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**THE IMPACT OF DISASTERS ON INTERNATIONAL TRADE**

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**Abstract**

In this paper we examine the impact of major disasters on international trade flows. Our panel data consists of more than 170 countries for the years 1962-2004 yielding approximately 300,000 observations. We find that the driving forces determining the impact of such events are the democracy level and, to a lesser extent, the area of the affected country. The less democratic and the smaller a country the more are its trade flows reduced in case it is struck by a disaster. Using a gravity model, we are able to distinguish between the effect for an importing and an exporting country.

**Keywords:** International trade, disasters, gravity model, governance

*JEL* classifications: F14, P52, P48, C23

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## I. INTRODUCTION

The year 2005 was the most expensive year on record in terms of damage to insured property caused by disasters. Swiss Re (2006) estimated that total disaster-related claims approached \$83 billion.<sup>1</sup> The record year continues the trend of more frequent and destructive natural disasters, a pattern that has been documented by arguably the most informed players in the world – reinsurance companies. In its annual report in 2005 another major reinsurer, Munich Re, observed the greater frequency of natural catastrophes which cause large losses. In the 1960s, average annual losses from disasters averaged about \$8.8 billion (in 2005 values); but in the last ten years, this has risen to an annual average of \$57.5 billion (Munich Re, 2006).

There are a number of possible explanations for this observed increase in the occurrence of disasters. One is just better reporting and collection of data. Another explanation is that some of the extreme weather and climate events that have been observed to date are linked with global warming. The report of the Intergovernmental Panel on Climate Change (IPCC, 2001) looked at the number of extreme weather and climate events that were observed in the last half of the 20<sup>th</sup> century. The IPCC noted that these observed events were qualitatively consistent with the results of global warming climate models used to simulate extreme weather and climate events towards the end of the 21<sup>st</sup> century.

Recent studies on hurricane activity in the North Atlantic, and the damage inflicted on the United States (US), may provide additional insights about the underlying causes of this trend. There appears to be two main explanations - more powerful hurricanes and economic, social and demographic changes. Emanuel (2005) demonstrates that an index of the potential destructiveness of hurricanes, known as total power dissipation, has increased markedly in the North Atlantic since the mid-1970s. He links this to rising tropical sea surface temperatures, reflecting the effect of climatic processes and global warming. Economic and social factors have contributed to the increasing likelihood of large losses. The growth of wealth puts more valuable property at risk. There is also increasing density of property and demographic shifts to coastal areas and storm-prone areas that are experiencing rising urbanization (Kunkel, Pielke and Chagnon, 1999). This suggests that similar processes (natural, economic and social) are at work in explaining the increased frequency and destructive power of natural disasters.

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<sup>1</sup> Throughout this paper, "dollars" or "\$" refer to United States dollars.

The increasing number of disasters has sparked research interest on their impacts. The effect of disasters on changes in demographic trends or structures has been examined (Smith and McCarty, 1996; Neumayer and Plümper, 2006). A number of studies have looked at the determinants of mortality rates from disasters (Anbarci, Escaleras and Register, 2005; Kahn, 2005). Some studies have attempted to distil lessons or patterns based on evidence from past disasters (Hirschleifer, 1991; OECD, 2003). A far larger number of studies have tried to assess the macroeconomic impacts of disasters (Albala-Bertrand, 1993; Pelling, Özerdem and Barakat, 2002; Skidmore and Toya, 2002; Auffret, 2003; Freeman, Keen and Mani, 2003; Rasmussen, 2004).

However, to the best of our knowledge, no empirical work on the impact of disasters on international trade flows exists although a recent paper by Yang (2006) examines how hurricanes affect international financial flows. This is surprising given the growing importance of global trade to many countries. This paper attempts to fill this lacuna by examining the impact of disasters on bilateral (merchandise) trade flows using a gravity model. Apart from the usual gravity model variables (per capita GDP, distance, etc.), we find that two factors in particular play an important role in the regressions – how democratic a country is and, to a lesser extent, the geographical size of a country. The less democratic and the smaller a country is the more are its trade flows reduced in case it is struck by a disaster. For a given democracy ranking, our lowest estimates indicate that an additional major disaster on average results in a reduction of imports by 0.3% while exports are reduced by 0.1%.

The plan for the rest of the paper is as follows. Section two examines the channels by which disasters are likely to affect international trade. Section three explores in some detail the database which is the principal source of information for disasters that we shall use in the paper. Section four explains the specifications of the gravity model that is employed in the paper. Section five presents the results that we obtain. Finally, section six concludes.

## **II. IMPACT ON TRADE**

The impact of a large disaster on international trade can be transmitted either directly or indirectly. Direct impacts on exports can occur due to the human losses and injuries (affecting companies' human resources) and the destruction and damage of physical capital and equipment in the export sector. Damage to public infrastructure, such as roads, bridges, railways and telecommunication systems, can cause disruption to the export supply chain.

In the case of imports, while similar direct channels can have an adverse effect on it, most of the impact of a disaster is likely to be transmitted indirectly through a reduction in aggregate economic activity (GDP). Auffret (2003) analyzes the impact of catastrophic events on 16 Caribbean and Latin American countries over a period of two decades (1970-99). He finds that these events generally lead to substantial declines in investment and output. He argues that one of the consequences of the frequency of disasters in this region is the higher volatility in private consumption of households. Given inadequate or undeveloped mechanisms for risk-bearing (e.g. insurance), households are unable to smoothen their consumption in response to the output-side shocks. Rasmussen (2004) looks at the same region, concentrating on the small island states in the Eastern Caribbean. The macroeconomic consequences of disasters include an immediate contraction in output and a worsening of fiscal balances. Given the dependence of imports on GDP, a disaster can reduce imports if it causes the level of aggregate economic activity to contract (even temporarily). But this requires the disaster to be sufficiently large or the affected economy to be relatively small. The larger the share of trade in an economy affected by a disaster, the larger will be the trade impacts.

In this connection, Rasmussen emphasizes the importance of considering the number of natural disasters in relation to country size. Small island states are especially vulnerable because of the especially higher frequency of natural disasters that have a proportionately large impact on GDP. The study by Pelling, Özerdem and Barakat (2002) also emphasizes how disaster impacts are shaped by the size of the affected country. Small and poorly diversified economies with spatially concentrated productive assets are highly vulnerable to disasters. Thus, both the Pelling, Ozerdem and Barakat (2002) and Rasmussen (2004) studies have highlighted the special vulnerability of geographically small countries to disasters.

However, even in this case where macroeconomic activity declines, there may be compensating factors at play to increase rather than decrease imports. Any major reconstruction or rebuilding of damaged infrastructure in the affected countries will likely increase imports, since the required materials, technology or skills may need to come from abroad. This effect is bound to be larger if external financial assistance is also provided to the affected country since there must be a corresponding inflow of goods and services to effect the transfer of financial assistance from external donors. In the Auffret (2003) and Rasmussen (2004) studies, the external imbalances of disaster-affected countries widen. This result would be consistent with a strong external assistance effect on imports.

Evidence about the long-term consequences of natural disasters is more elusive. Benson and Clay (2003) suggest that natural disasters have a negative impact on long-term economic growth.

However, Skidmore and Toya (2002) argue that countries which are the subject of frequent climatic disasters experience higher rates of human capital accumulation, total factor productivity and economic growth. The higher rate of human capital accumulation is because of a substitution towards investment in human capital as physical capital faces increased risk of damage or destruction. And their explanation for the paradoxical result that disasters lead to higher rates of total factor productivity and economic growth is because disasters provide the opportunity to update the capital stock and adopt new technologies. In this paper, we take no position on the long-run impacts of disasters on the pattern of international trade. And in any case, the gravity model would only capture the concurrent effects of disasters on merchandise trade flows.

A number of studies suggest that the political characteristics of a country may also have an important bearing on the economic consequences of a disaster. They have looked at the impact of disasters on mortality rates. What has emerged from these analyses is that the number of victims is strongly correlated with a country's per capita income, the level of income inequality and the degree of political democracy. Anbarci, Escaleras and Register (2005) argue that collective action (e.g. earthquake preparedness drills, strict enforcement of building and zoning codes, etc.) can reduce the number of fatalities from earthquakes. But the degree to which a society is able to take effective collective action depends on per capita income and the degree of income inequality. Collective action will be more effective with greater amount of resources (higher per capita incomes). But collective action will be less likely with higher levels of inequality, as "each man for himself" sentiment tends to rule. Similarly, Kahn (2005) finds that richer nations, democracies and nations with higher-quality institutions suffer less death from natural disasters. One possible reason that he supplies why undemocratic societies and nations with lower-quality institutions suffer more death is corruption. Government corruption could raise death counts through the lack of enforcement of building codes, infrastructure quality and zoning. The OECD's (2003) survey of five recent large disasters (Chernobyl, Hurricane Andrew, the Kobe earthquake, the Marmara earthquake in Turkey and the 11 September 2001 attacks) underlined the importance of the policy response. At the local level, authorities have to provide assistance targeted to people who have lost their properties and to provide temporary financial help to small businesses so that the local economy can get going again. The most important task of the authorities is to restore confidence, so that consumers and investors can resume their normal routines.

Why would the economic repercussions of a tragedy depend on how democratic a country is? One answer that could be mustered would be along the lines of Sen's analysis of the link between famines and democracies. He famously argues that there has never been a famine in a functioning multiparty democracy (Sen, 1999). This is because politicians need to be more responsive to their constituents in

a functioning democracy. Failure to plan for and respond to the consequences of disasters could cost them their jobs in the next election. Alternatively, democracy may be a proxy for other conditions of good governance (e.g. absence of corruption) or quality of the bureaucracy, all of which allow a country to deal rapidly and effectively with the effects of a disaster. This raises the possibility of similar links between the political characteristics of a country and the effects of a disaster on international trade flows.

### **III. DISASTERS DATA**

#### **A. DATA SOURCES AND DEFINITIONS**

The primary source of data on disasters that will be used in this paper is the "Emergency Events Database" (EM-DAT, 2005) maintained by the Centre for Research on the Epidemiology of Disasters (CRED) of the Université Catholique de Louvain.<sup>2</sup> CRED became a World Health Organisation Collaborating Centre in 1980. Although alternative sources of information on natural disasters are available, none are as comprehensive as that available from EM-DAT.<sup>3</sup> It contains data on the occurrence and effects of over 12,800 mass disasters in the world dating from 1900. The EM-DAT has also been used in a number of recent investigations on the economic effects of disasters (Skidmore and Toya, 2002; Auffret, 2003; Rasmussen, 2004; Kahn, 2005; Yang, 2006; Neumayer and Plümper, 2006).

For a disaster to be entered into the database at least one of the following criteria must be satisfied: (i) 10 or more people reported killed; (ii) 100 people reported affected; (iii) declaration of a state of emergency; or (iv) call for international assistance. EM-DAT distinguishes between two main types of disasters: natural and technological. Natural disasters include droughts, earthquakes, epidemics, extreme temperature events, famines, floods, insect infestations, (mud)slides, volcanic eruptions, waves/surges, wildfires and windstorms. Technological disasters include industrial accidents like chemical spills or radiation leaks, transport accidents like airline crashes and miscellaneous accidents. For this paper though, we have excluded counts of epidemics because we believe other mechanisms explain their spread and their economic effects differ systematically from those of other natural disasters.

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<sup>2</sup> EM-DAT: The OFDA/CRED International Disaster Database - [www.em-dat.net](http://www.em-dat.net) - Université Catholique de Louvain - Brussels – Belgium.

<sup>3</sup> Other sources include the GEsources Natural Hazards site and the US National Climatic Data Center (NCDC). The GEsources Natural hazards site draws together resources about a range of natural hazards. It focuses on a range of natural hazards around the globe: droughts, earthquakes, flooding, mass movements, storms, tsunamis, volcanoes and wildfires. The US NCDC website contains information on "Billion Dollar US Weather Disasters". Unlike EM-DAT though, it confines itself only to weather-related disasters and to those wholly or principally affecting the US.

Among the variables included in the database are figures which are particularly useful for analysing the economic impact of disasters: the number of persons killed, the number of persons injured, the number of persons affected and the monetary value of the losses sustained. The number of persons killed refers to the number of persons confirmed as dead, missing or presumed dead (based on official figures when available). The number of people injured is the number of people suffering from physical injuries, trauma or an illness requiring medical treatment as a direct result of a disaster. The number of people affected includes people requiring immediate assistance during the emergency; and displaced or evacuated people. In EM-DAT, estimated damage (if available) is given in thousands of dollars. If the estimated damage is given in the local currency, it is directly converted to dollars at the exchange rate of the date when the disaster occurred.

## B. CHARACTERIZING TRENDS AND PATTERS IN DISASTERS

The period to be covered by this study is from 1962 to 2004. They correspond to the years for which detailed bilateral trade flows are available. Excluding epidemics, there are a total of 12,666 disasters recorded in the database, 60 percent of them being natural disasters. There is also a statistically significant increase in the number of disasters over time, whether natural or technological, a trend which corresponds with the findings of other researchers in the field (see Figure 1).

Disasters tend to be concentrated in certain countries. Disasters are frequent in countries with large land areas and those located in Asia (Kahn, 2005). China, India, the US, Philippines, Indonesia, Bangladesh, Brazil, Mexico, Nigeria and Pakistan make up the top ten countries which are the most often struck by disasters (see Annex III). The disasters which have struck these countries constitute 40 percent of all disasters during the period 1962-2004 in the EM-DAT.

However, many of the disasters in EM-DAT seemed to have caused few casualties or damages. For example, only 10 percent of the disasters involve deaths of more than a hundred people. A similarly small proportion of disasters (about 10 percent) involve injuries to more than a hundred people. Only thirty percent of the disasters have estimates of damages, with the rest of the observations either with zero damages or with no reliable estimates.

## C. DECISION RULE

Munich Re (2006) classifies disasters into several categories. A *small-scale loss event* involves less than 10 fatalities and no damages. A *moderate loss event* involves less than 20 deaths and damage to buildings and other property. A *severe catastrophe* involves more than 20 deaths (but less than a hundred) and damages worth in excess of \$50 million. A *major catastrophe* involves more than a

hundred deaths (but less than 500) and damage of more than \$200 million. A *devastating catastrophe* involves more than 500 deaths and damage in excess of \$500 million. Finally, a *great natural catastrophe* involves thousands of deaths and extreme insured losses.

Since we are interested in estimating the impact of large scale disasters on international trade, we decided to confine our empirical analysis to disasters which meet any of the following criteria which represent an adaptation of Munich Re's *great natural catastrophe* category: (i) number of killed is no less than a thousand; (ii) the number of injured is no less than a thousand; (iii) number of affected is no less than a hundred thousand; or (iv) the amount of damages is no less than \$1 billion (in constant year 2000 dollars).<sup>4</sup> In order to make estimates of damage comparable over time, we have converted dollar values into constant 2000 dollars using the US GDP deflator. The adoption of this decision rule reduces the number of disasters for analysis to 1,589 (1,548 of which are classified as natural disasters and 41 of which are technological disasters).

For the subset of natural (less epidemics) and technological disasters during the 1962-2004 period, a thousand deaths represent the 98.7 percentile of the distribution of deaths. A thousand injured represents the 98.1 percentile of the distribution of injuries. Disasters with no less than a hundred thousand affected represent the 89.9 percentile of the distribution of the number affected. And disasters with no less than \$1 billion (in constant 2000 dollars) of damage represent the 97.8 percentile of the distribution of estimated damage (See Annex IV).

Note, that even with this drastically reduced dataset, the trend of increasing disasters is still apparent (see Figure 2). Both the time trends in the number of natural and technological disasters are still statistically significant, although the coefficients (annual growth rates) are much smaller. Finally, most of the countries who figured prominently in terms of frequency of disasters continue to do so even after the adoption of the decision rule. China, India, the US, Philippines, Indonesia, Bangladesh and Brazil are still in the top ten.

#### IV. EMPIRICAL MODEL AND VARIABLES

In order to estimate the effects of disasters on international trade we employ a standard gravity set-up. The basic specification is the following:

$$\ln(\mathit{rimp}_{iet}) = c_{iet} + \ln(\mathit{gdp}_{iet}) + \ln(\mathit{gdppc}_{iet}) + \mathit{lock}_{iet} + \ln(\mathit{dist}_{iet}) + X_{iet} + e_{iet} \quad (1)$$

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<sup>4</sup> Obviously the Munich Re's definitions involve the Boolean operation "and" while we use the "or" operation. This is driven by data availability. Not all figures are available for all events. However, if all values are available they are highly correlated.

where  $rimp_{iet}$  represents the nominal imports of country  $i$  from country  $e$  in year  $t$  deflated by the US GDP deflator,  $gdp_{iet}$  is the product of both countries' real GDP,  $gdppc_{iet}$  is the product of both countries' real GDP per capita,  $lock_{iet}$  is a dummy variable if at least one trading partner is land locked,  $dist_{iet}$  is the distance between the most populated cities of the trading pair,  $e_{iet}$  is the error term, and, finally,  $X_{iet}$  is a set of variables measuring colonial ties comprising the following variables: a dummy if the two countries share the same official language (*comlang*), a dummy if the trading partners have a common border (*contig*), a dummy if pairs were ever in a colonial relationship (*colony*), a dummy for a common colonizer post 1945 (*comcol*), a dummy for colonial relationships post 1945 (*col45*), and a dummy taking the value 1 if the partners are or were the same nation (*smcrty*).<sup>5</sup> The GDP variables originate from the World Bank's (2005) World Development Indicators (WB, 2005). The land-locked, distance and colonial ties data are taken from CEPII (2005).<sup>6</sup> In choosing these 'standard' gravity variables we basically follow the selection of Rose (2004). We have no interest in these variables apart from their serving as control variables in our analysis. However, they are all significant and have the correct sign.<sup>7</sup>

We apply two different set-ups which differ with respect to the specific effects ( $c_{iet}$ ). In all set-ups we include time-specific fixed effects. However, in the first set-up we have importer- and exporter-specific fixed effects, i.e. dummies for a given country being the importer or exporter, respectively. In the second set-up we correct for pair-specific effects, i.e. each trading pair gets a dummy variable. In the second set-up the pair-specific time invariant variables have to be dropped, i.e.  $lock_{iet}$ ,  $dist_{iet}$ , and  $X_{iet}$ . Both versions of correcting for country-specific characteristics are adoptions from Feenstra (2002) who introduces the notion of country-specific effects as multilateral resistance terms. Inclusion of country fixed effects controls for unobservable country characteristics. By incorporating fixed effects for importers and exporters we allow these unobservable effects to differ even if the same country is involved in importing and exporting.

Our dependent variable, real import flows, comes from Feenstra (2000) and covers the years 1962-2000. The originally nominal values have been converted into real import flows using the US GDP deflator. This is possible since nominal world trade is measured in dollars. The Feenstra data is only available until the year 2000. Since the most recent disasters are the ones most thought about, we expand the dataset by using Comtrade (2005) data for the years 2001-2004.<sup>8</sup> Again the data is

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<sup>5</sup> For the sources and exact definitions of all variables we refer to Annex I.

<sup>6</sup> CEPII stands for the *Centre d'Etudes Prospectives et d'Informations Internationales*.

<sup>7</sup> For further details on the theory of the gravity model we refer to Anderson and van Wincoop (2003).

<sup>8</sup> Comtrade is the abbreviation commonly used for the United Nations Statistical Division Commodity Trade Data Base.

deflated using the US GDP deflator. This sample, covering the period 1962-2004, is referred to as the Comtrade sample.

In our set-up we do not distinguish between natural and technological disasters since we believe that they are not systematically different with respect to the resulting damage and effect on trade flows. A formal test for this belief is not feasible since we have only 41 technological disasters as compared to 1,548 of natural origin. As mentioned above, in order to have an impact on international trade we presume that a disaster has to be sufficiently large. We have therefore constructed the following disaster variables from the data contained in the EM-DAT as described above. All disasters are counted for any given year and country if they fulfil the decision rule specified in part III C. Since this database covers the whole world, all countries are assigned a zero for years in which no observation in the database meets this criterion. This count variable is labelled  $drul_i$  or  $drul_e$  indicating the number of major disastrous events in the importing or exporting country, respectively.

## V. RESULTS

Our disaster measure is included as an explanatory variable in the gravity model specified in equation (1). The results are shown in Tables 1 and 2, columns (a) and (a'), which refer to the country- and pair-specific set-ups as described in the empirical model section.<sup>9</sup> Table 1 uses the Comtrade sample as described in the previous section. The results for the basic set-up show that the standard gravity variables all have the expected sign and are highly significant. Since there is an extensive literature on the gravity model we refrain from interpreting<sup>7</sup> the results for the standard variables here. The disaster count variable is not significant for the importing or exporting country in the country-specific set-up while it is marginally negatively significant for the exporter when using pair-specific effects.

In order to validate our results and ensure that outcomes are not driven by the inclusion of the Comtrade (2005) data we have also estimated equation (1) using the original Feenstra (2000) dataset. These results are presented in Table 2. For better readability we only display the estimated coefficients for the disaster measures.<sup>10</sup> Using the Feenstra sample we find a significantly negative trade effect of major disasters for both the importer and the exporter. This result suggests that the impact of disasters is not limited to the destruction of production capacity, which explains a negative exporting coefficient. Disasters may also alter consumption behaviour (as noted by Auffret, 2003). A decline in import demand may be a consequence of both lower incomes (following the destruction of

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<sup>9</sup> From this point onwards a model with a hyphen (-) indicates the pair-specific fixed effects specification.

<sup>10</sup> A complete set of results for this and all other specifications discussed in this paper are available upon request.

both physical and human capital) and higher savings in response to increased uncertainty about the future.

However, taking just the number of disasters into account might not tell the whole story. As highlighted in the literature, it obviously makes a difference whether the country hit by a disaster is large or small. When Florida is hit by a hurricane the effect for the US economy as a whole is likely to be different than when Grenada, one of the Eastern Caribbean island states, is hit by the same hurricane. In specification (b) we scale the number of disasters by the surface area of the affected country and substitute the resulting variables,  $disar_i$  and  $disar_e$ , for the disaster count variables.<sup>11</sup> Inclusion of the rescaled disaster measure leaves all other variables virtually unchanged. However, we find that the adjusted variable is negative and highly significant for the exporting country also in the Comtrade sample. Hence once the number of incidents has been corrected for the size of the country, disasters reduce exports. Again, this result is consistent with the notion that major disasters destroy both physical and human capital as well as trade infrastructure. No significant relationship is obtained for imports in the Comtrade sample. However, turning to the Feenstra results in Table 2, the area-adjusted disaster variable is negatively related to trade for both the importer and exporter in the importer- and exporter-specific as well as in the pair-specific set-ups. In other words, major disasters significantly reduce both imports and exports, and the more so the smaller the affected country. At least from the Feenstra sample, it can be concluded that declines in import demand following major disasters do not appear to be offset by additional imports that the country may need for reconstruction. Taking the land area of, for instance, Honduras into account, an additional major disaster reduces exports on average by about 1.8% (in the Comtrade and Feenstra samples). These correlations are highly significant at the 1% level. In the Feenstra sample, imports drop by about the same magnitude (equally significant at 1%).

Area might not be the only characteristic that determines the impact of a disaster on the economy. In the literature (Anbarci, Escaleras and Register, 2005; Kahn, 2005), it has been argued that governance is a key factor in determining the magnitude of the effect caused by catastrophes. To accommodate this notion we introduce an interaction term consisting of the number of disasters multiplied by the democracy score of the affected country. The democracy score is taken from the Polity IV database (Gurr, Jagers and Moore, 2003). The original values range from 0 to 10 where higher numbers indicate a more democratic political system. In order to test our hypothesis, the original scale is reversed and now runs from 1 to 11 where 1 indicates the highest democracy score and 11 the lowest. The respective interaction term is labelled  $disdem_i$  and  $disdem_e$  following our methodology of

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<sup>11</sup> The surface area is taken from World Bank (2005).

encoding variables. The regression outcomes are presented in specification (c). The inclusion of the interaction term again does not alter the results for the standard variables to any major extent. However, when interacted with the political system, disasters reduce both imports and exports in all our set-ups and samples.<sup>12</sup> For a given number of disasters, this effect is more pronounced the more undemocratic the affected country is. Democratic societies are better in coping with disasters. Nonetheless, even in countries with the most democratic score, disasters still reduce both exports and imports, all else being equal. For a given democracy score an additional major disaster reduces imports on average by 0.3% and exports by 0.1% (looking at the Comtrade sample). These results are significant at the 1% significance level. By the same token, a single disaster in South Africa and Kenya in the year 2001 would have resulted in a five times larger reduction of trade in Kenya, *ceteris paribus*.

So far we have found that both area and governance matter in determining the effects of disasters on trade. In order to test the robustness of these results we include both variables (i.e. area-adjusted disaster count and democracy interaction term) into the model at the same time. This specification (d) reinforces our previous findings. The democracy interaction term exhibits a significantly negative sign in all specifications. From Table 1 it can be seen that geographical country size seems to matter particularly for an exporting country. Smallness reinforces the negative trade impact in exporting countries. In the pair-specific set-up, the area-adjusted variable is marginally positive for importing countries. Interestingly, this would indicate an increase of imports particularly in small countries, i.e. a small country's reliance on imports in its efforts to rebuild is not trumped by income and savings effects.<sup>13</sup> The Feenstra sample (Table 2) confirms previous results, namely that smaller and more undemocratic countries are more affected by disasters. The results when incorporating both disaster measures in the Comtrade sample imply the following: Had Costa Rica been struck by a major disaster in the year 2003, exports would have declined by 3.9% and imports by 0.3% (0.4% if the area-adjusted importer effect is included, which is statistically not different from zero).

In order to further check the robustness of our findings we take two main courses of action presented in Table 3. Again, we suppress the results of the standard gravity variables which only serve as controls. As before, they are all significant and have the correct sign.

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<sup>12</sup> We estimated all models containing also the democracy score as such. This does not alter the findings for the interaction term, i.e. the interaction term does not act as a substitute for a potential direct effect of democracy on trade.

<sup>13</sup> Note that this is consistent with the finding of Auffret (2003) and Rasmussen (2004) about widening external imbalances for the many small countries in the Caribbean and Central America that were the subject of their analysis.

First, we re-estimate the regressions using reweighted least squares (RLS). This robust regression technique weighs observations in an iterative process. Starting with OLS, estimates are obtained through weighted least squares where observations with relatively large residuals get smaller weights. Therefore, the regression outcome is not driven by any specific observation. Extreme cases get dropped altogether. The results of this robustness check are shown in the two columns on the left hand side of Table 3. Only the RLS results of specification (d), labelled (d\*), which includes both the area-adjusted disaster count and the democracy interaction term are displayed.<sup>14</sup> The findings of Tables 1 and 2 virtually remain unchanged. The only difference is that the area-corrected term for the exporting country in the Feenstra sample is now slightly less significant. Other than that, this robustness check emphasizes that the previous findings are not driven by extreme observations.

Second, we split the sample into developed and developing countries. To determine the set of developed countries we follow the WTO convention (see Annex II). The remaining countries are classified as developing. In the middle columns of Table 3 the results for the developing countries are presented using the Comtrade sample with importer-, exporter- and time-specific fixed effects.<sup>15</sup> The basic findings of Table 1 do not change with the exception of the area-adjusted disaster count for the importer, which becomes marginally positive. In Table 1, this has only been the case in the pair-specific set-up. A positive coefficient would then corroborate our finding that disaster relief operations can lead to higher imports especially in small countries. Conceivably, this is particularly true for developing countries. For developed countries (right columns), only the democracy interaction term exhibits a significant relationship with trade flows while area does not seem to matter. The latter result implies that the resilience of an industrialized nation's trade is independent of whether it is large or small, which seems plausible.

Additional robustness checks that leave our results virtually unchanged and therefore are not presented include the re-estimation of all specifications with a time trend instead of time-specific fixed effects. We have also re-estimated our model applying a different decision rule that corresponds to the Munich Re (2006) definition of a "devastating catastrophe". At least one of the following criteria must be fulfilled: (i) at least five hundred persons killed; (ii) at least five hundred persons injured; (iii) at least fifty thousand persons affected; or (iv) at least \$500 million in real damages. This rule leaves us with an additional 438 natural and 40 technological disasters and leads to similar results albeit at lower levels of significance, as was to be expected owing to the lower severity of the events considered.

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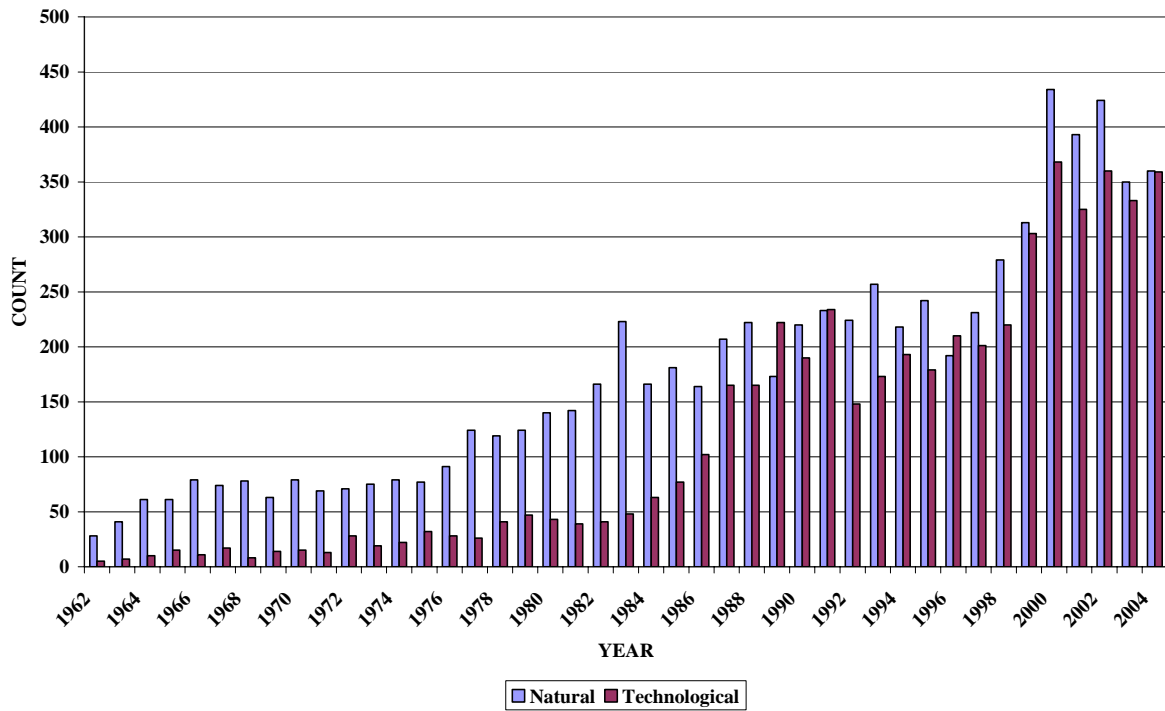
<sup>14</sup> The results of all other specifications remain stable and do not change by using RLS.

<sup>15</sup> Results of all other samples and specifications yield stable and similar results.

## VI. CONCLUSIONS

In this paper we have examined the impact of major natural and technological disasters on international trade flows. In general, disasters reduce trade in both exporting and importing countries. Most importantly, we find that governance is a key factor determining the magnitude of trade effects. The less democratic a country the more trade is lost. This result is remarkably stable. We use various samples, model set-ups and estimation techniques which all lead to the same outcome. Our most conservative estimate implies that, for a given democracy level, an additional major disaster reduces imports on average by 0.3% and exports by 0.1%, *ceteris paribus*. As a second result we find that the physical size of a country also seems to play a role. This is especially true for exporters, leading us to the conclusion that production capacity in small exporting countries is particularly vulnerable to external shocks. Combining our two main findings gives an indication of the potentially serious effects that disasters can have on trade. A single disastrous event in Costa Rica – a small, democratic and open developing country – in the year 2003 would have resulted in a reduction of exports by 3.9% and a reduction of imports by 0.3%, all else being equal.

**FIGURE 1: Frequency of Disasters, 1962-2004**



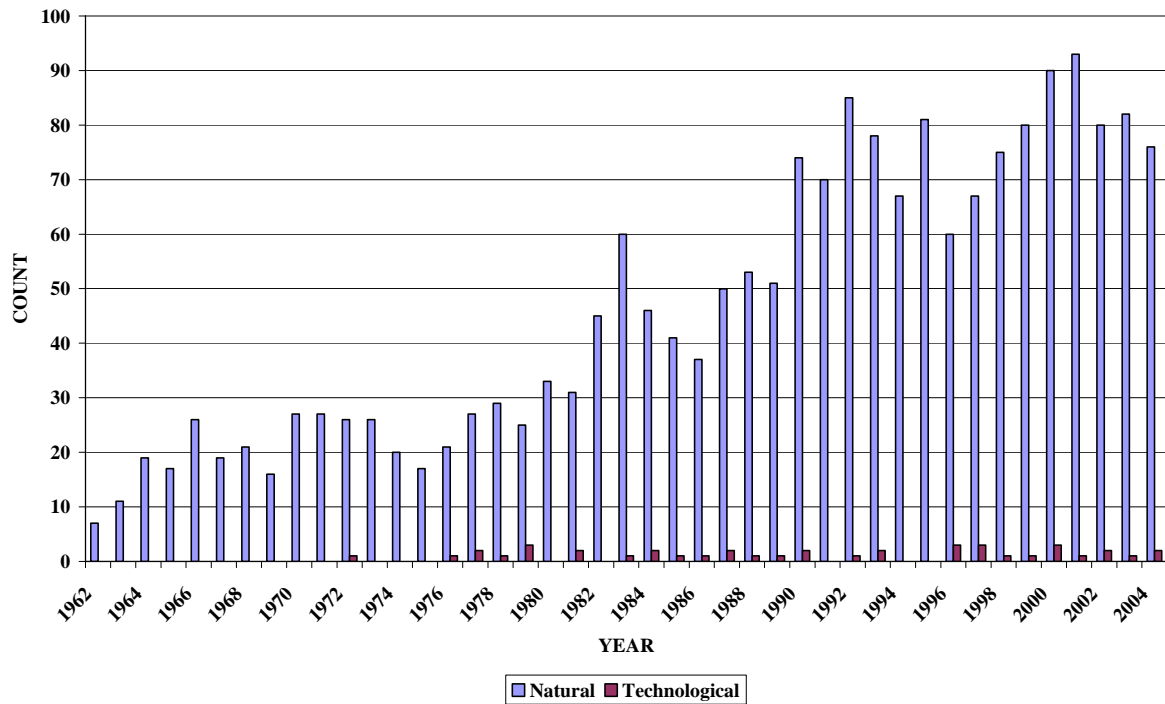
Source: EM-DAT.

Time trends:<sup>16</sup>

Type of Disaster	Growth rate	t-Statistic
Natural	5.135 %	22.51
Technological	10.088 %	28.25

<sup>16</sup> The time trend is estimated by regressing the natural log of the count of disasters on time (year). The resulting coefficient on time is thus the (annual) growth rate of the count of disasters.

**FIGURE 2: Frequency of Disasters with Decision Rule, 1962-2004**



Time trends:<sup>17</sup>

Type of Disaster	Growth rate	t-Statistic
Natural	4.833 %	16.68
Technological	2.476 %	4.93

<sup>17</sup> The time trend is estimated by regressing the natural log of the count of disasters on time (year). Now there were a number of years when the count of technological disasters, which satisfy our decision rule, was zero. Thus the time trend for technological disasters was estimated regressing the natural log of (1+ count of technological disasters) on time (year).

**TABLE 1: OLS Results Comtrade Sample – Dependent Variable: log of real imports (*lrimp*)**

	(a)	(b)	(c)	(d)	(a')	(b')	(c')	(d')
drul_i	0.006 (0.005)	-	-	-	-0.004 (0.004)	-	-	-
drul_e	-0.001 (0.005)	-	-	-	-0.006* (0.004)	-	-	-
disar_i	-	0.430 (0.578)	-	0.553 (0.626)	-	0.208 (0.447)	-	0.927* (0.483)
disar_e	-	-1.983*** (0.593)	-	-1.949*** (0.641)	-	-2.052*** (0.459)	-	-1.934*** (0.497)
disdem_i	-	-	-0.003*** (0.001)	-0.003*** (0.001)	-	-	-0.004*** (0.000)	-0.004*** (0.000)
disdem_e	-	-	-0.001*** (0.001)	-0.001** (0.001)	-	-	-0.002*** (0.000)	-0.002*** (0.000)
lgdp_ie	1.059*** (0.022)	1.059*** (0.022)	1.136*** (0.024)	1.134*** (0.024)	1.163*** (0.018)	1.159*** (0.018)	1.273*** (0.019)	1.272*** (0.019)
lgdppc_ie	0.196*** (0.022)	0.197*** (0.022)	0.247*** (0.023)	0.247*** (0.023)	0.189*** (0.018)	0.189*** (0.018)	0.188*** (0.019)	0.188*** (0.019)
lock_ie	-0.271*** (0.029)	-0.271*** (0.029)	-0.286*** (0.030)	-0.286*** (0.030)	-	-	-	-
comlang	0.473*** (0.011)	0.473*** (0.011)	0.482*** (0.012)	0.482*** (0.012)	-	-	-	-
contig	0.462*** (0.024)	0.463*** (0.024)	0.534*** (0.025)	0.534*** (0.025)	-	-	-	-
colony	0.600*** (0.032)	0.600*** (0.032)	0.528*** (0.033)	0.528*** (0.033)	-	-	-	-
comcol	0.687*** (0.017)	0.687*** (0.017)	0.724*** (0.018)	0.724*** (0.018)	-	-	-	-
col45	1.191*** (0.040)	1.191*** (0.040)	1.236*** (0.043)	1.236*** (0.043)	-	-	-	-
smctry	0.842*** (0.033)	0.842*** (0.033)	0.828*** (0.035)	0.828*** (0.035)	-	-	-	-
ldist	-1.125*** (0.005)	-1.125*** (0.005)	-1.083*** (0.006)	-1.083*** (0.006)	-	-	-	-
Obs.	281,762	281,762	242,424	242,424	281,762	281,762	242,424	242,424
Importers	163	163	143	143	-	-	-	-
Exporters	176	176	146	146	-	-	-	-
Pairs	-	-	-	-	21,382	21,382	16,723	16,723
R-sq	0.730	0.730	0.731	0.731	0.564	0.564	0.564	0.564

Note: The four columns on the left represent the results using fixed effects for importers and exporters as well as in the time dimension while the four columns on the right show the outcome when using pair- and time-specific fixed effects. The F-tests for all fixed effects are significant well beyond the 1% level. The reported R-sq is the adjusted overall R-squared. The dependent variable is taken from Feenstra (2000) until the year 2000 and from Comtrade (2005) for the years 2001-2004. The standard error is reported in brackets. \*/\*\*/\*\* indicates significance at the 10/5/1-% significance level.

**TABLE 2: OLS Results Feenstra Sample – Dependent Variable: log of real imports (*lrimp*)**

	(a)	(b)	(c)	(d)	(a')	(b')	(c')	(d')
drul_i	-0.011** (0.006)	-	-	-	-0.015*** (0.004)	-	-	-
drul_e	-0.018*** (0.005)	-	-	-	-0.019*** (0.004)	-	-	-
disar_i	-	-2.590*** (0.723)	-	-1.554** (0.800)	-	-2.749*** (0.542)	-	-1.873*** (0.601)
disar_e	-	-2.708** (0.796)	-	-2.188*** (0.882)	-	-2.037*** (0.602)	-	-1.646*** (0.668)
disdem_i	-	-	-0.005*** (0.001)	-0.005*** (0.001)	-	-	-0.006*** (0.001)	-0.005*** (0.001)
disdem_e	-	-	-0.004*** (0.001)	-0.003*** (0.001)	-	-	-0.004*** (0.001)	-0.004*** (0.001)
Obs.	232,149	232,149	203,752	203,752	232,149	232,149	203,752	203,752
Importers	145	145	135	135	-	-	-	-
Exporters	145	145	135	135	-	-	-	-
Pairs	-	-	-	-	13,379	13,379	11,911	11,911
R-sq	0.722	0.722	0.726	0.726	0.544	0.544	0.549	0.549

Note: The four columns on the left represent the results using fixed effects for importers and exporters as well as in the time dimension while the four columns on the right show the outcome when using pair- and time-specific fixed effects. The F-tests for all fixed effects are significant well beyond the 1% level. The results for the standard gravity variables as in Table 1 are suppressed to enhance readability but are available upon request. The reported R-sq is the adjusted overall R-squared. The dependent variable is taken from Feenstra (2000). The standard error is reported in brackets. \*/\*\* indicates significance at the 10/5/1-% significance level.

**TABLE 3: Robustness Check – Dependent Variable: log of real imports (*lrimp*)**

	(d*)	(d*)	(d)	(d*)	(d)	(d*)
disar_i	0.314 (0.568)	-1.744** (0.725)	0.314 (0.568)	1.759* (0.961)	0.045 (2.147)	0.579 (1.968)
disar_e	-2.466*** (0.582)	-1.279* (0.799)	-2.466*** (0.582)	-3.059*** (0.989)	2.320 (2.147)	1.045 (1.968)
disdem_i	-0.005*** (0.001)	-0.007*** (0.001)	-0.005*** (0.001)	-0.007*** (0.001)	-0.015** (0.007)	-0.014** (0.006)
disdem_e	-0.001*** (0.000)	-0.004*** (0.001)	-0.001*** (0.000)	-0.005*** (0.001)	-0.027*** (0.007)	-0.019*** (0.006)
Technique	RLS	RLS	OLS	RLS	OLS	RLS
Sample	Comtr	Feenstra	Dgc	Dgc	Ddc	Ddc
Obs.	242,424	203,752	106,492	106,492	15,730	15,730
Importers	143	135	122	122	21	21
Exporters	146	135	125	125	21	21

Note: The two columns on the left represent the results using reweighed least squares (RLS) for the Comtrade and the Feenstra sample. The two columns in the middle use the developing (Dgc) countries of the Comtrade sample while the two columns on the right use the developed (Ddc) countries of this sample. All specifications include fixed effects for importers and exporters as well as in the time dimension. The F-tests for all fixed effects are significant well beyond the 1% level. The results for the standard gravity variables as in Table 1 are suppressed to enhance readability but are available upon request. The standard error is reported in brackets. \*/\*\* indicates significance at the 10/5/1-% significance level.

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## ANNEX I

### List of Variables Used

Variable	Description	Source
nimp	nominal imports in dollars (for 1962-2000)	Feenstra (2000)
	(for 2001-2004)	Comtrade (2005)
defl	US GDP deflator (2000 = 1)	IMF (2005)
lrimp	$\ln(\text{nimp}/\text{defl})$	own calculations
drul_i	number of major disasters (decision rule) in importing country	EM-DAT (2005)
drul_e	number of major disasters (decision rule) in exporting country	EM-DAT (2005)
area_i	land area in 1,000 km <sup>2</sup> of importing country	WB (2005)
area_e	land area in 1,000 km <sup>2</sup> of exporting country	WB (2005)
disar_i	$\text{drul}_i / \text{area}_i$	own calculations
disar_e	$\text{drul}_e / \text{area}_e$	own calculations
democ_i	inverse of democracy score for importer: 1 = most democratic, 11 = least democratic	Gurr et al. (2003)
democ_e	inverse of democracy score for exporter: 1 = most democratic, 11 = least democratic	Gurr et al. (2003)
disdem_i	$\text{drul}_i * \text{democ}_i$	own calculations
disdem_e	$\text{drul}_e * \text{democ}_e$	own calculations
lgdp_ie	$\ln(\text{real GDP}_i * \text{real GDP}_e)$	WB (2005)
lgdppc_ie	$\ln((\text{real GDP}_i * \text{real GDP}_e)/(\text{population}_i * \text{population}_e))$	WB (2005)
comlang	dummy for both trading partners sharing an official language	CEPII (2005)
contig	dummy for common border	CEPII (2005)
colony	dummy for pairs ever in colonial relationship	CEPII (2005)
comcol	dummy for common colonizer post 1945	CEPII (2005)
col45	dummy for pairs in colonial relationship post 1945	CEPII (2005)
smctry	1 if countries were or are the same country	CEPII (2005)
ldist	$\ln$ of simple distance (most populated cities, km)	CEPII (2005)
lock_ie	dummy for at least one trading partner being landlocked	CEPII (2005)

## ANNEX II

### List of Developed Countries

Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, Greece, Iceland, Ireland, Italy, Japan, Liechtenstein, Luxemburg, The Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, Switzerland, USA.

## ANNEX III

### Countries with the Most Numbers of Disasters, 1962-2004

Rank	Country	Natural	Technological	Total
1	China, People's Republic	430	566	996
2	India	358	522	880
3	United States	578	220	798
4	Philippines	321	173	494
5	Indonesia	261	144	405
6	Bangladesh	207	139	346
7	Brazil	139	108	247
8	Mexico	154	91	245
9	Nigeria	35	206	241
10	Pakistan	103	135	238
11	Iran Islamic Republic	140	95	235
12	Japan	168	48	216
13	Russia	99	114	213
14	Australia	174	22	196
15	Turkey	98	96	194
16	Peru	105	84	189
17	South Africa	66	103	169
18	Colombia	109	49	158
19	France	91	64	155
20	Viet Nam	109	43	152

Source: EM-DAT (2005).

## ANNEX IV

### Decision Rule

	<b>Number of deaths no less than 1,000</b>	<b>Number of injured no less than 1,000</b>	<b>Number of affected no less than 100,000</b>	<b>Damages no less than \$1 billion (in 2000 dollars)</b>
Number of observations	170	239	1,280	279
- Natural	162	214	1,267	264
- Technological	8	25	13	15
Percentile	98.7%	98.1%	89.9%	97.8%

Note: Number of observations satisfying decision rule: 1,589 (1,548 of which are natural disasters and 41 technological).  
Source: EM-DAT (2005).