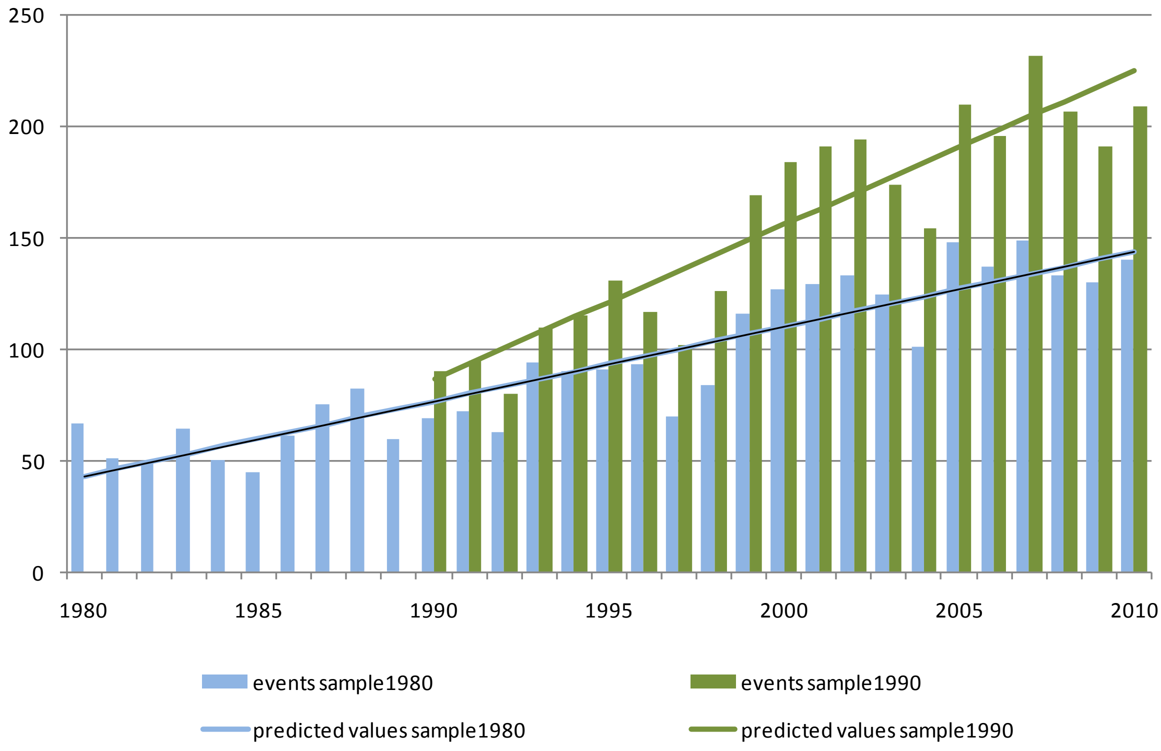
Figure 2. Annual number of events for all natural disasters for sample1980 (co-efficient: 3.48, p-value: 0.00)



This trend is almost entirely due to weather-related disasters. Geophysical disasters[6] show a slight but still statistically significant upwards trend, and when only weather-related disasters are analysed the trend is still upwards and still highly statistically significant, with an extra 3.4 disasters reported each year (Figure 3). This is equivalent to a 233 per cent rise of weather-related disasters averaged over 30 years, equivalent to an annual average increase of 4.1 per cent.[7]

When the 101 countries that began reporting in 1990 or before are analysed, the trend is even steeper: with an extra 6.9 reported weather-related disasters happening each year (Figure 3). Note that the trend in geophysical disasters is not statistically significant in this sample, giving further strong evidence that the increase is due to weather-related disasters. The 1990 sample showed a higher upward trend of an average 159 per cent increase over the 20 years, the equivalent to an average 4.9 per cent increase per year.

Figure 3. Number of events for weather-related disasters for sample1980 and sample1990 (sample 1980: co-efficient: 3.35, p-value: 0.00; sample1990: co-efficient: 6.90, p-value: 0.00)



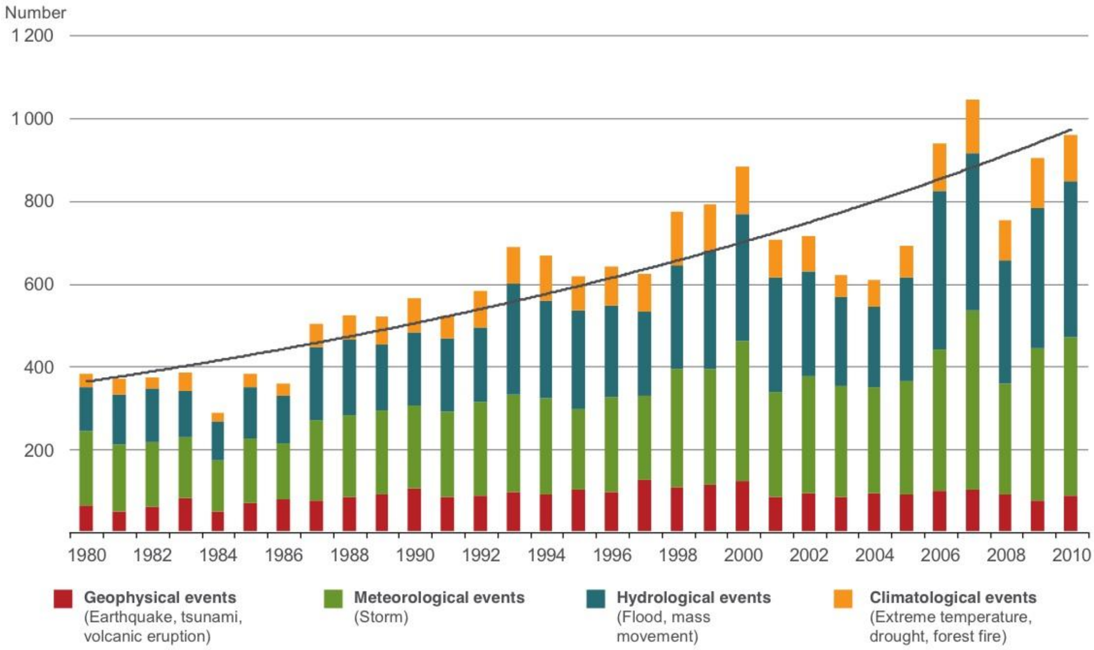
The shorter time period of the sample1990 data means that the increase in the second type of reporting bias (increased proportion of disasters reported over time) is likely to be smaller than in the longer period (sample1980). Note, though, that that the shorter period gives less certainty in the nature of the trend.

When analysed separately by region, there is a highly statistically significant upwards trend for all disaster types in all three regions, for both sample1980 and sample1990 (Annex 4). When different types of disaster are analysed, there is an upward trend in floods and storms in all regions and for both samples (with the exception of storms in Asia in sample1990). There is little evidence of an increasing number of droughts. Extreme temperature events show a positive trend only in Asia and the Americas and only in the sample from 1980. This shows that the positive trend in reported natural disasters is driven largely by an increasing number of floods.

2.3 What other sources are telling us

The independent Munich Re disaster database[8] shows an increase in the number of reported natural disasters worldwide (Figure 5). The same figure also indicates that an increase in the numbers of reported floods, and to some extent storms, is behind this increase, with numbers of other disasters changing to a lesser degree. It is therefore unlikely that the trends described in section 2.2 are unique artefacts of the EM-DAT data.

Figure 5: Number of natural catastrophes worldwide 1980–2010, Munich Re (2011)[9]



3. What is causing these trends?

3.1 Controlling for the drivers of the observed trends

If the three main drivers of the trend in reported disasters are increasing hazards, increasing exposure, and increased reporting, then excluding one will allow estimation of the size of the other two. However, there is no convenient way of estimating changes in the number of hazards, which means that any remaining trend after estimating the effects of exposure and reporting should be due to hazards.

3.1.1 Controlling reporting bias: geophysical disasters

One approach to restricting reporting bias is to use geophysical events as a benchmark. Geophysical events are not affected by climate change and there is no reason to believe that the number of geophysical hazards should have increased since 1980. Therefore, the first main driver of an increasing number of reported events can be excluded for these disasters. Under the assumption that the reporting bias is the same for geophysical and weather-related disasters, we can derive an estimate for the extent to which the upwards trend is due to an increase in weather-related hazards and/or exposure to weather-related events.

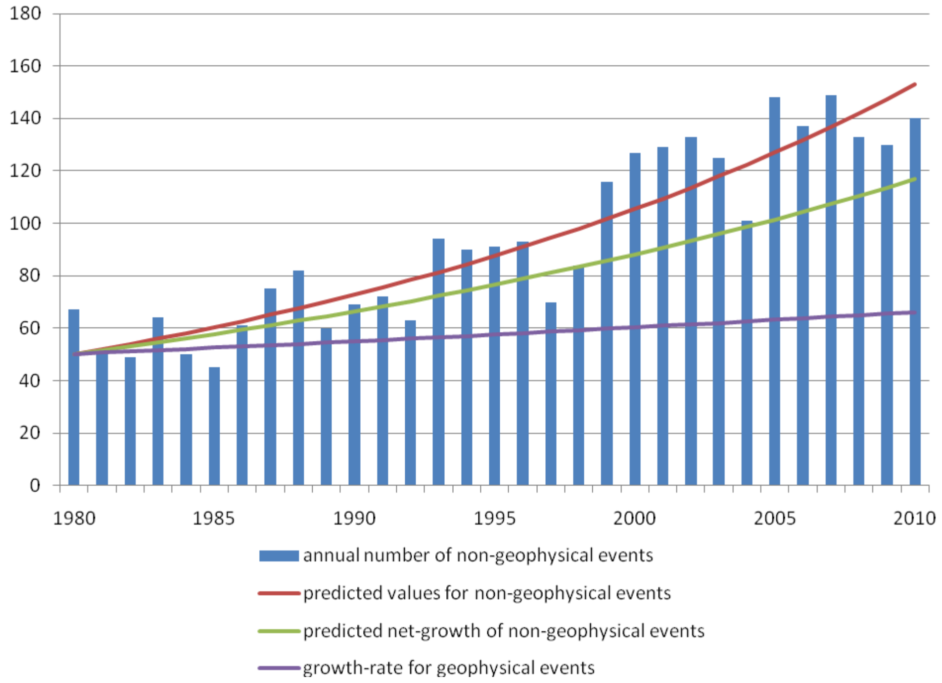
The results indicate that the number of reported geophysical events has increased by 0.9 per cent per year (significant at the 5 per cent level) and the number of weather-related events by 3.7 per cent per year (significant at the 1 per cent level). The 0.9 per cent increase in geophysical events is a combination of reporting bias and change in exposure. Assuming that the reporting bias is the same for weather-related events, the net growth of weather-related disasters is 2.8 per cent per year. This figure represents the growth rate of weather-related hazards and/or exposure to weather-related events above the exposure for geophysical events. Figure 6 illustrates this relationship.

The net increase in weather-related events by 2.8 per cent per year indicates that hazards and/or exposure have risen more strongly for these disaster types. There are several potential explanations for this:

1. Since the intensity of geophysical disasters is not bound to increase, the affected areas should remain the same and only an increase in the population in these areas affects the results. In contrast, climate change could have led to larger areas being affected by droughts or floods, which directly increases the number of events.
2. Particularly flood-prone and coastal areas provide many amenities to people, therefore population diffusion should be greater into areas prone to weather-related risks than to geophysical events.
3. Earthquakes and volcanic eruptions take place in well-known areas where we might expect people and states to have a strong incentive to invest in DRR measures, which lowers exposure.

Some caution should be applied to this finding: the assumption that the reporting bias is the same for geophysical and non-geophysical events may not be entirely valid. Volcanic eruptions and earthquakes take place in very confined and well-known locations, and detection of such hazards is possible far away from the disaster site. This may render a reporting bias less likely than for weather-related events, but does not exclude the possibility that information about the number of people killed or affected by a remotely detected event might still have been absent in earlier years, and thus the disaster not registered on the database.

Figure 6. Net growth in non-geophysical events in sample1980

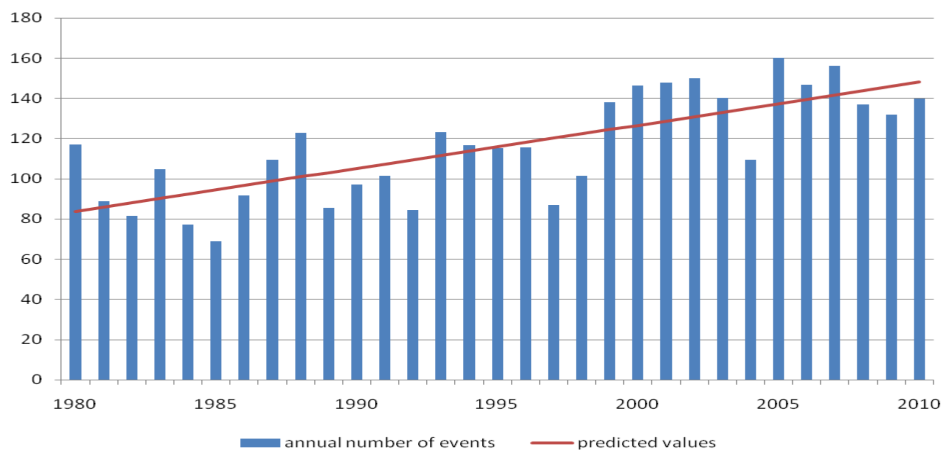


3.1.2 Controlling for changes in exposure: population growth

An increase in the number of people exposed to hazards is the second main potential driver of increasing trends in reported disasters. Exposure is difficult to measure directly, as it can be increased by population growth and by increasing vulnerability (e.g. caused by migration to more hazard-prone areas, increasing poverty, or local environmental degradation) but decreased by increasing wealth or effective DRR.[10] As a first approximation, the following analysis uses population change.

Analysis of the number of reported disasters adjusted for population change ('normalised'[11]) shows a statistically significant upwards trend (Figure 7). Weather-related disasters increase by 2.1 per year, compared with 3.4 per year in the non-normalised data (Figure 3), suggesting that increased exposure makes a considerable contribution to the increased trend in reported disasters. Nonetheless, the upwards trend is still statistically significant, indicating that hazards and/or reporting are increasing over time.

Figure 7: Annual number of normalised non-geophysical events for sample1980 (co-efficient: 2.14, p-value: 0.000)



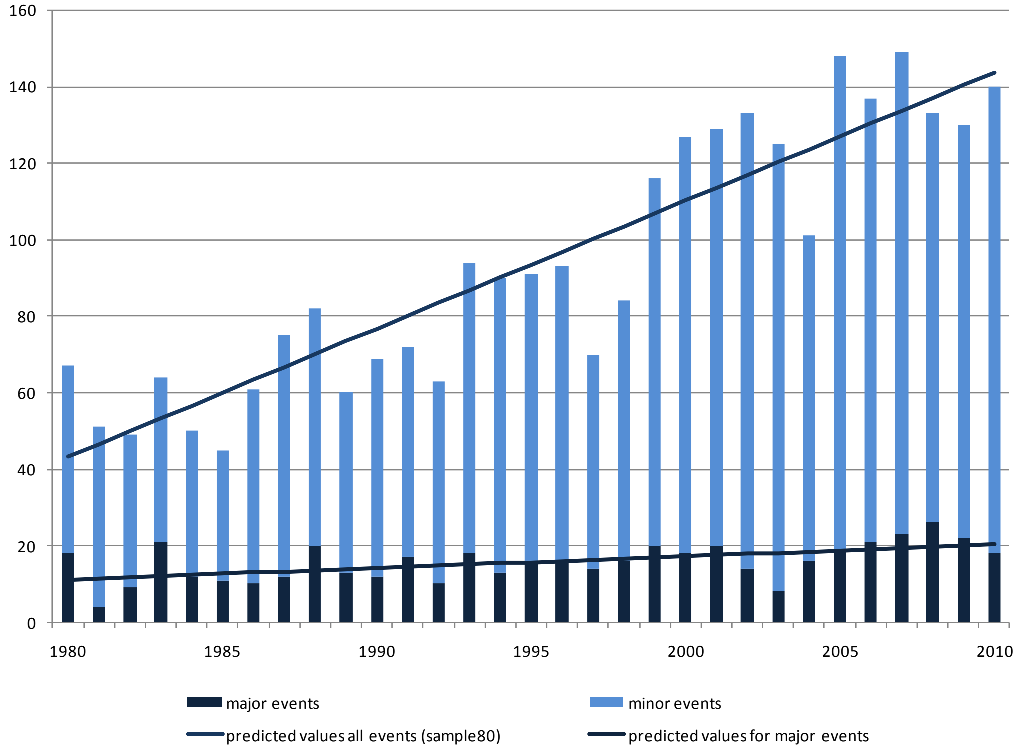
At a regional level, there is a positive trend for all normalised reported disasters in Asia and the Americas, but a negative and significant trend for normalised disaster numbers in Africa in sample1980 (Annex 5). This negative trend for Africa suggests that growth in population overcompensates for the increase in reported events (there was a significant upward trend in non-normalised data), suggesting that a change in population might overestimate a change in exposure. The upwards trend in non-geophysical events is again driven mainly by floods. The same holds true for the sample from 1990. The normalised number of geophysical events is decreasing throughout, but only in a few samples is this statistically significant. Since for these events an increase in hazards can be excluded, this provides further evidence that population overestimates exposure.

3.1.3 Restricting reporting bias further: major disasters

Major disasters should not suffer from reporting bias: even in the early 1980s, news of a devastating disaster should have spread around the world. We assume that all such large-scale events should therefore be included in the database.

The definition of a 'major disaster' is essentially arbitrary. For a threshold of 250,000 people affected, there is a modest (but still statistically significant) upwards trend in the number of major disasters in the sample from 1980. This is an average annual increase of 0.3 events, equivalent to an increase of 2 per cent per year (Figure 8). With the assumption that all disasters of this size are reported, the finding that the slope is less steep than that for all natural disasters suggests that changes in reporting are responsible for some of the increase in reported disasters over time. However, this analysis has a number of caveats. Firstly, different definitions of a 'major disaster' yield different results – the thresholds of more than 1 million people affected, or more than 99 people killed, do not yield statistically significant trends. This reflects a trade-off between setting the threshold sufficiently high to be able to assume that major disasters are consistently reported over time and increased volatility of the data caused by reducing the number of events included in the analysis (e.g. only 8 per cent of the events in sample1980 had more than 1 million people affected, whereas 19 per cent affected more than 250,000 people). The interpretation of this trend also rests on the additional assumptions that changes to exposure are the same for major disasters and smaller ones, and that the smaller hazards are changing at the same rate as larger ones.

Figure 8: Annual number of major disasters (affecting at least 250,000 people) for sample1980 (co-efficient: 0.304, p-value: 0.005)



3.1.3 Summary

In summary, attempts to control the different drivers of the trends in the reported number of disasters indicate that:

1. Assuming that any reporting bias for geophysical hazards is the same as for weather-related hazards, there is an upwards trend in disasters caused by increasing hazards and/or increasing exposure;
2. Assuming that population change is a reasonable measure for exposure, there is an upwards trend in disasters caused by increasing hazards and/or reporting bias;
3. Assuming that major disasters suffer from no reporting bias, and that changes in exposure and the number of hazards are the same for smaller disasters as for major ones, then part but not all of the increase in reported disasters is driven by changes in reporting over time.

3.2 Structural model

While a trend analysis provides valuable insights into changes in the number of disasters over time, it is not able to separate the influence of various factors which affect the number of reported disasters. To do so, a multivariate analysis using a negative binomial model with unconditional fixed effects is undertaken to examine whether the number of events systematically varies with certain factors.[12] This model does not examine trends; rather, it examines what determines the number of disasters reported in a country. These factors include both those that can influence the number of actual disasters that occur (e.g. population) and others that affect the likelihood that disasters are reported (e.g. press freedom). Given this purpose, all natural disaster types are included, and for the global data set (i.e. not limited to the regions analysed above). 1980 is taken as the start date for the data set, but the sample includes countries for which the first reports began after that date (countries for which no disasters are reported in 1980 should not be excluded, as the purpose of this exercise includes assessing the factors that influence reporting).

The following variables are used to estimate what determines the number of disasters reported:

- *Total population:* An increased population would be expected to result in an increased number of disasters (i.e. the co-efficient would be expected to be positive), for two reasons. First, a higher population increases the probability that a natural hazard will lead to a natural disaster surpassing the reporting threshold. Second, population is an indicator of exposure to disasters.
- *Share of urban population:* While people living in cities are less vulnerable to some disaster types, a natural hazard affecting an urban agglomeration is more likely to be reported. As a consequence, a higher proportion of urban population could either increase or decrease the number of reported disasters (co-efficient positive or negative).
- *GDP per capita:* GDP per capita is measured in constant US dollars. In general, richer countries are better able to mitigate the impact of smaller natural hazards, which should reduce the total number of reported events (co-efficient negative).
- *Press freedom* measures threats to the independence of media and classifies countries into those with a free press, a partly free press, and a non-free press. Since repressive governments might have an incentive to restrict reporting about the impact of natural disasters, it is expected that fewer events would be reported for countries with less press freedom (co-efficient negative).
- *Democracy:* research by Keefer et al. (2011)[13] shows that democratic systems invest more in DRR measures for earthquakes. If this can be generalised to other disaster types, an increase in the democracy indicator should be associated with a decrease in the number of disasters. However, democratic systems also have less of an incentive to conceal natural disasters, which would explain a positive sign (co-efficient negative or positive).
- *Conflicts:* since information availability could be severely limited if a country suffers from armed conflicts, then conflict should be associated with a decrease in the number of reported disasters (co-efficient negative).
- *Bureaucratic quality* is a measure of institutional strength and quality of government services. It is not necessarily correlated with the indicator for democracy (China, for example, would score highly on bureaucratic quality but is not a democratic system). Countries with strong institutions that can implement their policies should be better able to protect their populations from minor natural hazards, which makes it less likely that a given event would exceed the reporting threshold (co-efficient negative).
- *Corruption:* this measure provides an assessment of corruption in the political system. Higher values are associated with less corruption and, for the same reasons as the measure of bureaucratic quality, we would expect less corruption to be associated with fewer disasters (co-efficient negative).
- *Income inequality:* broadly we might expect that increasing income inequality would be associated with an increasing number of people exposed to hazards and thus affected by disasters (co-efficient positive). However, inequality can be low and a large proportion and absolute number of the population exposed to hazards if everyone is poor.
- To control for development in information technology and increased awareness, which make the recording of disasters more likely in any country, a t-1 set of year dummies is included. They capture any year-specific effect that does not vary across countries.

Not all of the variables are available for the full set of countries, and therefore a series of models are run adding those variables which are only partially complete or which are likely to be related (e.g., bureaucratic quality and corruption). A summary of the results of this analysis is given in Table 1.

Table 1: Results of the structural model exploring what determines the number of disasters reported in a country

Model	I	II	III	IV	V	VI	VII
Total population (ln)	0.775***	1.138***	1.128***	1.158***	1.794***	1.869***	1.151***
	(3.50)	(4.09)	(4.05)	(4.16)	(3.20)	(3.28)	(2.63)
Share of urban population	-0.00165	0.0124*	0.00932	0.0123*	-0.017	-0.0169	-0.027**
	(-0.29)	(1.74)	(1.32)	(1.72)	(-1.19)	(-1.18)	(-2.57)
GDP per capita (ln)	-0.0536	-0.116	-0.144	-0.126	-0.147	-0.112	0.0317
	(-0.65)	(-1.17)	(-1.44)	(-1.27)	(-0.61)	(-0.45)	(0.17)
Partly free press	-0.112**	-0.126**	-0.120**	-0.124**	-0.254***	-0.265***	-0.26***
	(-2.09)	(-2.10)	(-2.01)	(-2.08)	(-2.98)	(-3.06)	(-3.38)
Non-free press	-0.274***	-0.262***	-0.249***	-0.256***	-0.165	-0.171	-0.219*
	(-3.63)	(-3.13)	(-2.97)	(-3.05)	(-1.30)	(-1.34)	(-1.90)
Democracy	0.122**	0.147**	0.147**	0.152**	0.242***	0.236**	0.151*
	(2.21)	(2.33)	(2.32)	(2.42)	(2.64)	(2.56)	(1.86)
Minor conflict	-0.0727	-0.0425	-0.0421	-0.0498	-0.141	-0.147*	-0.12
	(-1.39)	(-0.70)	(-0.69)	(-0.81)	(-1.61)	(-1.68)	(-1.57)
Major conflict	-0.0548	-0.0413	-0.034	-0.0516	-0.176	-0.182	-0.134
	(-0.78)	(-0.50)	(-0.41)	(-0.63)	(-1.59)	(-1.64)	(-1.43)
Bureaucratic quality risk		-0.0854***		-0.0742**	-0.0544	-0.0525	
		(-2.90)		(-2.36)	(-1.06)	(-1.02)	
Corruption risk			-0.0438**	-0.0245	-0.0393	-0.0406	
			(-1.97)	(-1.04)	(-1.01)	(-1.04)	
Income inequality						0.00495	0.00802
						(0.73)	(1.28)
Constant	-10.84***	-19.34***	-18.71***	-19.53***	-24.50***	-26.28***	-15.70**
	(-3.41)	(-4.41)	(-4.27)	(-4.45)	(-2.95)	(-3.05)	(-2.48)
Observations	3,795	2,788	2,788	2,788	1,331	1,331	1,820
Number of countries	150	123	123	123	91	91	110
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*Notes: Dependent variable is the number of disasters in country i in year t; z-values shown in parentheses; co-efficients on (t-1) year dummies not shown and a full set of country dummies not shown; variables marked 'ln' are transformed on a natural logarithmic scale; * denotes statistically significant at 0.1, ** 0.05, or *** 0.01 level.*

As expected, the total *population size* of a country positively affects the number of reported events. While the size of the co-efficient somewhat depends on model composition and sample size, it is highly significant at the 1 per cent level in all models. Taking Model I as a reference, a 1 per cent increase in the population is associated with 2.2 additional reported events, keeping all other variables constant. The *share of urban population* fails to reach conventional significance levels in three out of seven specifications. Interestingly, it is positive and significant in Model II and Model IV, but negative and significant in Model VII. However, Model VII has around 1,000 fewer observations than Model II and IV. This provides some – but not strong – evidence that the geographical clustering of people increases vulnerability and therefore the event count.

After controlling for other political measures correlated with *GDP per capita*, there is no effect for this variable in any specification. Regarding *press freedom*, there is evidence that more disasters are reported in countries in which the media are independent and not subject to pressure from the government. As expected, the effect is stronger for countries classified as having a non-free press than for those with a partly free press. Holding all other variables constant, in a country with a partly free press, 1.1 fewer events are reported compared with a country with a free press. For countries with a non-free press, the effect is 1.3 events. We assume that this does not represent a causal relationship in the sense that press freedom decreases vulnerability or exposure, rather that reporting is better in countries with independent media (although Amartya Sen's argument that famine does not occur in countries that have a free press springs to mind, it is not obvious that Sen's mechanism – that a free press and an active political opposition give advance warning of famine – would hold for fast-onset disasters such as floods or storms). Similarly, more events are reported for democratic countries (1.1 events). Again this does not mean that democratic systems are more vulnerable to natural hazards, but that information quality is better.

In line with expectations, the co-efficients on the *conflict* dummy variables are negative, but insignificant throughout. After controlling for press freedom and democracy, the existence of a conflict does not seem to affect the number of reported events. The inclusion of *bureaucratic quality* in Model II leads to a loss of around 1,000 observations compared with Model I. Increased bureaucratic quality has a highly significant and negative effect on the number of disasters, as expected. A one-point increase in the measure ranging from zero to four is associated with 1.1 fewer events. The same is true for corruption if this measure rather than the bureaucratic quality measure is included (Model III). A one-point increase in this variable ranging from zero to six leads to 1.0 fewer reported disasters. The two variables are highly correlated at 0.66 since they are both measures of governance. This leads to multicollinearity problems if they are estimated simultaneously. As a consequence, the corruption measure loses significance while the co-efficient on bureaucratic quality becomes somewhat smaller. As argued above, countries with better governance seem to be better able to deal with minor hazards, and therefore experience fewer disasters above the reporting threshold.

Data on *income inequality* is only available until 2002. Adding this variable to the estimation model reduces the number of estimations by half. Since this reduction in sample size is non-random, we re-estimate Model IV with the new sample to assess the effect of the loss of observations (Model V). While the effect of total population, a partly free press, and democracy becomes considerably larger, bureaucratic quality and a non-free press are no longer statistically significant. The co-efficient on income inequality is not significant (Model VI). It remains insignificant if the measures for good governance are dropped, which leads to a larger sample in Model VII.

Two potentially important types of variable were unfortunately not obtainable in a form suitable for analysis. The first would have been an indicator of climate change, which would have allowed a direct estimation of the impact of climate change on the number of hazards reported by countries. Unfortunately, the type of climatic data widely available at this scale (such as temperature) would be unlikely to reveal much about changes in hazards. Secondly, although we had measures of economic activity (GDP) and income inequality, we were unable to find suitable data on poverty, which would have allowed a better understanding of the impact of vulnerability (and hence exposure) on country-level disasters.

In summary, this model indicates that the number of reported disasters is greater in more populous countries. This is partly explained by how disasters are defined but, more interestingly, population is also a first-order approximation of the number of people exposed to disasters. This is important because populations in most developing countries are set to increase in the coming decades, which implies that there will be more disasters and more humanitarian assistance needed. Conversely, countries with higher 'bureaucratic quality' (a measure of effective governance) have fewer reported disasters, presumably because a responsible state with functioning services is willing and able to put in place measures such as DRR that can prevent a hazard becoming a disaster. Unsurprisingly, more democratic countries or those with a freer press report more disasters than those that are less democratic or where freedom of the press is curtailed.

3.3 What are other sources are telling us?

Most of the existing literature focuses on reported economic losses or deaths from disasters rather than on the number of reported disasters, meaning that there is little that can be compared directly with the trend analysis and the structural model described above. There is, however, some recent evidence on trends in hazards and exposure. There are also some analyses of different aspects of disasters that may relate to the analysis of factors affecting the number of disasters reported by countries.

3.3.1 Trends in weather-related hazards

Extreme precipitation and floods: There is no absolute relationship between extreme precipitation and floods i.e. many extreme rainfall events do not cause floods, and some floods are caused by other factors that are connected with climate change (e.g. sea-level rise), and some are essentially unconnected to weather events (e.g. infrastructure failure). Nonetheless, increased intensity in precipitation has been reported for northwest Mexico[14] and São Paulo,[15] and most of South America has become wetter, with more extreme events (except for parts of southern South America which show the opposite trends).[16] In central India, a 10 per cent increase per decade in the level of heavy rainfall events has been reported, with the number of very heavy rainfall events more than doubling since the 1950s.[17] Whereas one study detected that the proportion of annual rainfall that came from extreme events had increased in the tropical South Pacific,[18] a study of the wider Asia-Pacific region found no significant trends in extreme rainfall.[19] The Intergovernmental Panel on Climate Change (IPCC)'s Fourth Assessment Report concluded that 'it is *likely*[20] that the frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) has increased over most areas' over the past 50 years, and 'It is *more likely than not* that human influence has contributed to a global trend towards increases in … the frequency of heavy precipitation events'. The IPCC also concluded that, 'Sea-level rise and human development are together contributing to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas.'[21]

Tropical cyclones: Recent research implies that neither hurricane landfall activity nor hurricane wind speeds exceed the long-term variability found in the historic record since at least 1900.[22] The IPCC Fourth Assessment Report concluded that 'There is no clear trend in the annual numbers of tropical cyclones.'[23] We are unable to find analysis of other storms of lesser intensity than tropical cyclones.

Extreme temperatures: Extreme daily maximum and minimum temperatures have warmed for most regions since the 1950s.[24] There is evidence of increasing trends in warm extremes and reduction in cold extremes from several countries in Africa[25] and Asia and the Pacific,[26] with the evidence less clear for South America.[27] The IPCC Fourth Assessment Report concluded that, 'It is *likely* that heat waves have become more frequent over most land areas' and 'It is *more likely than not* that anthropogenic forcing has increased the risk of heat waves'.[28]

Droughts: Increased temperatures appear to have contributed to increased regions under drought.[29] The IPCC Fourth Assessment Report concluded that, 'Globally, the area affected by drought has *likely* increased since the 1970s' and 'It is *more likely than not* that human influence has contributed to a global trend towards increases in area affected by drought since the 1970s'.[30]

In summary, there is strong evidence that the frequency and intensity of most weather-related hazards are increasing (except for tropical cyclones), although these changes vary from place to place. What is less certain is how much they may be contributing to an increasing number of disasters.

3.3.2 Trends in disaster exposure

The UNISDR's Global Assessment Report 2011[31] shows an increase in the number of people exposed[32] to weather-related hazards (particularly floods and tropical cyclones). For example, the number of people exposed to floods has doubled since 1970 (Table 2).

Table 2: Flood exposure by region (millions of people per year)

Region	1970	1980	1990	2000	2010
East Asia and Pacific (EAP)	9.4	11.4	13.9	16.2	18.0
Europe and Central Asia (ECA)	1.0	1.1	1.2	1.2	1.2
Latin America and Caribbean (LAC)	0.6	0.8	1.0	1.2	1.3
Middle East and North Africa (MENA)	0.2	0.3	0.4	0.5	0.5
OECD	1.4	1.5	1.6	1.8	1.9
South Asia (SAS)	19.3	24.8	31.4	38.2	44.7
Sub-Saharan Africa	0.5	0.7	1.0	1.4	1.8
World	**32.5**	**40.6**	**50.5**	**60.3**	**69.4**

Source: UNISDR Global Assessment Report 2011

3.3.3 Factors affecting other aspects of disasters

Economic losses: Analysis of disaster loss studies shows that economic losses from weather-related natural hazards have increased around the globe. The studies show no trends in losses, corrected for changes (increases) in population and capital at risk, that could be attributed to anthropogenic climate change.[33]

Mortalities: Increasing GDP has been shown to result in fewer mortalities from a range of natural disasters.[34] The same study also suggests that less democratic nations and nations with more income inequality suffer higher mortality risks from natural hazards. The UNISDR Global Assessment Report finds that, for weather-related hazards, countries with low GDP and weak governance have higher mortality risks compared with wealthier nations with stronger governance.[35] The Global Assessment Report also finds that, despite an increase in populations exposed to weather-related hazards (see above), mortality risk is decreasing globally. For example, in East Asia and the Pacific, two of the regions most exposed to weather-related hazards, mortality risk from weather-related events has fallen by a third since 1980.

Major natural disasters: The Munich Re data shows a long-term increase in 'great natural catastrophes',[36] similar to the analysis shown above in Figure 8.

4. Conclusions

The purpose of this paper is to analyse trends in the number of reported natural disasters and the factors that influence disaster counts. The geographical focus of this work is developing countries in Latin America and sub-Saharan Africa, as well as in Southern and South-East Asia. Particular effort has been made to reduce and control for reporting bias.

There is a statistically significant increase in all disasters, and this trend is driven mainly by a rising number of floods in all regions and by more storm events in Asia and the Americas. Changes in population do not fully explain the rising number of floods, nor can the trend be entirely attributed to changes in how disasters are recorded. It was not possible to directly analyse the effect of climate change on disaster trends; however, there is insufficient evidence to exclude the possibility that climate change is increasing hazards and hence trends in reported disasters. This effect is unlikely to be very large, because the magnitude of climate change over the past 20-30 years is relatively small when compared with (for example) the growth in the world's population over that time.

Analysis of the factors determining the number of reported events in a country reveals that more events are reported for more populous countries and for democracies. Fewer disasters are reported for countries with good governance and for countries in which media are not independent. Since populations, especially in developing countries, are bound to grow further over the next decades, the number of natural disasters is likely to rise in future. This is mainly due to increasing exposure to natural hazards. Our results also show that countries with better governance are less vulnerable to natural hazards, which implies that securing increased standards of governance could help to mitigate future increases in exposure and hazards.

Annex 1: Biases in disaster databases

The EM-DAT database

The Centre for Research on the Epidemiology of Disasters (CRED) maintains a publicly accessible database on emergency events. The EM-DAT (Emergency Events Database) is a comprehensive database carrying data for various types of natural disaster by both country and date (year and month). For the analysis shown, we have not used any data from before 1980. For a disaster to be entered into the database, at least one of the following criteria must be fulfilled: ten or more people reported killed; 100 people reported affected; declaration of a state of emergency; or a call for international assistance. The main sources for events listed are UN agencies, but information also comes from national governments, insurance organisations, and the media. Three groups of disasters are distinguished in EM-DAT: natural disasters, technological disasters, and complex emergencies. Natural disasters are in turn categorised into five main groups (biological, climatological, geophysical, hydrological, and meteorological) and then into 11 main types.

Treatment of biases in this analysis

The analysis presented in this paper both minimises potential biases in EM-DAT and explicitly analyses the likely impact of any remaining biases through the following measures:

1. **Using the number of disasters:** The number of disasters is (1) generally considered to be more reliable than the number of people affected (which is hard to quantify and open to political influence); (2) reduces the influence of very populous countries (e.g. if India or China suffers a large-scale disaster, then the numbers of people affected spike irrespective of any underlying global trend); and (3) has much less volatility (shallower troughs and spikes) than the number of people affected.
2. **Using a standard set of countries:** A reporting bias can be introduced if the countries reporting on disasters change over time. There has been a clear increase over time in the number of countries that are included in EM-DAT. To exclude any bias arising from a change in the country sample, we have restricted our main analysis to countries for which a disaster is reported in 1980 (sample1980).
3. **Using different 'start dates':** A second cause of reporting bias occurs when the proportion of events that are reported changes over time. This is most likely due to advances in the field of information technology, which make global disaster information more easily accessible. This source of reporting bias is much harder to quantify. Therefore, we have run a separate analysis for the period from 1990 to 2010 and restricted this sample to countries which reported their first event in 1990 or earlier (sample1990). From a statistical point of view, there is a trade-off between the length of the study period and the reporting bias. On the one hand, a longer study period (sample1980) provides more information and makes the detection of a statistically significant trend easier. On the other hand, a longer time series is more likely to be subject to changes in the proportion of disasters reported, which is less the case for sample1990.
4. **Analysing major disasters separately:** We would expect major disasters to be reported whenever and wherever they occur, and therefore to be free from reporting bias. However, the definition of a 'major disaster' is essentially arbitrary. In this work we chose three definitions: (1) a disaster with more than 250,000 people affected; (2) a disaster with more than 99 people killed; and (3) a disaster with more than 1 million people affected. The threshold used has a marked effect on the result of the trend

analysis, reflecting a trade-off between setting the threshold sufficiently high to be able to assume that major disasters are consistently reported over time and increased volatility of the data caused by reducing the number of events included in the analysis. It is also based on the assumptions that changes to exposure are the same for major disasters and smaller ones and that the smaller hazards are changing at the same rate as larger ones. Neither assumption is particularly robust.

5. **Analysing indicators of reporting bias:** The analysis described in section 3.2 includes three variables that enable some quantification of the likely size of remaining reporting bias:

   a) 'Press freedom': repressive governments might have an incentive to restrict reporting about the impact of natural disasters. It is expected that fewer events are reported for countries with less press freedom.

   b) 'Democracy': a more democratic government is presumably more likely to report disasters than a less democratic one.

   c) 'Conflicts': we might expect that reporting of natural disasters would be restricted in conflict.

Annex 2: Countries included in the analyses of EM-DAT data

Composition of Sample1980

Country	Number of events	Share	Country	Number of events	Share
Afghanistan	109	3.27%	Jamaica	27	0.81%
Argentina	72	2.16%	Mali	24	0.72%
Bangladesh	207	6.20%	Martinique	9	0.27%
Barbados	9	0.27%	Mauritania	22	0.66%
Bolivia	52	1.56%	Mexico	168	5.03%
Brazil	132	3.95%	Nepal	61	1.83%
Burkina Faso	20	0.60%	Nicaragua	48	1.44%
Colombia	117	3.51%	Niger	22	0.66%
Costa Rica	48	1.44%	Pakistan	128	3.83%
Cuba	55	1.65%	Peru	99	2.97%
Djibouti	14	0.42%	Philippines	352	10.55 %
Dominica	9	0.27%	Reunion	8	0.24%
Dominican Republic	42	1.26%	Somalia	41	1.23%
Ecuador	45	1.35%	South Africa	71	2.13%
Gambia The	14	0.42%	Sri Lanka	56	1.68%
Grenada	6	0.18%	St Lucia	15	0.45%
Haiti	72	2.16%	St Vincent & the Grenadines	10	0.30%
Honduras	53	1.59%	Thailand	100	3.00%
India	375	11.23%	Venezuela	38	1.14%
Indonesia	293	8.78%	Viet Nam	150	4.49%
Iran Islamic Republic	145	4.34%	**Total**	**3,338**	

Composition of Sample1990

Country	Number of events	Share	Country	Number of events	Share
Afghanistan	103	2.81%	Liberia	8	0.22%
Angola	27	0.74%	Madagascar	38	1.03%
Anguilla	1	0.03%	Malawi	30	0.82%
Antigua and Barbuda	7	0.19%	Malaysia	43	1.17%
Argentina	57	1.55%	Maldives	3	0.08%
Bahamas	12	0.33%	Mali	21	0.57%
Bangladesh	163	4.44%	Martinique	7	0.19%
Barbados	6	0.16%	Mauritania	19	0.52%
Belize	13	0.35%	Mauritius	7	0.19%
Benin	13	0.35%	Mexico	139	3.79%

Bolivia	41	1.12%	Montserrat	6	0.16%
Botswana	8	0.22%	Mozambique	42	1.14%
Brazil	94	2.56%	Myanmar	23	0.63%
Burkina Faso	15	0.41%	Namibia	15	0.41%
Burundi	29	0.79%	Nepal	41	1.12%
Cambodia	21	0.57%	Netherlands Antilles	1	0.03%
Cameroon	14	0.38%	Nicaragua	45	1.23%
Cape Verde Islands	5	0.14%	Niger	19	0.52%
Central African Republic	17	0.46%	Nigeria	39	1.06%
Chad	18	0.49%	Pakistan	108	2.94%
Chile	47	1.28%	Panama	30	0.82%
Colombia	94	2.56%	Paraguay	20	0.54%
Comoros	6	0.16%	Peru	68	1.85%
Congo	8	0.22%	Philippines	265	7.22%
Costa Rica	43	1.17%	Puerto Rico	14	0.38%
Côte d'Ivoire	6	0.16%	Reunion	4	0.11%
Cuba	43	1.17%	Rwanda	15	0.41%
Djibouti	9	0.25%	Senegal	16	0.44%
Dominica	6	0.16%	Sierra Leone	8	0.22%
Dominican Republic	34	0.93%	Somalia	33	0.90%
Ecuador	35	0.95%	South Africa	58	1.58%
El Salvador	34	0.93%	Sri Lanka	40	1.09%
Ethiopia	53	1.44%	St Kitts and Nevis	4	0.11%
Gabon	2	0.05%	St Lucia	9	0.25%
Gambia The	13	0.35%	St Vincent & the Grenadines	6	0.16%
Ghana	12	0.33%	Swaziland	8	0.22%
Grenada	5	0.14%	Tanzania	38	1.03%
Guadeloupe	6	0.16%	Thailand	89	2.42%
Guatemala	47	1.28%	Togo	11	0.30%
Guinea	11	0.30%	Trinidad and Tobago	10	0.27%
Guinea Bissau	8	0.22%	Turks and Caicos Islands	5	0.14%
Guyana	7	0.19%	Uganda	29	0.79%
Haiti	56	1.53%	Uruguay	21	0.57%
Honduras	43	1.17%	Venezuela	26	0.71%
India	279	7.60%	Viet Nam	128	3.49%
Indonesia	220	5.99%	Virgin Islands (US)	5	0.14%
Iran Islamic Republic	113	3.08%	Zaire/Congo Dem Republic	30	0.82%
Jamaica	20	0.54%	Zambia	17	0.46%
Kenya	46	1.25%	Zimbabwe	14	0.38%
Lao P Dem Republic	18	0.49%	**Total**	**3,672**	
Lesotho	9	0.25%			

Annex 3: Proportion of regional populations covered by the analysed samples

Region	Regional population 2010 (1,000s)	Population in countries in sample1980	Population share covered in sample1980	Population in countries in sample1990	Population share covered in sample1990
Caribbean	42,311	35,464	83.8%	42,124	99.6%
Central America	153,115	128,723	84.1%	153,115	100.0%
South America	393,221	364,735	92.8%	392,463	99.8%
Eastern Africa	327,187	11,075	3.4%	321,679	98.3%
Middle Africa	128,908			128,050	99.3%
Western Africa	306,590	50,618	16.5%	306,056	99.8%
Southern Africa	57,968	50,492	87.1%	57,968	100.0%
South-Eastern Asia	589,616	483,302	82.0%	583,201	98.9%
Southern Asia	1,719,122	1,718,100	99.9%	1,718,414	100.0%

Annex 4: Results overview of analysis of trends in reported natural disasters

	sample1980				sample1990			
	Africa	Asia	Americas	All three regions	Africa	Asia	Americas	All three regions
Geophysical events	-0.00	0.12**	0.01	0.13**	0.03	0.05	-0.10	-0.24
	(0.56)	(0.031)	(0.795)	(0.048)	(0.579)	(0.685)	(0.318)	(0.886)
Non-geophysical events	0.38***	1.82***	1.15***	3.35***	2.89***	2.11***	1.92***	6.92***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Floods	0.31***	1.23***	0.54***	2.08***	2.26***	1.66***	0.98***	4.89***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Droughts	-0.01	0.01	0.07**	0.07	0.12	0.05	0.09	0.26**
	(0.91)	(0.72)	(0.039)	(0.278)	(0.23)	(0.219)	(0.303)	(0.036)
Extreme temperature	0.01	0.08**	0.08**	0.16***	-0.02	0.04	0.13	0.15
	(0.28)	(0.013)	(0.003)	(0.00)	(0.307)	(0.586)	(0.118)	(0.198)
Storms	0.04*	0.25***	0.41***	0.71***	0.36***	0.17	0.68**	1.21***
	(0.072)	(0.004)	(0.002)	(0.00)	(0.005)	(0.290)	(0.049)	(0.001)
All disasters	**0.37*** **	**1.95*** **	**1.16*** **	**3.48*** **	**2.92*** **	**2.16*** **	**1.81*** **	**6.92*** **
	(0.00)	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**	**(0.00)**

*Notes: Co-efficients on year variable shown; p-values in parentheses; * trend statistically significant at 0.1, ** 0.05, or *** 0.01 level.*

Annex 5: Results overview for analysis of normalised number of disasters

	sample1980				sample1990			
	Africa	**Asia**	**Americas**	**All three regions**	**Africa**	**Asia**	**Americas**	**All three regions**
Geophysical events	-0.01	-0.08	-0.10*	-0.19**	-0.02	-0.19	-0.25*	-0.46*
	(0.352)	(0.273)	(0.074)	(0.033)	(0.819)	(0.176)	(0.072)	(0.065)
Non-geophysical events	0.27**	1.04***	0.83***	2.14***	2.58***	1.07**	1.47***	5.12***
	(0.015)	(0.00)	(0.00)	(0.00)	(0.00)	(0.045)	(0.004)	(0.00)
Floods	0.30***	0.94***	0.36***	1.60***	2.15***	1.23**	0.78***	4.16***
	(0.00)	(0.00)	(0.001)	(0.00)	(0.00)	(0.013)	(0.001)	(0.00)
Droughts	-0.09	-0.02	0.05	-0.06	-0.01	0.03	0.05	0.07
	(0.392)	(0.438)	(0.254)	(0.599)	(0.957)	(0.548)	(0.617)	(0.635)
Extreme temperature	0.01	0.05	0.07***	0.12**	-0.03	-0.02	0.11	0.05
	(0.271)	(0.190)	(0.007)	(0.022)	(0.183)	(0.812)	(0.212)	(0.752)
Storms	0.03	-0.13	0.35**	0.25*	0.31**	-0.24	0.56	0.64*
	(0.292)	(0.231)	(0.015)	(0.100)	(0.033)	(0.218)	(0.122)	(0.094)
All disasters	**-0.19****	**0..96*****	**0.73*****	**2.44*****	**2.56*****	**0.88**	**1.12****	**4.66*****
	(0.033)	**(0.001)**	**(0.001)**	**(0.00)**	**(0.00)**	**(0.106)**	**(0.011)**	**(0.00)**

*Notes: Co-efficients on year variable shown; p-values in parentheses; * trend statistically significant at 0.1, ** 0.05, or *** 0.01 level.*

Annex 6: Summary statistics and data sources for the independent variables used in the structural model

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum	Source
Disaster count	3,795	1.84	3.44	0	37	CRED (2011)
Total population (ln)	3,795	16.16	1.49	12.77	21.00	World Bank (2011)
Share of urban population	3,795	49.90	22.76	4.30	98.36	World Bank (2011)
GDP per capita (ln)	3,795	7.39	1.58	4.13	10.65	World Bank (2011)
Partly free press	3,795	0.30	0.46	0	1	Freedom House (2011)
Non-free press	3,795	0.34	0.47	0	1	Freedom House (2011)
Democracy	3,795	0.53	0.49	0	1	Marshall et al. (2006)
Minor conflict	3,795	0.13	0.33	0	1	Gleditsch et al. (2002)
Major conflict	3,795	0.06	0.23	0	1	Gleditsch et al. (2002)
Corruption risk	2,788	3.05	1.36	0	6	PRS Group (2011)
Bureaucratic quality risk	2,788	2.14	1.19	0	4	PRS Group (2011)
Income inequality	1,331	42.01	6.62	22.69	64.36	University of Texas (2011)

Notes: variables marked 'ln' are transformed on a natural logarithmic scale; 'Observations' denotes the number of observations included in the models for which the arithmetic average 'mean'; and standard deviation and minimum and maximum are also shown.

References for data sources used in the structural model

CRED (2011) EM-DAT, Brussels: Centre for Research on the Epidemiology of Disasters.

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PRS Group (2011) *International Country Risk Guide*, East Syracuse: PRS Group.

University of Texas (2011) 'Inequality Project', available at: http://utip.gov.utexas.edu/data.html (last accessed 23 April 2011).

Notes

[1] A note on terminology: a *hazard* is a potentially damaging physical event, phenomenon, or human activity that may cause loss of life or injury, property damage, social and economic disruption, or environmental degradation. Examples include droughts, hurricanes, and earthquakes. Hazards only result in *disasters* when they meet *vulnerable people*: those affected by economic, social, physical, environmental, or political conditions, which increase the susceptibility of a community to the impact of hazards.

[2] Centre for Research on the Epidemiology of Disasters (CRED): http://www.emdat.be/criteria-and-definition (accessed 18 May 2011).

[3] United Nations International Strategy for Disaster Risk Reduction (2009) UNISDR Terminology on Disaster Risk Reduction. http://www.unisdr.org/we/inform/terminology

[4] For ease of reading, only co-efficients and p-values are reported in this document. The co-efficient shows the average increase in the number of reported events per year. The p-value shows statistical significance: a trend is significant at the level of p-value, e.g. a p-value of 0.1 indicates that the trend is significant at the 10 per cent level. Statistical significance results from the interplay between the size of the co-efficient and the volatility of the data (a higher co-efficient (steeper slope) makes it more likely to be indistinguishable from zero, whilst greater volatility makes the slope less likely to be indistinguishable from zero).

[5] Please contact the author via swootton@Oxfam.org.uk

[6] Geophysical disasters are earthquakes, volcanic eruptions, and dry mass movements. All other natural disasters are weather-related: floods, droughts, storms, wet mass movements, extreme temperature events, and wildfires.

[7] Percentage increases reported here are the compound annual growth rate, which is the average annual growth rate. Rather than simply comparing the number of events in 1980 (1990) and 2010, the predicted values of the fitted trend line are used as a basis for calculation.

[8] Munich Re's NatCatSERVICE database is independent of EM-DAT and is often used for analyses of economic losses to disasters. It is based on insurance claims, and thus has good coverage for developed countries but weaker coverage in many of the developing countries of interest to development practitioners and policy makers.

[9] Munich Re (2010) 'Topics Geo natural catastrophes 2009: Analyses, assessments, positions', Munich: Munich Reinsurance Company.

[10] An example of effective DRR measures is provided by Bangladesh. In 1971, Cyclone Bhola (a Category 3 cyclone) killed 300,000 people. Partly as a result of this, massive investment in cyclone shelters and early warning systems took place. In 2007, Cyclone Sidr (a Category 5 cyclone) killed 3,000 people – two orders of magnitude fewer, despite the population of Bangladesh having more than doubled during the intervening period.

[11] For details of the analysis, please contact the author via swootton@Oxfam.org.uk for the background paper.

[12] For full details of the analytical method, please contact the author via swootton@Oxfam.org.uk for the background paper.

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