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Shaken, Not Stirred:

The Impact of Disasters on International Trade*

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Abstract

This paper examines the impact of major disasters on trade flows using a gravity model (170 countries, 1962-2004). As a conservative estimate, an additional disaster reduces imports on average by 0.2% and exports by 0.1%. Despite the apparent persistence of bilateral trade volumes, the impact of catastrophes depends on the democracy level and size of the affected country. In autocracies, exports and imports are significantly reduced: Had Togo been struck by a major disaster in 2000, it would have lost 6.8% of its imports and 8.2% of its exports. Democratic countries' exports suffer modest decreases, while imports are hardly affected.

Keywords: International trade, disasters, gravity model, governance

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

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1 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.[1] 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^{th} 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^{st} 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 appear 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.

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,

[1] Throughout this paper, "dollars" or "$" refer to United States dollars.

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; Tavares, 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 the physical size of a country.

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 specification of the gravity model we employ. Section five presents the results that we obtain. Finally, section six concludes.

2 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. Our first hypothesis is therefore:

Hypothesis 1: Disasters reduce exports.

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 supply-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.

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. Summarizing the discussion, we can formulate the following alternative hypotheses:

Hypothesis 2a: Disasters reduce imports.

Hypothesis 2b: Disasters increase imports.

Evidence about the long-term consequences of natural disasters is more elusive. Benson and Clay (2003) as well as Tavares (2004) 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.

Rasmussen (2004) 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 area of the affected country. Small and poorly diversified economies with spatially concentrated productive assets are highly vulnerable to disasters. Thus, both the Pelling, Özerdem and Barakat (2002) and Rasmussen (2004) studies have highlighted the special vulnerability of geographically small countries to disasters. As a consequence, we hypothesize:

Hypothesis 3: Disasters affect trade more the smaller the country is.

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" sentiments tend 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 also 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.[2] This raises the possibility of similar links between the political characteristics of a country and the effects of a disaster on international trade flows.[3] From these arguments, we derive the hypothesis:

Hypothesis 4: Disasters affect trade more the less democratic a country is.

3 Disasters Data

3.1 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.[4] 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.[5] It contains data on the occurrence and effects of over 12,800 mass disasters in the world dating from 1900.

[2]Neither corruption, nor quality of bureaucracy data is available for a long enough time span to be directly incorporated in our set-up. However, the link between democracy and corruption is shown by e.g. Treismann (2000), Dreher and Siemers (2005) and Serra (2006). The connection between the quality of bureaucracy and democracy is addressed in Bai and Wei (2001). Conceivably, autocratic rulers may also be efficient in responding to disasters by exercising their power to decree a certain course of action without the need to coordinate and consult with a wider range of authorities or stakeholders. Such considerations are beyond the scope of this paper and merit further research, in particular on the basis of panel data.

[3]Rodrik (1999) hypothesizes that the effect of external shocks on growth is larger the weaker a country's institutions of conflict management. He finds that democratic processes can be viewed as the ultimate institutions of conflict management and turn out to have been good for managing the shocks of the 1970s.

[4]EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net - Université Catholique de Louvain - Brussels – Belgium.

[5]Other sources include the GEsource Natural Hazards site and the US National Climatic Data Center (NCDC). The GEsource 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.

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; Neumayer and Plümper, 2006; Yang, 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.[6]

Among the variables included in the database are figures which are particularly useful for analyzing 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.

3.2 Characterizing trends and patterns in disasters

The period to be covered by this study is from 1962 to 2004. It corresponds 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% 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 in the Appendix).

[6] In particular, people in affected countries might try to avoid contact to other persons as much as possible in order to minimize the risk of contagion. This is generally not the case for the disasters we are taking into account in this study.

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 Table A-1 in the Appendix). The disasters which have struck these countries constitute 40% of all disasters during the period 1962-2004 in EM-DAT.

However, many of the disasters in EM-DAT seemed to have caused few casualties or damages. For example, only 10% of the disasters involve deaths of more than a hundred people. A similarly small proportion of disasters (about 10%) involve injuries to more than a hundred people. Only 30% of the disasters have estimates of damages, with the rest of the observations either with zero damages or with no reliable estimates. Given this distribution of the disaster data, it is conceivable that many of the disasters included in EM-DAT will not have any impact on international trade flows. For a disaster to have an empirically discernible impact on trade flows, it should be of a magnitude that can directly cause damage to production facilities, public infrastructure and affect a substantial number of people. It should be of a size that can indirectly affect macroeconomic activity. The damage or loss should trigger significant reconstruction expenditures or induce a large inflow of foreign assistance. For this reason, we adopt a decision rule which filters the disasters included in EM-DAT and only includes them in the estimation if they satisfy the rule.

3.3 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).[7] 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 sub-set of natural (less epidemics) and technological disasters during the 1962-2004 period, a thousand deaths represent the 98.7%ile 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%ile 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 Table A-2 in the Appendix).

Note, that even with this drastically reduced dataset, the trend of increasing disasters is still apparent (see Figure 2 in the Appendix). 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.

4 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:[8]

$$\ln(rimp_{iet}) = c_{iet} + \ln(gdp_{iet}) + \ln(gdppc_{iet}) + lock_{iet} + contig_{iet} + \ln(dist_{iet}) + X_{iet} + e_{iet} \quad (1)$$

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 taking a value of one if at least one trading partner is land locked, $contig_{iet}$ is a dummy indicating whether the trading partners have a common border, $dist_{iet}$ is the distance between the most populated cities of the trading pair, e_{iet} is

[7]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. In particular, consideration of the "number of affected" for the purposes of our decision rule maximizes the exploitation of our data, since observations of this variable are available for almost all events.

[8]For a derivation of our estimating equation from international trade theory see Appendix B.

the error term, and, finally, X_{iet} is a set of variables measuring colonial ties comprising the following variables: a dummy taking a value of one if the two countries share the same official language (*comlang*), a dummy taking a value of one 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 a value 1 if the partners are or were the same nation (*smcrty*).[9] The GDP variables originate from the World Bank's (2005) World Development Indicators (WB, 2005). The land-locked, common border, distance and colonial ties data are taken from CEPII (2005).[10] 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.[11] However, in contrast to Rose we focus on i's imports from e rather than bilateral trade flows. This avoids what Baldwin (2006) calls the "silver-medal of gravity mistakes". He shows that averaging bilateral trade flows as the dependent variable in the usual manner may lead to potentially sizeable upward biases when a country pair's trade is imbalanced.

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. 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 adopted from Feenstra (2004) who introduced 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. The importance of correcting for these three-way fixed effects is pointed out by Baltagi, Egger and Pfaffenmayer (2003) as well as Baldwin (2006) who calls the omission of these effects the "gold-medal of gravity mistakes".

Our dependent variable, real import flows, comes from Feenstra (2000) and covers the years 1962-2000. The original 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. Since the most recent disasters are the ones most thought about, we expand the Feenstra dataset by using

[9]For the sources and exact definitions of all variables we refer to Table 1.

[10]CEPII stands for the *Centre d'Etudes Prospectives et d'Informations Internationales.*

[11]For further details on the theory of the gravity model we refer to Anderson and van Wincoop (2003).

Comtrade (2005) data for the years 2001-2004.[12] Again the data is 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 Wald test for this belief is not feasible since we have only 41 technological disasters as compared to 1,548 of natural origin.[13] 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 EM-DAT as described above. All disasters are counted for any given year and country if they fulfill the decision rule specified in section 3.3. 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 labeled $drul_i$ or $drul_e$ indicating the number of major disastrous events in the importing or exporting country, respectively.

It should be noted that there are other ways to empirically represent disasters in the estimation. An alternative to the count variable that we employ is to use a dummy variable which takes on a value of unity if at least one disaster satisfying our decision rule occurred during the calendar year. However, the advantage of a count variable is that it allows us to obtain a more precise estimate of the impact of disasters on international trade. All things being equal, a country which is hit more than once by a major disaster in the same year will suffer a sharper reduction in economic activity and exports than a country which suffers only a single incident.[14] It turns out that there are a significant number of instances when a country suffers from more than one disaster that meets our decision rule during the same year. More than a sixth of all cases included in the estimation involved multiple disasters during the same year.[15] This "frequency effect" is captured by a count variable while it would be lost if one just uses a dummy variable. In effect, the count variable allows us to retain more information about disasters than the use of a dummy variable. Nevertheless, as part of our robustness tests, we have also estimated the gravity model using a dummy variable to represent the occurrence of disasters satisfying our decision rule.

[12] Comtrade is the abbreviation commonly used for the United Nations Statistical Division Commodity Trade Data Base.

[13] Note that our results do not change when the 41 technological disasters are excluded.

[14] Imagine the southern part of a country has been hit by a hurricane. Rescue and rebuilding efforts are concentrated in that region. Now, an earthquake shatters its northern part. It is this type of scenario that motivates our assumption. As stated above, like Munich Re, which singles out a category of *great natural catastrophes* subject to a homogeneous set of insurance premia, we also confine ourselves to a group of major disasters with comparably large economic repercussions.

[15] Out of the 1,589 disasters satisfying the decision rule, 268 involved two or more disasters in the same year. The highest number of multiple disasters was 14 in the case of the People's Republic of China during 2003.

5 Results

Our disaster measure is included as an explanatory variable in the gravity model specified in equation (1). The results are shown in Tables 2 and 3, columns (a) and (a'),[16] which refer to the country- and pair-specific set-ups as described in the empirical model section.[17] Table 2 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 the results for the standard variables here.[18] 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.[19] These results are presented in Table 3. For better readability we only display the estimated coefficients for the disaster measures.[20] 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 both physical and human capital) and higher savings in response to increased uncertainty about the future. These findings lend support to our hypotheses 1 and 2a.

However, the significance of the simple disaster count depends on the chosen sample. Taking just the number of disasters into account might not tell the whole story. As highlighted in the

[16] From this point onwards a model with a hyphen (') indicates the pair-specific fixed effects specification.

[17] Note that given our fixed effect set-up all results discussed in the text are likely to represent conservative estimates since this technique tends to remove some of the explanatory power of the remaining variables.

[18] Well-known gravity studies are Anderson (1979) and McCallum (1995). Examples of the recent literature are e.g., Baier and Bergstrand (2001), Evenett and Keller (2002), Anderson and van Wincoop (2003), Haveman and Hummels (2004), Freund and Weinhold (2004), Chen (2004) and Fink, Mattoo and Neagu (2005).

[19] Almost one quarter of the disasters recorded in EM-DAT and fulfilling our decision rule took place in the years 2001 to 2004. This is why the extension of the Feenstra (2000) dataset using Comtrade (2005) data is important to examine the impact of disasters on trade. By the same token, the concentration of disasters in the four most recent years explains why our simple count variable is significant in the Feenstra sample, but less so in the Comtrade sample. While one additional disaster can be assumed to have a proportional effect on trade when disaster frequency is sufficiently low, this may not always hold at the higher frequencies observed between 2001 and 2004, especially when other factors that play a role are not accounted for. As is shown below, country size and government responsiveness are such cushioning factors. When the latter are taken into consideration, our results below confirm that the relationships between the frequency of disasters and their trade impacts also hold when the years 2001 and 2004 are included.

[20] A complete set of results for this and all other specifications discussed but not presented in this paper are available upon request.

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 smaller 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.[21] 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 3, 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. In other words, besides hypotheses 1 and 2a, hypothesis 3 also seems to hold. 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 a score of the political system of the affected country.[22] The regime score we use is the polity variable taken from the Polity IV database (Gurr, Jaggers and Moore, 2003).[23] It is a measure of a state's "general institutionalized authority traits". It is the difference between a country's "democracy" and "autocracy" indices. The democracy index ranges from 0 to 10

[21] The surface area is taken from World Bank (2005).

[22] In this approach, we follow Tavares (2004) who interacts terrorism incidence with the level of political rights using a similarly constructed ordinal indicator.

[23] In fact, we are using the "polity 2" indicator of the database, which is a single regime score derived by subtracting the annual measures for institutionalized democracy and autocracy, as many polities exhibit mixed qualities of both authority patterns.

where higher values indicate a more open and competitive political system with institutionalized constraints on executive authority. The autocracy index ranges also from 0 to 10 with higher values representing a political system where participation is restricted, or limited to an elite, and where there are few checks on executive power. Since the polity score is the result of subtracting the autocracy index from the democracy index, its value ranges from -10 to 10 where higher numbers indicate a more open political system. In order to test our hypothesis, this scale is transformed to run from 1 to 21 and the ordering is reversed so that 1 now indicates the most democratic system and 21 the most autocratic. The interaction terms are labelled $disdem_i$ (for importers) and $disdem_e$ (for exporters) following our methodology of 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.[24] For a given number of disasters, this effect is more pronounced the more undemocratic the affected country is, thus confirming our fourth hypothesis: Democratic societies are better in coping with disasters. For a given democracy score an additional major disaster reduces imports on average by 0.2% and exports by 0.1% (see specification (c), Table 2). These results are significant at the 1% significance level.

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 samples. From Table 2 it can be seen that, in addition, geographical country size matters: 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, as we have conjectured in our hypothesis 2b.[25] The Feenstra sample (Table 3) confirms previous results, including for importers, namely that disasters reduce both exports and imports

[24] 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.

[25] Results for importing countries are less stable than in the case of exporters. This indicates that importing countries, in particular if they are small, experience ambiguous effects. There is a tendency for imports to rise with small countries' reliance on external help in their efforts to rebuild. 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. At the same time, income and savings effects may exert a negative pressure on imports.

and the more so the smaller and more undemocratic a country is. When incorporating both area and quality of the political system in the Comtrade sample these results imply the following: Had Costa Rica been struck by a major disaster in the year 2003, exports would have declined by 4,6% and imports by 0.2%.

In order to further check the robustness of our findings we take three main courses of action presented in Table 4. 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.

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. The results of this robustness check are shown in the two columns on the left hand side of Table 4. Only the RLS results of specification (d), labelled (d*), which includes both the area-adjusted disaster count and the democracy interaction term are displayed.[26] The findings of Tables 2 and 3 virtually remain unchanged. The only differences are that the democracy interaction term for the exporter in the Comtrade sample is now highly significant (at the 1 % instead of the 10% level) and that the area-corrected term for the exporting country in the Feenstra sample is slightly less significant. Other than that, this robustness check emphasizes that the previous findings do not depend on the estimation method used.

Second, we split the sample into developed and developing countries. To determine the set of developed countries we follow the WTO convention (see Appendix A). The remaining countries are classified as developing. The columns of Table 4 labeled "Dgc" show the results for the developing countries using the Comtrade sample with importer-, exporter- and time-specific fixed effects.[27] Again, the findings of Table 2 do not change (and significance levels are even higher) with the exception of the area-adjusted disaster count for the importer, which becomes marginally positive. In Table 2, 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 (hypothesis 2b) especially in small countries (hypothesis 3). Conceivably, this is particularly true for developing countries. This finding is consistent with Sen's observation that democratically elected politicians care more about the quick restitution of the livelihood of their constituencies. Especially in small countries that are naturally more open to trade imports are the obvious route to offer immediate relief. For developed countries ("Ddc" columns), only the democracy interaction term exhibits

[26] The results of all other specifications remain stable and do not change by using RLS.

[27] Results of all other samples and specifications yield stable and similar results.

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. Hence, apart from size which matters in the developing, but not in the developed world, our results are robust to variations in the chosen sample.

Third, given the importance of the political regime for our findings on the trade effects of disasters and the ambiguous results for importers, we employ an alternative way to model democracy. Instead of the Polity IV democracy score, we abandon ordinal measurement of democracy altogether and include the democracy measure developed by Alvarez *et al.* (1996) and Przeworski *et al.* (2000) and updated by Cheibub and Gandhi (2004).[28] This dummy variable takes a value of one for autocracies (i.e. non-democracies) and zero otherwise. Przeworski and colleagues define democracy essentially as a political system in which incumbents can lose elections and comply with the results. More specifically, they require that the executive and the legislature be filled through *contested* elections, where more than one party has a chance of winning. Rather than employing a single dummy variable to differentiate political regimes, we employ two variables (*disautoc* and *disdemoc*) thus *explicitly* partitioning the sample into autocracies and democracies. These variables, when interacted with the disaster count (including when scaled by area), offer the advantage that the resulting coefficients can be more readily interpreted.

As can be seen from specification (e) in Table 5, estimations using the new autocracy variable ($disautoc_i$ and $disautoc_e$) reaffirm our finding of highly significant negative import and export effects of disasters in undemocratic countries.[29] In fact, all else being equal, in case of a major disaster, an undemocratic country sees its imports reduced by 5.8% and its exports by 4.8%. The results are similar once area is taken into account in specification (f) ($disautocar_i$ and $disautocar_e$), although in this case exports decline more strongly than imports. Had, for example, Togo experienced one major disaster in the year 2000, the result would have been a contraction of imports by 6.8% and a decline of exports by 8.2%. Interestingly, for democratic countries, several results become insignificant indicating that disasters may not have a discernible impact on trade. For the full sample, even exports may not necessarily suffer in democratic countries ($disdemoc_e$) (although they do in the developing world). By contrast, imports go up both in the full and developing country sub-sample ($disdemoc_i$) by 1.6% and 3%, respectively. We take this finding as

[28]In order to avoid ordinal measurement while maintaining the Polity IV data, we have also grouped countries in three classes: high, middle and low democracy. Incorporating this measure also underscores the importance of governance. The low and middle democracy countries experience more pronounced declines in both trade flows (in most set-ups at high levels of significance). In high democracy countries, in particular if they are small, disasters lead to higher imports. This result is corroborated in the developing country sub-sample, with the respective coefficients being insignificant for developed countries.

[29]Note that this alternative democracy measure is only available until the year 2000.

a strong indication of democratic countries' swift efforts to restore production facilities and export infrastructure and of their inclination to rely on imports in relief operations. Hence, using the alternative democracy measure fortifies our fourth hypothesis. In addition, it provides evidence that hypothesis 2b cannot easily be dismissed.

To further confirm that the trade of autocratic countries is more adversely affected by disasters than that of democracies, we conduct a Wald test on the null hypothesis that the coefficients on the disaster variables interacted with democracy ($disdemoc_i$ and $disdemoc_e$) and autocracy ($disautoc_i$ and $disautoc_e$) are equal.[30] This is done for the democracy ($disdemocar_i$ and $disdemocar_e$) and autocracy (($disautocar_i$ and $disautocar_e$) variables scaled by area as well. Based on the results of the Wald tests, we can reject the null hypothesis for the unscaled democracy and autocracy variables at the 1% level of significance. The null hypothesis is also rejected for the democracy and autocracy variables scaled by area at the 5% level of significance. All of these results hold whether we use the model with pair and time fixed effects or the model with importer, exporter and time fixed effects.[31]

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. As discussed in Section IV, an alternative measure for disasters would be a dummy taking a value of one if at least one disaster occurred in a country in a given year. The use of this measure does not yield qualitatively different results from the frequency count of disasters. Both exports and imports are negatively affected. Finally, when scaling the disaster count variable, we replace surface area as a standard measure of country size used in the literature[32] by population density. This change produces similar results. The coefficients of the scaled disaster count variable for imports remain unstable; they sometimes turn out significantly positive, especially for the developing country sub-sample. This corroborates our suspicion that

[30] In other words, the idea is to test the following (joint) null hypothesis: coefficient on $disdautoc_i$ = coefficient on $disdemoc_i$ and coefficient on $disdautoc_e$ = coefficient on $disdemoc_e$

[31] The statistics associated with the Wald test are 36.95 (p-value 0.00) and 4.03 (p-value 0.02).

[32] See, for instance, Pelling, Özerdem and Barakat (2002) and Rasmussen (2004).

densely populated countries, in particular in the developing world, may have to rely on additional imports for disaster relief and that this effect may outweigh tendencies to import less owing to reduced incomes and increased uncertainty. In line with our alternative hypotheses 2a and 2b, when taking account of country size, the effect of disasters on imports is ambiguous owing to these neutralizing forces.

Finally, we turn to the impact that disasters have had on international trade over the past four decades. The Comtrade dataset shows that between 1962 and 2003 world trade grew by an annual average of 6.4% in real terms even while the frequency of disasters was also rising. This expansion in world trade can be attributed to changes in technology which have lowered trade costs; financial and trade policies which have lowered barriers to trade and investments, and other economic processes which have underpinned global economic growth. They clearly have been more powerful drivers of international trade since even the rising count of large disasters have not stemmed this expansion. We realize that gravity equations are meant to ascertain what factors affect the distribution of a country's trade rather than to determine the aggregate amount. Still, there is information contained in our gravity equation results that can be used to shed some light on the question of how much large disasters have reduced trade over the past four decades. Also we shall proceed in a way so that it is the *relative difference* in the volume of world trade rather than the level which will be estimated. First, we generate the predicted path of world imports over time given all the exogenous variables in the model and the coefficient estimates. While our favored specification for this analysis is specification (d) from Table 2 with importer, exporter and time fixed effects, we have also used three other specifications to provide a range of estimates. The alternative specifications from Table 2 are (c) with the same fixed effects but with only the democracy and disaster interaction terms; and specifications (c') and (d') with pair and time fixed effects. Then, we generate an alternative path of world imports using the same specifications but this time with the assumption that no major disasters took place. This means setting the values of the variables $disar_i$, $disar_e$, $disdem_i$ and $disdem_e$ to zero. The relative difference between the two series represents our estimate of how much disasters have reduced world trade. Applying this procedure, our favored specification suggests that large disasters have reduced world trade by an average of 4% over the 40-year period ending in 2003 (see Figure 3). The alternative specifications give a lower bound of 1.2%. But in all specifications, the cost of disasters has been rising. Thus, our gravity equation results imply a sizeable impact on world trade with the proportion of trade lost to disasters rising over time.

6 Conclusions

In this paper we have examined the impact of major natural and technological disasters on international trade flows using a panel dataset yielding approximately 300,000 observations. In general, disasters “shake up” trade relationships reducing both exports and imports. Yet, whether they result in a major “stir-up” of trade depends on a number of factors. 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 0.2% and exports by 0.1% when the size of a country is not accounted for, *ceteris paribus*. The persistence of bilateral trade volumes despite output and expenditure shocks points to the existence of fixed costs in establishing trade relationships. This question deserves further attention independently of the motivation underlying this study.

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 4,6% and a reduction of imports by 0.2%, all else being equal. Applying an alternative way to measure democracy, a dichotomous variable taking the value of one for autocratic states, we find that one disaster fulfilling our decision rule in the year 2000 in Togo would have resulted in a loss of 6.8% of Togo’s imports and 8.2% of its exports. In democratic countries, exports suffer less (or not at all). Imports are hardly affected and even rise in small countries, notably in the developing world. These results support the notion that better governed countries are more inclined to preserve/restore export capacity and seek immediate disaster relief, including through higher imports. As a final result, our gravity equation estimates imply that large disasters have reduced world trade by between 1.2% and 4% over the last forty years and that the impacts have become larger over time.

We end by sounding the note for a deeper examination of the role of democracy in mitigating the effects of a disaster. In this paper, we have provided a number of conjectures on how democracy might work - the “direct” effect of badly-prepared politicians getting voted out of office and the “proxying” effect where democratic societies see less corruption and have a better quality of bureaucracy. This of course does not exhaust the list of possible mechanisms. We have not tried to test these conjectures formally although this could be done with alternative econometric specifications. In addition, future work could go beyond the specification of disasters adopted in this paper as either a count or a dummy variable. This could be accomplished by obtaining more refined estimates of the magnitude of a disaster, notably by filling the gaps in EM-DAT dataset.

Table 1: Variables – Descriptions and Sources

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 (nimp/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 of importing country (in 1,000 km^2)	WB (2005)
$area_e$	land area of exporting country (in 1,000 km^2)	WB (2005)
$disar_i$	$drul_i$ / $area_i$	own calculations
$disar_e$	$drul_e$ / $area_e$	own calculations
dem_i	inverse of Polity IV score for importer: 1 = most democratic, 21 = most autocratic	Gurr et al. (2003)
dem_e	inverse of Polity IV score for exporter: 1 = most democratic, 21 = most autocratic	Gurr et al. (2003)
$disdem_i$	$drul_i \cdot dem_i$	own calculations
$disdem_e$	$drul_e \cdot dem_e$	own calculations
$democ_i$	dummy for importer being democratic	Przeworski et al. (2000)
$democ_e$	dummy for exporter being democratic	Przeworski et al. (2000)
$autoc_i$	dummy for importer being autocratic	Przeworski et al. (2000)
$autoc_e$	dummy for exporter being autocratic	Przeworski et al. (2000)
$disdemoc_i$	$drul_i \cdot democ_i$	own calculations
$disdemoc_e$	$drul_e \cdot democ_e$	own calculations
$disautoc_i$	$drul_i \cdot autoc_i$	own calculations
$disautoc_e$	$drul_e \cdot autoc_e$	own calculations
$disdemocar_i$	($drul_i \cdot democ_i$) / $area_i$	own calculations
$disdemocar_e$	($drul_e \cdot democ_e$) / $area_e$	own calculations
$disautocar_i$	($drul_i \cdot autoc_i$) / $area_i$	own calculations
$disautocar_e$	($drul_e \cdot autoc_e$) / $area_e$	own calculations
$lgdp_{ie}$	ln (real $GDP_i \cdot$ real GDP_e)	WB (2005)
$lgdppc_{ie}$	ln ((real $GDP_i \cdot$ real GDP_e)/($population_i \cdot population_e$))	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)

Table 2: OLS Results Comtrade Sample – Dependent Variable: log of real imports

	(a)	(b)	(c)	(d)	(a')	(b')	(c')	(d')
$drul_i$	0.006	–	–	–	-0.004	–	–	–
	(0.005)				(0.004)			
$drul_e$	-0.001	–	–	–	-0.006*	–	–	–
	(0.005)				(0.004)			
$disar_i$	–	0.430	–	0.635	–	0.208	–	0.808*
		(0.578)		(0.612)		(0.447)		(0.473)
$disar_e$	–	-1.983***	–	-2.339***	–	-2.052***	–	-2.064***
		(0.593)		(0.629)		(0.459)		(0.488)
$disdem_i$	–	–	-0.002***	-0.002***	–	–	-0.002***	-0.003***
			(0.000)	(0.000)			(0.000)	(0.000)
$disdem_e$	–	–	-0.001**	-0.001*	–	–	-0.001***	-0.001***
			(0.000)	(0.000)			(0.000)	(0.000)
$lgdp_{ie}$	1.059***	1.059***	1.150***	1.147***	1.163***	1.159***	1.278***	1.277***
	(0.022)	(0.022)	(0.023)	(0.023)	(0.018)	(0.018)	(0.019)	(0.019)
$lgdppc_{ie}$	0.196***	0.197***	0.229***	0.229***	0.189***	0.189***	0.186***	0.186***
	(0.022)	(0.022)	(0.023)	(0.023)	(0.018)	(0.018)	(0.019)	(0.019)
$lock_{ie}$	-0.271***	-0.271***	-0.281***	-0.281***	–	–	–	–
	(0.029)	(0.029)	(0.030)	(0.030)				
comlang	0.473***	0.473***	0.480***	0.480***	–	–	–	–
	(0.011)	(0.011)	(0.012)	(0.012)				
contig	0.462***	0.463***	0.538***	0.538***	–	–	–	–
	(0.024)	(0.024)	(0.025)	(0.025)				
colony	0.600***	0.600***	0.538***	0.538***	–	–	–	–
	(0.032)	(0.032)	(0.033)	(0.033)				
comcol	0.687***	0.687***	0.723***	0.723***	–	–	–	–
	(0.017)	(0.017)	(0.018)	(0.018)				
col45	1.191***	1.191***	1.227***	1.227***	–	–	–	–
	(0.040)	(0.040)	(0.042)	(0.042)				
smctry	0.842***	0.842***	0.851***	0.851***	–	–	–	–
	(0.033)	(0.033)	(0.034)	(0.034)				
ldist	-1.125***	-1.125***	-1.083***	-1.083***	–	–	–	–
	(0.005)	(0.005)	(0.006)	(0.006)				
Obs.	281,762	281,762	249,551	249,551	281,762	281,762	249,551	249,551
Importers	163	163	143	143	–	–	–	–
Exporters	176	176	147	147	–	–	–	–
Pairs	–	–	–	–	21,382	21,382	16,811	16,811
R-sq	0.730	0.730	0.731	0.731	0.259	0.259	0.270	0.270

Note: *drul* represents the number of disasters according to the decision rule; *disar* is the disaster count scaled by area; *disdem* stands for the interaction of disasters and the democracy score; the subscripts i, e and ie indicate importer, exporter and trading pair, respectively.
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 at the 1% level. The reported R-sq is the adjusted R-squared for the left part of the table and the within (without fixed effects) R-squared for the right part. 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 3: OLS Results Feenstra Sample – Dependent Variable: log of real imports

	(a)	(b)	(c)	(d)	(a')	(b')	(c')	(d')
$drul_i$	-0.011**	–	–	–	-0.015***	–	–	–
	(0.006)				(0.004)			
$drul_e$	-0.018***	–	–	–	-0.019***	–	–	–
	(0.005)				(0.004)			
$disar_i$	–	-2.590***	–	-1.797**	–	-2.749***	–	-2.081***
		(0.723)		(0.774)		(0.542)		(0.583)
$disar_e$	–	-2.708***	–	-2.405***	–	-2.037***	–	-1.624***
		(0.796)		(0.851)		(0.602)		(0.645)
$disdem_i$	–	–	-0.003***	-0.003***	–	–	-0.004***	-0.003***
			(0.000)	(0.000)			(0.000)	(0.000)
$disdem_e$	–	–	-0.002***	-0.002***	–	–	-0.003***	-0.002***
			(0.000)	(0.000)			(0.000)	(0.000)
Obs.	232,149	232,149	210,679	210,679	232,149	232,149	210,679	210,679
Importers	145	145	135	135	–	–	–	–
Exporters	145	145	135	135	–	–	–	–
Pairs	–	–	–	–	13,379	13,379	11,949	11,949
R-sq	0.722	0.722	0.723	0.723	0.286	0.286	0.293	0.293

Note: *drul* represents the number of disasters according to the decision rule; *disar* is the disaster count scaled by area; *disdem* stands for the interaction of disasters and the democracy score; the subscripts i and e indicate importer and exporter, respectively.
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 at the 1% level. The results for the standard gravity variables as in Table 2 are suppressed to enhance readability but are available upon request. The reported R-sq is the adjusted R-squared for the left part of the table and the within (without fixed effects) R-squared for the right part. 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 4: Results Robustness Check – Dependent Variable: log of real imports

	(d*)	(d*)	(d)	(d*)	(d)	(d*)
$disar_i$	0.173	-2.190***	1.601*	1.587*	-0.163	0.332
	(0.556)	(0.703)	(0.950)	(0.936)	(2.112)	(1.934)
$disar_e$	-2.811***	-1.552**	-3.064***	-3.719***	1.657	0.580
	(0.572)	(0.772)	(0.986)	(0.971)	(2.112)	(1.934)
$disdem_i$	-0.003***	-0.004***	-0.003***	-0.004***	-0.012**	-0.010**
	(0.000)	(0.000)	(0.001)	(0.000)	(0.005)	(0.005)
$disdem_e$	-0.001***	-0.002***	-0.003***	-0.003***	-0.018***	-0.013***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.005)
Technique	RLS	RLS	OLS	RLS	OLS	RLS
Sample	Comtrade	Feenstra	Dgc	Dgc	Ddc	Ddc
Obs.	249,551	210,679	109,863	109,863	15,954	15,954
Importers	143	135	122	122	21	21
Exporters	147	135	126	126	21	21

Note: *disar* is the disaster count scaled by area; *disdem* stands for the interaction of disasters and the democracy score; the subscripts i and e indicate importer and exporter, respectively.
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 only the developing (Dgc) countries of the Comtrade sample while the two columns on the right use only 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 at the 1% level. The results for the standard gravity variables as in Table 2 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.

Table 5: OLS Results Alternative Democracy Measure – Dependent Variable: log of Real Imports

	(e)	(f)	(e)	(f)	(e)	(f)
disautoc$_i$	-0.058***	–	-0.110***	–	-0.231**	–
	(0.007)		(0.011)		(0.115)	
disautoc$_e$	-0.048***	–	-0.094***	–	-0.187*	–
	(0.007)		(0.010)		(0.115)	
disdemoc$_i$	0.016**	–	0.030**	–	0.006	–
	(0.008)		(0.013)		(0.013)	
disdemoc$_e$	-0.008	–	-0.038***	–	-0.046***	–
	(0.007)		(0.012)		(0.013)	
disautocar$_i$	–	-3.688***	–	-3.544**	–	-115.882**
		(0.957)		(1.604)		(57.598)
disautocar$_e$	–	-4.435***	–	-4.524**	–	-91.158
		(1.097)		(1.992)		(57.598)
disdemocar$_i$	–	-1.092	–	1.244	–	-0.316
		(1.062)		(1.784)		(2.868)
disdemocar$_e$	–	-1.227	–	-6.559***	–	-0.729
		(1.102)		(1.925)		(2.868)
Sample	Feenstra	Feenstra	Dgc	Dgc	Ddc	Ddc
Obs.	219,964	219,964	88,405	88,405	16,213	16,213
Importers	143	143	122	122	21	21
Exporters	143	143	122	122	21	21
R-sq	0.724	0.724	0.574	0.573	0.900	0.900

Note: The subscripts i and e indicate importer and exporter, respectively.
The two columns on the left represent the results when incorporating dummies to separate countries into democratic (*democ*) and autocratic (*autoc*) using the dichotomous democracy variable developed by Prezeworski et al. (2000). This allows to estimate different coefficients for the effect of disasters and disasters scaled by area (*ar*) for the two country groups in the Feenstra sample. The two columns in the middle use only the developing (Dgc) countries while the two columns on the right use only 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 2 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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Appendix

A 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, United States of America.

B Derivation of the Gravity Equation

We show that the estimating equation 1 in the main text of the paper can be derived from a standard model of international trade. Consider the basic trade model of monopolistic competition (Krugman, 1980). Production is characterized by increasing returns and markets are monopolistically competitive. Consumers are identical and have homothetic tastes. In a free-trade equilibrium, a given country will produce and specialize in a range of product varieties. Consumers of that country will purchase part of domestic production while consumption of other varieties will have to be accommodated through imports. It can be shown that total imports of country i from country e will be given by:

$$M_{ie} = s_i Y_e$$

where M_{ie}, s_i and $Y_e$are imports of country i from country j, the share of country i in world output and aggregate output of the exporting country respectively. Rewriting $s_i = Y_i/Y_W$ where Y_W is world output, we obtain the basic gravity specification:

$$M_{ie} = Y_i Y_e / Y_W$$

We formally introduce disasters in the model through the random variables $\theta_i(N_i, X_i)$ and $\theta_e(N_e, X_e)$ which act as multiplicative shocks to the aggregate outputs of countries i and e. Thus, $\theta_i(N_i, X_i) \cdot Y_i$ represents the disaster-affected level of output of country i. The assumption that theta is a shock on aggregate output rather than on the production of a specific variety implies that the disaster must be of a sufficiently large size (as in Munich Re's *great natural catastrophe*).

Here the natural number N_i (N_e) stands for the count of large disasters that afflict country i (e). The additional explanatory vector X_i (X_e) in theta allows for the possibility that the severity of the effect on output, i.e. the value of theta, will be affected by economic or physical variables (e.g. area) other than the number of disasters. We assume that theta lies in the half-closed interval between zero and one and that it is decreasing in N.

$0 < \theta(N, X) \leq 1 \quad \text{and} \quad \theta(N', X) < \theta(N, X)$, for $N' > N$

The gravity equation is then given by:

$$M_{ie} = (\theta_i Y_i)(\theta_e Y_e)/Y_W$$

Taking natural logs on both sides gives us:

$$\ln(M_{ie}) = \ln(Y_i Y_e) + \ln(\theta_i) + \ln(\theta_e) - \ln Y_W$$

Note, that in the special case of an exponential, i.e., $\theta_i = e^{(\alpha_2 N_i)}$ and $\theta_e = e^{(\alpha_3 N_e)}$, taking the natural log of theta gives us $\ln(e^{(\alpha_2 N_i)}) = \alpha_2 N_i$ and $\ln(e^{(\alpha_3 N_e)}) = \alpha_3 N_e$. This leads to the estimating of following equation with the hypothesis that $\alpha_2 < 0$ and $\alpha_3 < 0$:

$$\ln(M_{ie}) = \alpha_0 + \alpha_1 \ln(Y_i Y_e) + \alpha_2 N_i + \alpha_3 N_j + \ldots$$

Table A-1: 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

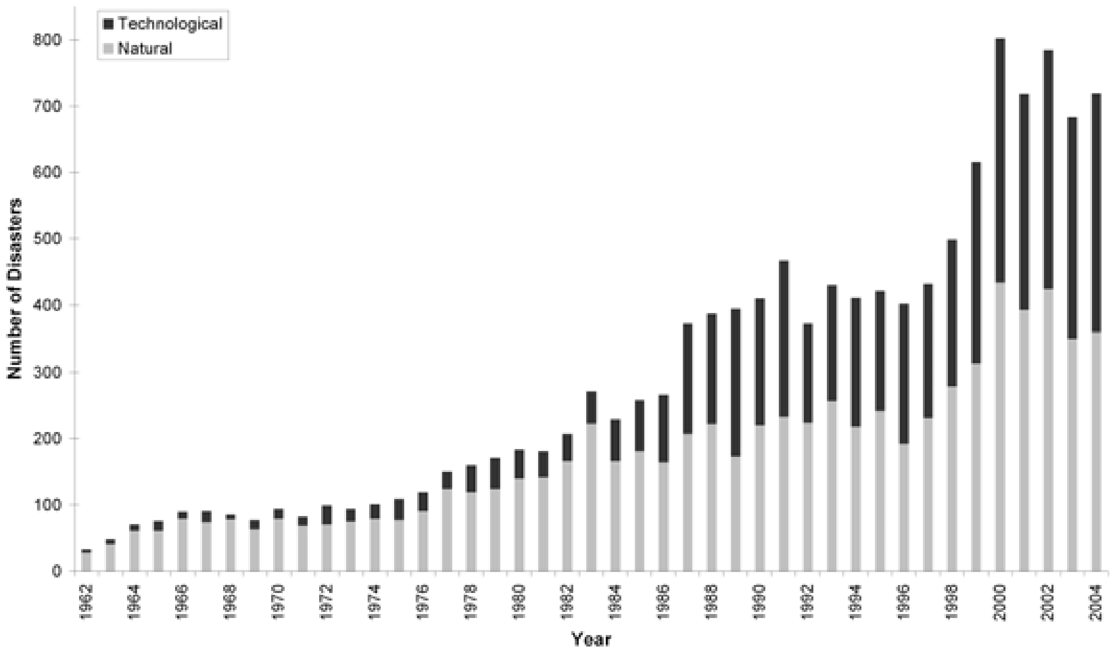
Source: EM-DAT (2005).

Table A-2: Disasters Satisfying the Decision Rule

	Number of deaths more than 1,000	Number of injured more than 1,000	Number of affected more than 100,000	Damages more than $1 billion (in 2000 dollars)
Disasters	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%

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

Figure 1: Frequency of Disasters, 1962-2004



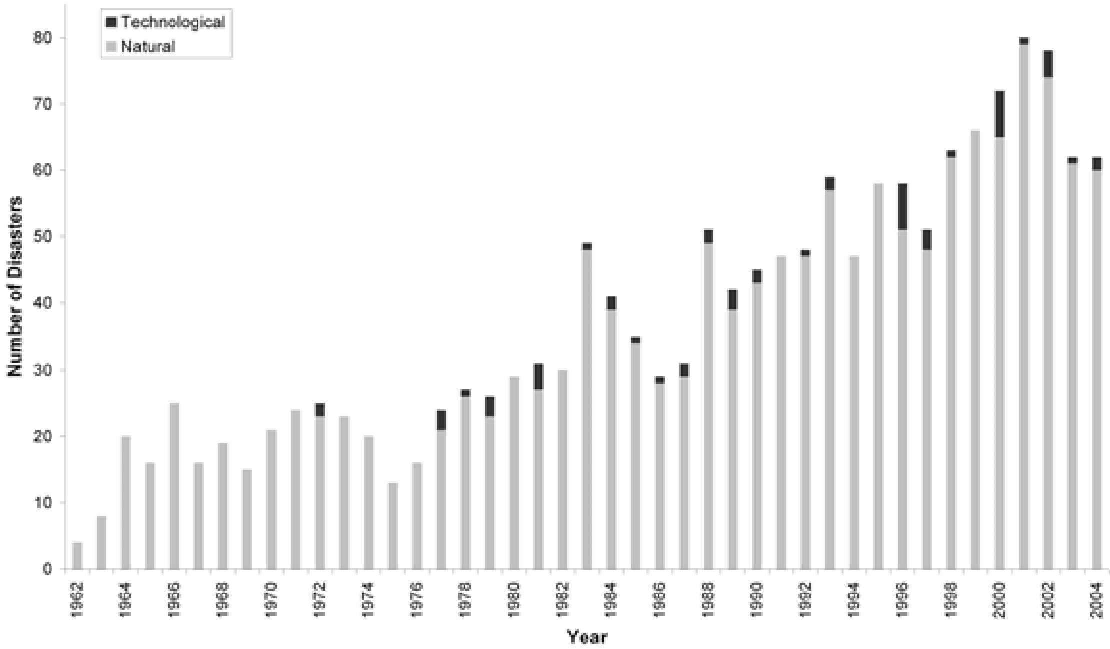
Source: EM-DAT (2005).

Time trends:[33]

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

[33]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. This result corresponds to the average annual growth rate and its standard deviation.

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



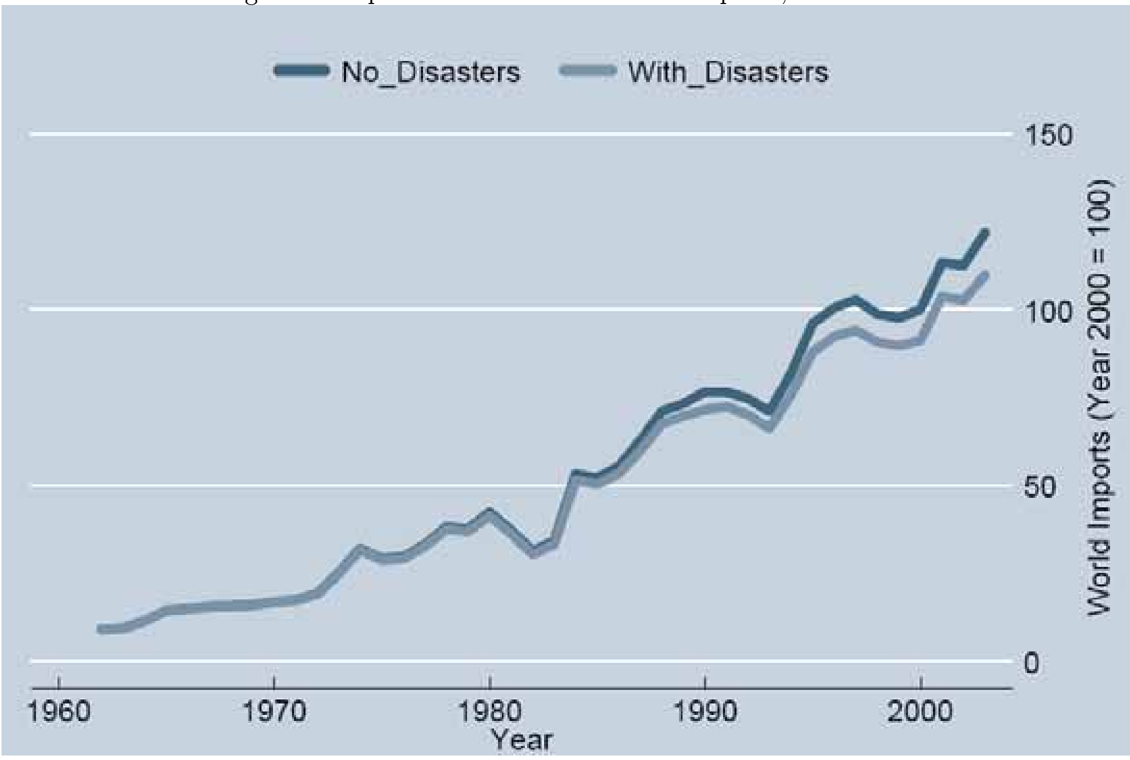
Source: EM-DAT (2005).

Time trends:[34]

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

[34]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).

Figure 3: Impact of Disasters on World Imports, 1962-2003



Note: The graph uses specification (d) of Table 2 to estimate the impact of disasters on world imports. Using the obtained coefficients to predict and aggregate world imports and then obtain the same by setting all disaster values to zero produces an estimated reduction of world trade by catastrophes of 4%. The specification shows larger effects over time.