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Climatic natural disasters, political risk, and international trade

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ABSTRACT

This paper statistically analyzes the effects of climatic natural disasters and political risk on bilateral trade in a large-*N* sample of countries and years. Our theory suggests that the effects of these forces on trade need to be studied together and that the two forces may interact with one another. In the statistical analysis, the unit of analysis is a pair of countries and the model is based on the trade gravity design. The results show that the direct effects of increases in the incidence of disasters and the political risk level in the importer or the exporter countries are negative, reducing trade. The results for the interaction between the two forces show (1) as the incidence of disasters increases, the marginal effect of political risk on trade becomes more negative, which indicates a greater decline in trade and (2) as political risk declines the marginal effect of disasters becomes less negative, indicating a smaller decline in trade. Additional analyses demonstrate the robustness of these results to changes in model specification, disaster measure, and estimation method. In the bigger picture, our findings suggest that if climate change increases the incidence of climatic disasters as projections of the global science suggest, the growth of economic globalization may decline, *ceteris paribus*.

1. Introduction

Natural disasters have increasingly been one of the most vexing problems facing humanity. The average number of natural disasters worldwide has increased from about 30 per year in the 1950s to more than 400 since 2000. The average number of people affected, defined as those requiring survival needs such as medical care, food, and shelter during and in the wake of disasters, rose from about 25 million per year in the 1960s to 300 million since 2000 (EM-DAT, 2009a). Adjusting for inflation, the average economic loss has risen from about 12 billion dollars per year in the 1970s to 83 billion since 2000 (United Nations, 2008).

What may account for this rising trend? Population growth (Strömberg, 2007) and increase in population and housing units in vulnerable areas (Pielke et al., 2008) are said to have driven much of the trend. More complete reporting due to improvements in information technology may have also played a role, though by the 1970s the media had achieved global coverage of events, including natural disasters (Peduzzi, 2005). The importance of these factors not withstanding there is a reason to suspect that another force has also been at play: a rise in extreme weather events, including storms, floods, droughts, heat waves, sea waves, heavy rainfall, and wet ground slides. We refer to these hazardous events as climatic disasters.

In the 1950s there were 232 climatic disasters worldwide, in the 1980s 1498, and in 2000–2008 there were 3217 climatic disasters, accounting for more than 75% of all natural disasters. On average, 23 climatic disasters occurred per year in the 1950s, 150 in the 1980s, and 357 in 2000–2008 (UNISDR, 2008; EM-DAT, 2009a,b). Integrating a large body of global research, the Intergovernmental Panel on Climate Change concluded this rising trend is likely to have been partly driven by anthropogenic global climate change (IPCC, 2007a).

Climatic disasters can be devastating. For example, in 2005, Hurricane Katrina destroyed most of New Orleans, Louisiana and much of the Gulfport-Biloxi metro area, Mississippi, causing damage of more than $180 billion (Romilly, 2007) and displacing more than a million people (Reuveny, 2008). Other examples of devastating disasters hitting the US, include Hurricane Rita (Houston, Texas, 2005), Hurricane Gustav (New Orleans, Louisiana, 2008), and Hurricane Ike (Galveston, Texas, 2008). Elsewhere, long droughts often strike Sub-Saharan Africa, the Middle East, and Australia, intense floods and landslides hit Central America, powerful storms batter Asia, and extreme heat waves and wide-spread floods hit Western Europe.

Assuming business as usual, projections of the global science suggest that the number and intensity of climatic disasters will continue to increase worldwide, making global climate change ever more crucial for climatic hazards in the coming decades (IPCC,

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2007a,b). This projection gives a rise to the focus of this paper. In recent decades, economic globalization has expanded quickly, driven in part by growing international trade flows. What is the effect of climatic disasters on international trade? Do they diminish international trade due to, for example, the damage they cause? Or, perhaps, do they promote international trade since, for example, domestic production declines?

We analyze the annual effect of climatic disasters on trade in a large-*N* sample of countries and years.[2] Our focus does not mean to indicate that trade is currently the most worrying climate change-related concern; concerns regarding possible impacts on socio-economic aspects such as displacement or agriculture are perhaps more worrying. However, we think that our focus is important because trade is immensely essential in the world economy. Since climate change will likely continue for many decades even if we cease producing greenhouse emissions today, our finding may inform us about the effect of climate change on a key economic force in the foreseeable future, assuming that the past can tell us something about the future.

Our research question, however, cannot be examined without considering the effect of other forces, including the economic and population size of the trading nations, their institutional links, and the distance between them, as suggested by the widely used trade gravity model. Non-climatic natural disasters such as earthquakes should also be considered. One additional force is particularly important for our purpose: the political risk level of a country, defined broadly to include factors such as interstate and/or intrastate militarized conflict, religious and/or ethnic tension, political instability, weak rule of law, civic disorder, low level of democracy, public and private sector corruption, socioeconomic conditions that promote public discontent, inhospitable investment climate, and incapable bureaucracy.

The effect of political risk on trade flows has received attention in the literature, but the effect of climatic disasters has received almost no attention. The two forces, however, may affect each other. Climatic disasters may increase political risk, and political risk may indicate how well the economy can respond to disasters and recover. For example, in New Orleans, looting and killing occurred in the wake of Hurricane Katrina. In the wake of Hurricane Ike, the state of Texas enforced a curfew in Houston to prevent such events. In California, in the 1930s, residents clashed with newcomers fleeing from dust storms in the Great Plains. In India, residents fought with people fleeing storms and droughts in Bangladesh (Reuveny, 2008). In Darfur, droughts played a role in the violence (Straus, 2005). The 1971 secession of East Pakistan and the India–Pakistan war was linked to anger in East Pakistan toward West Pakistan due to the delay in state relief after storms, particularly after the devastating 1970 Bhola cyclone (New York Times, 1970; Olson, 2005). In all these cases, the political instability hampered relief efforts. Thus, trade studies that exclude one of these two forces may incorrectly attribute their result to the force they include when, in reality, the result is partly attributable to the other force.

In the statistical analysis, we develop a trade gravity model for a large-*N* sample of countries between 1985 and 2003, as determined by data availability. Our indicator of climatic disasters includes a broad spectrum of extreme weather-related events and our political risk indicator includes a broad spectrum of international and domestic problems. Since there are reasons to expect that the effects of climatic disasters and political risk on trade may depend on each other, respectively, we also consider the effect of their interaction on trade.

[2] The implied assumption that climatic disasters affect trade is appropriate for the annual values used here. Countries relying on trade, however, may develop their seaports more than other places. Since some seaports may face more hurricanes and cyclones, over the long term more trade may imply facing more climatic disasters.

We find that an increase in political risk or the incidence of disasters substantially reduces bilateral trade. As the incidence of disasters increases, a rise in political risk generates a greater decline in trade. As political risk declines, a rise in the incidence of disasters causes a smaller decline in trade. These results held in a number of robustness analyses. Recalling that projections of the global science suggest that the number of climatic disasters will rise as climate change progresses, our analysis may inform us of the potential effects of climate change on trade, *ceteris paribus*.

This paper is organized as follows. Section 2 presents our theory and Section 3 discusses previous empirical studies. The next three sections describe our model and variables and presents the results. Section 7 summarizes and discusses implications for climate change policy.

2. Theory

The previous sections argued that climatic disasters and political risk affect trade flows. This section lays out the theoretical foundations for this argument.

2.1. The direct effect of disasters

A rise in climatic disasters can reduce or increase trade. Beginning with channels reducing trade, disasters can destroy human and physical capitals (e.g., kill people, destroy plants, and damage storage, transportation, energy, and communication infrastructures). As a result of the fall in production, income may decline, which reduces private spending and investments, and tax revenues may decline, which reduces public spending. The decline in aggregate demand and supply may reduce trade flows since the domestic importers and exporters may not be able to absorb or produce the pre-disaster levels, respectively.

Second, disasters may increase the cost of trade. For example, traders may need to use longer routs or other ports and airports to reach markets, increasing the costs of distribution and transportation. Insurance premiums may rise, as insurers seek to cover the increased risk. Disasters may also lead to new regulations, requiring goods to be less vulnerable to disasters through design changes or sturdier packaging. As a result, production and distribution technologies may require redesign, which increases costs. A rise in costs, in turn may raise the price of goods, causing a decrease in the total quantity demanded.

Third, economic activity may be partly driven by waves of optimism. Disasters can exhaust people and reduce their willingness to engage in normal economic activities such as consumption, production, and investment. Since disasters destroy sources of livelihood and homes, people may not be able to pay for goods. As a result, trade markets may collapse. In this vein, the OECD (2004) suggests that governments should focus on restoring confidence in the aftermath of disasters so that economic agents will resume their normal routines.

Consider next the possibility that disasters promote trade. First, a country hit by a disaster may lose production capacity. Other nations may enter the local market, motivated by humanitarian or other reasons (e.g., increase market share, influence leaders). In doing so, they may grant aid or reduce their export price, enabling their partner to buy more of their exports.

Second, countries hit by disasters may choose policies aimed at increasing their bilateral trade flows. For example, the reconstruction efforts of damaged infrastructures in the affected countries may rely on imports of materials, technology, and skill. External aid may intensify this effect by providing foreign currency. Seeking to rebuild areas hit by a disaster, the government may increase exports in order to gain foreign currency. Seeking to intensify these effects, the government may also liberalize its export and import markets, which will likely further promote its trade flows.

Third, the price of traded goods may rise as the result of a climatic disaster, as traders may seek to cover the larger costs and risks associated with doing business in this case. It is also possible that suppliers may revert to price gouging during and in the wake of disasters (e.g., CNN, 2008; L.A. Times, 2005). The quantity of traded goods may decrease due to a disaster. If the price increase is larger than the decrease in the quantity, the trade value (i.e., price $\times$ quantity) will rise.

Finally, whereas risk-averse traders are likely to exit markets hit by a disaster, risk-loving traders or speculators may view the situation as an opportunity to make extra normal profits. This basic idea can be traced back to Kelley's (1974) argument that trade may rise with risk due to fires. If the number of speculators and traders entering a market hit by a climatic disaster is larger than the number of traders exiting the market, the value of the bilateral trade may rise.

2.2. The direct effect of political risk

As in the case of climatic disasters, a rise in the level of political risk may increase or decrease trade flows. On the negative side, first, political risk rises when contextual uncertainty grows due to an unexpected change in government foreign policy from friendliness to hostility. As the uncertainty regarding the political relations grows, bilateral trade may decline because traders may fear that governments may introduce edicts forbidding trade in some goods and limiting trade in others, or that trade contracts may not be honored. At the extreme, formal trade ties may cease altogether.

Second, the external or internal violent conflict stemming from political risk may harm trade (e.g., damage goods, delay distribution, and destroy transportation infrastructure). This damage implies higher costs to traders due to larger insurance premiums, longer trade routes or a need for an increase in personnel to guard shipments. Facing rising costs, some traders may exit the market and others may face lower demand, as they raise the price to cover the higher costs. As trade declines, national output and income may fall, further reducing exports and imports. Growing government instability may also raise costs and risk, as a new government may change trade policies in ways that negatively affect traders.

Third, political risk may increase due to a decline in the quality of institutions, involving factors such as corruption, socioeconomic policies that fuel public discontent, involvement of the military in politics, which may lead to military conflicts, and an incapable bureaucracy. Another risk increasing factor may involve a decline in the level of law and order, including forces such as nonviable contracts, unenforceable penalties for payment delays and inabilities to repatriate profits without incurring losses due to the need to pay kickbacks to corrupt officials. Autocracy and government accountability may also matter. An autocracy prevents expression of public concerns and political competition, and an unaccountable government is less likely to be responsive to the public, creating discontent and tension. Each of these factors may lead to a decline in bilateral trade.

In contrast, growing political risk may also lead to more trade. First it may increase the domestic demand for imports, assuming imports can substitute the local goods. For example, in the short term a rise in public corruption may lower the productivity of labor and physical capital, leading to a rise in imports in order to meet the domestic demand.[3]

[3] See Awokuse and Gempesaw (2005) and Lambsdorff (2003). In the medium and longer run, however, a fall in productivity will reduce income and therefore consumption, including imports.

Second, while some traders may exit the market as political risk increases other traders may take their place. These traders may charge a higher price to compensate for the higher risk, speculating that countries having no readily available substitutes may pay the higher price while keeping quantity intact (Kobrin, 1979). The possibility of making extra normal profits may appeal to traders on both sides of a dyad, increasing the bilateral trade value as long as some high prohibitive risk threshold is not crossed.

2.3. The effect of the disaster–political risk interaction

Climatic disasters and political risk may interact in affecting bilateral trade. The marginal effect of disasters on trade may depend on political risk, and the marginal effect of political risk on trade may depend on disasters. The interaction effect can reinforce or weaken the direct effects since both forces can imply potential excessive costs and uncertainty or an opportunity to earn extra profits. Risk-averse traders may reject the disasters–political risk combined situation, while risk-loving traders may welcome it.

Given the possibilities discussed in Sections 2.1 and 2.2, there are eight possible combinations, though perhaps not all are equally likely. It makes sense to expect that traders approach situations involving disasters and political risk in the same way, either rejecting both or welcoming both. However in principle, traders may reject disasters and welcome political risk, or welcome disasters and reject political risk, but these situations may not be common.

Consider first situations in which traders approach disasters and political risk in the same way. In one case, the direct effects of disasters and risk on trade are positive and the interaction term is positive. Thus, the positive marginal effect of disasters rises when political risk rises, and the positive marginal effect of political risk rises when disasters increase, because risk-loving traders welcome the combined risk as an even greater opportunity to make extra profits (e.g., charge a higher price, pay a lower price or increase market share).

Second, the direct effects of disasters and political risk are positive and the interaction term is negative. In this case, the marginal effect of disasters decreases when political risk increases, and the marginal effect of political risk decreases when disasters increase. This outcome may happen because traders who welcome each situation alone as an opportunity to make extra profits reject the combined situation as being too costly and uncertain.

Third, the direct effects of disasters and political risk are both negative, and the interaction term is negative. In this case, the marginal effect of disasters becomes increasingly negative as political risk increases, and the marginal effect of political risk becomes increasingly negative when disasters increase. This outcome may happen because a trader's risk aversion increases even more when the two forces work together.

Fourth, the direct effects of disasters and political risk are negative, and the interaction term is positive. In this case, the marginal effect of disasters becomes less negative when risk rises, and the marginal effect of risk becomes less negative when disasters increase. Traders that dislike either situation may find the combined situation more attractive (e.g., a chance to increase a market share). This outcome is improbable, but not impossible.

Situations in which the direct effects of disasters and political risk have different signs are also improbable, though not impossible. In two of these cases, the interaction term is negative: Traders who welcome disasters reject political risk, or traders who welcome political risk reject disasters. In both cases, traders may reject the combined situation as too risky and costly. In two other cases, the interaction term is positive: Traders who welcome disasters reject political risk, or traders welcome political risk and reject disasters. In these cases, traders may welcome the combined situation as a chance to make speculative profits.

3. Previous empirical studies

Several previous empirical studies come close to our goal in terms of utilizing a broad measure of political risk in bilateral trade models. For example, Anderson and Marcouiller (2002) used indicators from surveys focusing on contract enforcement, impartiality and transparency of economic policies, police quality, crime, and resolving disputes legally. They found that trade in 1996 declined with risk. Awokuse and Gempesaw (2005) found that the U.S. agricultural export in 1990–2000 rose with assassinations, riots, political violence, and unrest in the importer countries. Using a 1984–1997 sample 2 of the 12 risk components from Political Risk Services (2008a), Long (2008) found that external and internal violent conflicts reduced trade. We also rely on this source, but we use all of the 12 components. These studies, however, did not consider the effect of disasters on trade.

Research on the economic effect of disasters is generally in its infancy, though two research strands are relatively more developed. One strand examined cases studies focusing on the effect of specific disasters. A smaller strand used multi-country/disaster statistical models. Case studies examined the direct and indirect costs of actual disasters (e.g., the Northridge Earthquake, Hurricane Katrina) or hypothetical disasters (e.g., earthquake hitting the U.S. Midwest or a California port, electricity blackout in Los Angeles). These studies devised several models, including a before-and-after macroeconomic model (Albala-Bertrand, 1993a), an input–output (IO) supply-shock model with reallocation of surviving production capacity (Cochrane, 1997), a network-economic-spatial allocation model (Gordon et al., 1998), a simulation of port revenue generation (Pachakis and Kiremidjian, 2004), a general equilibrium model (Rose et al., 2007), and an IO model with importation (Hallegatte, 2008).

Only a few studies used a large-*N* statistical framework and most of these studies aggregated all disasters in one measure. One group examined the economic damage and death impacts of disasters. Higher income per capita and government effectiveness (Kahn, 2005; Strömberg, 2007), education attainment and trade openness (Skidmore and Toya, 2007), and government stability and better investment climate (Raschky, 2008) were found to reduce the impact. Increases in the population and housing units in vulnerable areas (Pielke et al., 2008), the number of affected people (Raschky, 2008), population size (Kahn, 2005), and economic inequality were found to increase the impact (Kahn, 2005, Anbarci et al., 2005).

A second group examined the macroeconomic impacts of disasters. Auffret (2003) found that disasters reduced consumption in Caribbean and Latin American countries from 1970 to 1999. Noy (2009) found that disasters reduced economic growth from 1970 to 2003. Coming closest to our interest in terms of its focus, Gassebner et al. (2006) found that disasters reduced trade from 1962 to 2004, but they considered only disasters classified as sufficiently severe according to their own decision rule, did not examine political risk, and included both natural and technological disasters in their measure.

A third group of studies provided some results for climatic disasters. Skidmore and Toya (2002) found that climatic disasters increased the average rate of economic growth over the period 1960–1990. Raddatz (2007) found that various adverse economic and non-economic shocks, including climatic disasters, reduced GDP per capita in the less developed countries (LDCs) from 1965 to 1997. Romilly (2007) found that Canada and Central Asia faced the highest risk to economic activity due to exposure to extreme temperatures, while South America and Southern Asia faced the lowest risk.

Taking these studies and our goal into consideration, we think there is ample room for empirical work focusing on the direct and interactive effects of climatic disasters and political risk on international economic flows. We now turn to this task in the context of trade.

4. Empirical model and variables

Section 2 theorized that the impacts of climatic disasters and political risk exhibit competing forces. While the relative strength of the competing forces determining the effects of these variables on trade cannot be predetermined without introducing additional assumptions, the net effects can be evaluated empirically.[4] This section presents our empirical model and variables.

Eq. (1) presents our model, which employs the widely used trade gravity design (e.g., Fratianni and Oh, 2009; Fratianni, 2009; Long, 2008). This approach typically examines the level of trade, though it can also be used to examine the change in trade (see Section 6).

$$\begin{aligned}\ln \mathrm{IMPORT}_{i,j,t} = {} & \alpha_0 + \beta_1 \ln(\mathrm{CD}_{i,t}) + \beta_2 \ln(\mathrm{CD}_{j,t}) + \beta_3 \ln(\mathrm{PS}_{i,t-1}) \\ & + \beta_4 \ln(\mathrm{PS}_{j,t-1}) + \beta_5 \ln(\mathrm{PS}_{i,t-1}) \times \ln(\mathrm{CD}_{i,t}) \\ & + \beta_6 \ln(\mathrm{PS}_{j,t-1}) \times \ln(\mathrm{CD}_{j,t}) + \alpha_1 \ln(\mathrm{GDP}_{i,t-1}) \\ & + \alpha_2 \ln(\mathrm{GDP}_{j,t-1}) + \alpha_3 \ln(\mathrm{POP}_{i,t-1}) + \alpha_4 \ln(\mathrm{POP}_{j,t-1}) \\ & + \alpha_5 \ln(\mathrm{DIST}_{i,j,t}) + \alpha_6 \mathrm{CBORD}_{i,j,t} + \alpha_7 \mathrm{CLANG}_{i,j,t} \\ & + \alpha_8 \mathrm{CCOL}_{i,j,t} + \alpha_9 \mathrm{COLR}_{i,j,t} + \alpha_{10} \mathrm{CURU}_{i,j,t-1} \\ & + \alpha_{11} \mathrm{RTA}_{i,j,t-1} + \alpha_{12} \mathrm{GD}_{i,t} + \alpha_{13} \mathrm{GD}_{j,t} + \mu_i + \nu_j \\ & + \varepsilon_{i,j,t}, \qquad (1)\end{aligned}$$

where the subscript *i* denotes the importer, the subscript *j* denotes the exporter, *t* denotes year, and the Greek symbols denote the coefficients to be estimated empirically. The dependent variable, $\mathrm{IMPORT}_{i,j,t}$, is the real value of the trade flow from country *j* (the exporter) to country *i* (the importer), as reported by country *i*. There are six independent variables, or key variables of interest. $\mathrm{CD}_{i,t}$ and $\mathrm{CD}_{j,t}$ measure climatic disasters in *i* and *j*, respectively. $\mathrm{PS}_{i,t-1}$ and $\mathrm{PS}_{j,t-1}$ measure the political risks of countries *i* and *j*, respectively, lagged one year. As discussed below, we use the notation PS since in the data source of this variable a larger value indicates less political risk, or more political safety (PS). These four variables are followed by two climatic disasters–political risk interaction terms, for countries *i* and *j*, respectively.

We included the usual control variables. $\mathrm{GDP}_{i,t-1}$, $\mathrm{POP}_{i,t-1}$, $\mathrm{GDP}_{j,t-1}$, and $\mathrm{POP}_{j,t-1}$ are *i*'s and *j*'s real GDP and population size. $\mathrm{DIST}_{i,j,t}$ is the distance between *i* and *j*. $\mathrm{CBORD}_{i,j,t}$, $\mathrm{CLANG}_{i,j,t}$, $\mathrm{CCOL}_{i,j,t}$, $\mathrm{COLR}_{i,j,t}$, $\mathrm{CURU}_{i,j,t-1}$ and $\mathrm{RTA}_{i,j,t-1}$ are set to 1 if *i* and *j* share a common border, language, colonizer or colonial relationship, belong to the same currency union, or belong to the same regional trade agreement, respectively. Otherwise, they are set to 0. To this set, we add geophysical disasters (e.g., earthquakes, volcano eruptions) in *i* and *j*, $\mathrm{GD}_{i,t}$ and $\mathrm{GD}_{j,t}$. Finally, μ_i and ν_j are the country-fixed effect of *i* and *j* (i.e., dummy variables for a country being either the importer or the exporter in a dyad), and $\varepsilon_{i,j,t}$ is a residual term. The inclusion of the country-fixed effects in the model controls for unobservable country attributes, as well as for the presence of a multilateral trade resistance, which is the cost of trade between a country and all of its partners (e.g., Anderson and van Wincoop, 2003). The inclusion of the country-fixed effects may absorb much of the variability in the dependent variable, reducing

[4] Theories presenting competing effects whose relative strength cannot be predetermined are quite common in the social sciences. In our issue area, Skidmore and Toya (2002) and Gassebner et al. (2006) argue that the effect of disasters on the economy can be positive or negative. Other examples include theories studying the effects of democracy on the environment, warfare on the environment, natural resource scarcity on civil war, trade on interstate armed conflict, tax rate on tax revenue, and democracy on economic growth. These examples do not mean to suggest, however, that all of our social science theories cannot predict sign; some can.

the explanatory power of the remaining other variables, but we prefer to take a conservative approach.

PS, GDP, POP, CURU, and RTA may be affected by trade (from hereon, we drop the t, i, and j subscripts in order to simplify the discussion). To mitigate this possible endogeneity, we used the one-year lags of these variables instead of their contemporaneous values. Following Frankel (1997) and others, the idea is that the value of the dependent variable in period t cannot affect the value of the independent variables in period $t-1$, or the present cannot affect the past. DIST, CBORD, CLANG, CCOL, COLR, and CD are exogenous and, therefore, not lagged.

IMPORT is measured by the real dollar value of trade flowing from country j to country i, as reported by i. The trade data came from the World Trade Analyzer (2007). This source provides the data in thousands of current dollars, converting values denominated in foreign currency to dollars by using the monthly market exchange rates (MER). We express these trade data in real terms by deflating them using the U.S. average consumer price index (CPI). The CPI time series was computed by the U.S. Bureau of Labor Statistics (2008) using the average of the price indices in 1982–1984 as the base value.

The data for CD came from the Emergency Events Database (EM-DAT, 2008), as in the relatively small body of literature that statistically examined any macroeconomic facets of natural disasters (e.g., Noy, 2009; Raddatz, 2007; Gassebner et al., 2006; Auffret, 2003; Skidmore and Toya, 2002). EM-DAT collects data from a wide array of national sources that report natural disaster events, including climatic, geophysical, and biological events. To qualify as a disaster, an event must fulfill at least one of the following criteria: (1) 10 or more people are reported killed or missing and assumed dead; (2) 100 or more people are reported affected (require immediate help, including medical treatment, food, water, shelter); (3) The regime asked for external help; or (4) The regime declared a state of emergency.

In compiling CD, we considered several issues. First, we include 10 types of disasters: droughts, extreme temperatures, famines, floods, landslides, waves and surges, wild fires, storms, epidemics, and insect infestations. We included all these disasters because it is reasonable to assume that traders consider the exposure of a country to all climatic disasters, not only to some.

Second, the EM-DAT records the occurrence of disasters per country, and their impacts in terms of the numbers of people killed or affected, and the monetary damages. Using these data records, one may compute the total numbers of disasters, people killed, people affected, and the total damages, per country, during some time period. When the values of these measures are all available, they are highly correlated.

Third, the impact data bring intensity into the picture, but some of the affected and killed observations are not available and about 70% of the damage observations are missing or set to zero. The available impact data may also be overstated, as countries, particularly LDCs, tend to overstate them in order to secure external aid, and are often inaccurate due to inadequate bookkeeping, lack of insurance markets, and poor data collection practices (Albala-Bertrand, 1993b; Skidmore and Toya, 2002, 2007; Kahn, 2005; Raschky, 2008).

Fourth, the compilation of the disaster impact data is lengthy and involves uncertainty and competing assessments, but the occurrence of a disaster is a clear signal that travels relatively fast. It thus seems reasonable to assume that traders may allocate greater importance to the occurrence data than to the impact data, at least in the short term.

Fifth, the impact of disasters in terms of damages and people affected or killed may depend on the economic attributes of a country. Developed countries (DCs) spend more than the LDCs on safety and rescue measures, which reduce the impact of disasters, but they also have more physical assets, which puts more things at harms way.[5] This issue may also apply here since trade and income are correlated and the DCs have larger trade flows than the LDCs. Physical data (e.g., storm speed, wave height) seem better suited to measure intensity, but they are not systematically available and their collection is outside the scope of our study.

In light of these considerations, we decided to compute our measure based on the yearly total number of the abovementioned 10 types of climatic disasters occurring in a country, though Section 5 reports findings obtained from using different disaster measures. In some cases, however, the number of disasters was zero (i.e., there were no disasters), which created a problem since the ln(0) is undefined. One simple solution to this type of a problem involves taking the natural exponent 'e' raised to the power of the total number of disasters. The natural log of this measure returns the number of disasters. Our theory indicates that increases in CD and its interaction with PS can either increase or decrease IMPORT.

The political safety level of a country, PS, is measured by an index compiled by Political Risk Service (PRS) (2008a). The index aggregates 12 scores spanning different ranges, representing their relative contribution to the index, where 0 indicates the lowest score (e.g., maximum government instability): government stability (0–12); socioeconomic conditions fueling public discontent (0–12); investment profile (e.g., contract viability, payment delays, ability to repatriate profits) (0–12); internal conflict (e.g., civil strife) (0–12); external conflict (e.g., war) (0–12); corruption (0–6); military involvement in politics (0–6); religious tension (0–6); law and order (0–6); ethnic tension (0–6); government democratic accountability (0–6); and bureaucracy quality (0–4). The resulting index spans the range 0–100, where 0 denotes maximum risk and a score of 100 denotes no risk (or safety). Since this score rises with safety, we also refer to it as political safety.

The empirical model employs the aggregated PRS index. Similar to the climatic disasters, this reflects our assumption that traders take into account the overall political risk of the country they trade with, not only one or a few of the PRS components. In our sample, the index was never zero, so using the log of this index did not pose a problem. Our theory indicates that an increase in PS can either increase or decrease IMPORT.

The PRS data were used by other studies, although not in the context of climatic disasters (e.g., Hall and Jones, 1999; Long, 2008). Comparing several political risk indices, Oetzel et al. (2001) concluded that the PRS index works the best in predicting risk compared to other political risk data. PRS (2008b) reported that this index was used by 80% of the top companies in the world, as ranked by Fortune Magazine, which makes it all the more attractive for our purpose and for its practical implication.

Turning to the control variables, the data for population (expressed in individuals) and GDP (in dollars) come from the World Bank (2006). GDP is compiled by expressing the nominal GDP in real terms using the U.S. CPI. The data for CBORD, CLANG, CCOL, and COLR come from the Central Intelligence Agency (2006). The data for CURU, RTA, and DIST (expressed in miles) come from Fratianni and Oh (2009). The data for geophysical disasters come from EM-DAT. GD is compiled as 'e' to the power of the number of geophysical disasters in a country, per year (to deal with the zero disaster-problem). The trade gravity theory expects that the coefficients of the GDP terms and the dummy variables will be positive, and those of the two POP terms and DIST will be negative. Our theory implies that the coefficients of the GD terms can be positive or negative.

[5] Aware of this issue, Noy (2009) nevertheless studied the effect of the impact data on the economy, but Raddatz (2007), Gassebner et al. (2006), and Skidmore and Toya (2002) used the number of disasters. Pachakis and Kiremidjian (2004) and Werner et al. (1997) discussed this issue for the effect of seismic events on seaports.

Table 1
Descriptive statistics.

	Mean	Standard deviation	Minimum	Maximum
1. ln(IMPORT$_{ij}$)	9.0069	3.0823	−0.4898	18.5940
2. ln(GDP$_i$)	24.1958	2.0847	18.5628	29.4077
3. ln(GDP$_j$)	24.4026	1.9801	18.5628	29.4077
4. ln(POP$_i$)	16.4879	1.5889	12.3415	20.9701
5. ln(POP$_j$)	16.6000	1.5854	12.3415	20.9701
6. ln(DIST)	8.2003	0.7857	4.3995	9.4215
7. CBORD	0.0272	0.1627	0.0000	1.0000
8. CLANG	0.1945	0.3959	0.0000	1.0000
9. CCOL	0.0583	0.2344	0.0000	1.0000
10. COLR	0.0244	0.1542	0.0000	1.0000
11. CURU	0.0065	0.0804	0.0000	1.0000
12. RTA	0.0298	0.1701	0.0000	1.0000
13. ln(PR$_i$)	4.1589	0.2685	2.5649	4.5486
14. ln(PR$_j$)	4.1759	0.2623	2.5649	4.5486
15. CD$_i$	2.1980	3.9316	0.0000	35.0000
16. CD$_j$	2.3508	4.0416	0.0000	35.0000
17. GD$_i$	0.2748	0.8302	0.0000	11.0000
18. GD$_j$	0.3034	0.8800	0.0000	11.0000

Note: N = 127,270.

5. Empirical results

This section presents the empirical results obtained from the estimation of the basic model presented in Eq. (1). Table 1 shows the mean, standard deviation, minimum, and maximum values obtained for each variable. Table 2 shows the variables' correlation matrix.

The estimation sample includes 116 countries from 1985 to 2003, as dictated by data availability. The number of observations is 127,270, and the countries included in the sample are listed in Appendix B. The estimation employs ordinary least squares (OLS), but to reduce the possibilities of heteroscedasticity and autocorrelation due to the panel data nature of the sample, we compute robust, heteroscedasticity and autocorrelation-consistent standard errors by using the Huber–White estimator with clustering by dyad (e.g., Kennedy, 2003).

Table 3 includes four models. Model 1 and Model 2 add the importer and exporter political safety (risk) scores and climatic

Table 2
Correlation matrix.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.ln(IMPORT$_{ij}$)																	
2. ln(GDP$_i$)	0.401																
3. ln(GDP$_j$)	0.482	−0.263															
4. ln(POP$_i$)	0.252	0.652	−0.126														
5. ln(POP$_j$)	0.270	−0.132	0.635	−0.059													
6. ln(DIST)	−0.211	0.040	0.091	0.078	0.127												
7. CBORD	0.139	0.008	−0.009	0.035	0.024	−0.401											
8. CLANG	0.015	−0.075	−0.093	−0.051	−0.057	−0.135	0.135										
9. CCOL	−0.098	−0.148	−0.165	−0.086	−0.093	−0.101	0.034	0.248									
10. COLR	0.142	0.057	0.045	0.038	0.027	−0.041	0.049	0.220	−0.039								
11. CURU	0.044	−0.012	−0.019	−0.021	−0.023	−0.144	0.084	0.065	0.128	0.002							
12. RTA	0.231	0.085	0.071	0.010	−0.002	−0.332	0.212	0.049	−0.009	0.020	0.193						
13. ln(PS$_i$)	0.189	0.509	−0.176	−0.034	−0.080	0.002	−0.022	−0.04	−0.104	0.026	0.016	0.095					
14. ln(PS$_j$)	0.254	−0.170	0.486	−0.069	−0.090	0.017	−0.033	−0.056	−0.113	0.017	0.011	0.087	−0.056				
15. CD$_i$	0.150	0.411	−0.067	0.584	−0.031	0.124	0.009	0.007	−0.049	−0.001	−0.001	−0.007	0.031	−0.013			
16. CD$_j$	0.160	−0.072	0.408	−0.032	0.598	0.151	0.003	0.002	−0.052	−0.007	−0.004	−0.014	−0.06	−0.004	−0.004		
17. GD$_i$	0.073	0.214	−0.029	0.381	−0.014	0.065	0.016	−0.064	−0.054	−0.018	−0.016	−0.004	−0.067	−0.007	0.375	−0.004	
18. GD$_j$	0.069	−0.039	0.203	−0.021	0.393	0.082	0.010	−0.072	−0.058	−0.022	−0.017	−0.010	−0.010	−0.104	−0.006	0.377	−0.006

Note: N = 127,270.

Table 3
Directional real imports, climatic disasters, and political safety, 1985–2003.

	(1)	(2)	(3)	(4)
ln(Importer's political safety)	0.2618***		0.2515***	0.1604***
	(0.0373)		(0.0373)	(0.0406)
ln(Exporter's political safety)	0.2025***		0.2009***	0.0660†
	(0.0386)		(0.0386)	(0.0424)
Importer's climatic disasters		−0.0273***	−0.0268***	−0.2222***
		(0.0026)	(0.0026)	(0.0371)
Exporter's climatic disasters		−0.0062**	−0.0059**	−0.2694***
		(0.0026)	(0.0026)	(0.0360)
ln(Importer political safety) × importer's climatic disasters				0.0462***
				(0.0087)
ln(Exporter political safety) × exporter's climatic disasters				0.0623***
				(0.0085)
Importer's geophysical disasters	0.0053	0.0034	0.0059	0.0078
	(0.0082)	(0.0082)	(0.0082)	(0.0082)
Exporter's geophysical disasters	0.0216***	0.0199**	0.0223***	0.0247***
	(0.0078)	(0.0078)	(0.0078)	(0.0078)
ln(Importer's real GDP)	0.3509***	0.3740***	0.3555***	0.3558***
	(0.0202)	(0.0201)	(0.0202)	(0.0202)
ln(Exporter's real GDP)	0.3695***	0.3927***	0.3735***	0.3743***
	(0.0205)	(0.0204)	(0.0205)	(0.0205)
ln(Importer's population)	−0.5197***	−0.2956***	−0.4639***	−0.4441***
	(0.0634)	(0.0604)	(0.0640)	(0.0643)
ln(Exporter's population)	−0.2649***	−0.0264	−0.1708**	−0.1360**
	(0.0667)	(0.0636)	(0.0673)	(0.0676)

Table 3 (*Continued*)

	(1)	(2)	(3)	(4)
ln(Distance)	−1.3570***	−1.3551***	−1.3566***	−1.3563***
	(0.0086)	(0.0086)	(0.0086)	(0.0086)
Common border	0.1092***	0.1094***	0.1093***	0.1099***
	(0.0329)	(0.0329)	(0.0329)	(0.0329)
Common language	0.3752***	0.3753***	0.3751***	0.3749***
	(0.0154)	(0.0154)	(0.0154)	(0.0154)
Common colonizer	0.4901***	0.4889***	0.4896***	0.4896***
	(0.0247)	(0.0247)	(0.0247)	(0.0247)
Colonial relationship	1.0620***	1.0629***	1.0624***	1.0627***
	(0.0344)	(0.0344)	(0.0343)	(0.0343)
Currency union	0.1687***	0.1770***	0.1745***	0.1689***
	(0.0618)	(0.0618)	(0.0618)	(0.0618)
Trade agreements	−0.0131	−0.0068	−0.0114	−0.0097
	(0.0318)	(0.0318)	(0.0318)	(0.0318)
Constant	12.8958***	7.3436***	11.2465***	11.0414***
	(1.1264)	(0.9905)	(1.0922)	(1.0937)
N	127,270	127,270	127,270	127,270
R^2	0.7130	0.7131	0.7133	0.7135
Test statistics: χ^2value ($p > \chi^2$)			From (1) 110.4 (0.000)	From (3) 81.5 (0.000)

Note: $^*p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$. Two-tailed test. Country-fixed effects are estimated for all models but are not shown. Robust standard errors clustered per dyad are shown in parentheses.

disaster indices to the standard gravity specification, respectively, Model 3 includes both variables, and Model 4 includes both variables and their interaction terms. Model 3 exhibits the highest average and individual VIFs (1.87 and 3.64, respectively), and the cross correlations in Table 2 are almost always very small. Thus, multicollinearity is not a concern.[6] The R^2 scores for all of the models are about 0.71, suggesting good fitness to the data.[7] Almost all of the variables in Table 3 are statistically significant in a two-tailed test, and their signs are consistent across the models.[8] Taken together, these diagnostics suggest that our modeling platform is statistically sound.

The signs and statistical significance levels obtained for the coefficients of the control variables are consistent across the four models. A rise in geophysical disasters in the importer country does not impact its import, while a rise in geophysical disasters in the exporter country increases this trade flow. The coefficients of the importer's and exporter's GDPs are positive and significant, the coefficients of the populations and distance are negative and significant, and the coefficients of common language, common colonizer, colonial relationship, common border and currency union are positive and significant. These results agree with the theoretically expected effects, further suggesting that our platform is statistically sound.

We now turn to our key variables: climatic disasters, political risk, and their interaction term. In Model 1, the coefficients of the importer's and the exporter's political safety scores are positive and significant, indicating that a rise in safety (less risk) raises the bilateral imports. This finding agrees with the results reported in the studies previously cited, further suggesting that our platform is robust. However, we bring a new aspect, as we show that the overall political risk score of both countries in a dyad determines bilateral trade.

Model 2 excludes the political risk scores and adds the importer's and exporter's climatic disaster indices. The coefficients of these indices are both negative and significant. Thus, countries that exhibit more climatic disasters, and countries whose trade partners exhibit more climatic disasters, both see a decline in their bilateral imports.

Model 3 includes political risk and climatic disasters. A likelihood-ratio test from comparing Model 3 to Model 1 is significant ($\chi^2 = 110.37$). Thus, adding climatic disasters to Model 1 improves the explanatory power, which is in-line with our theory that both political risk and climatic disasters play a role in trade. The results support those obtained for Models 1 and 2. An increase of 1% in the importer's or exporter's safety increases the import by 0.25% and 0.20%, respectively. An additional climatic disaster in the importer or exporter countries reduces the import by 2.68% and 0.59%, respectively (100$\times$ the coefficient).

Auxiliary tests indicate that the effects on trade of political safety and climatic disasters are significantly different for both the importer and exporter countries ($F = 55.74$ and $F = 28.69$, respectively). The effects of the climatic disasters and the geophysical disasters are also significantly different for the importer and exporters sides ($F = 14.31$ and $F = 11.73$, respectively). Thus, if a country experiences both a climatic natural disaster and a geophysical natural disaster in a given year, the combined effect of both disasters is negative, reducing trade.

Model 4 adds the interactions terms between the political risk and climatic disasters variables. A likelihood test from comparing Model 4 to Model 3 is significant ($\chi^2 = 81.57$). Thus, adding the interactions to Model 3 improves the explanatory power, which is in-line with our theory that the disaster–risk interaction plays a role in trade. The coefficients of political safety and climatic disasters are positive and negative, respectively. When no disaster occurs, the marginal effect of political risk is quite small. A rise of 1% in the importer safety raises the import by 0.16%. A rise of 1% in the exporter safety raises the import by 0.06% (significant only at one-tailed test).

The coefficients of the two disaster–risk interaction terms are positive and significant. Thus, the marginal effect of climatic disasters rises with political safety for the importer and exporter, and the marginal effect of political safety rises with climatic disasters. Figs. 1 and 2 present the marginal effects of climatic disasters and political safety as a function of the political safety or

[6] The average VIF score of Model (4) is larger than 10. A closer examination reveals that the average score is solely attributed to the interaction terms included in this model, which cannot be helped.

[7] The rise in R^2 is quite small when the climatic disasters are added to models 2–4 because the country fixed effects soak up a substantial part of the variation in the dependent variable, but, as we show below, the effect of the climatic disasters on trade is both statistically significant and substantive.

[8] We could have employed one-tailed tests in the interpretation of the test results, as the effects of the changes in the control variables are theoretically signed, and testing the effects of political safety and climatic disasters can be understood as choosing among theories that expect a certain sign. However, we decided to take a more conservative approach and use two-tailed tests.

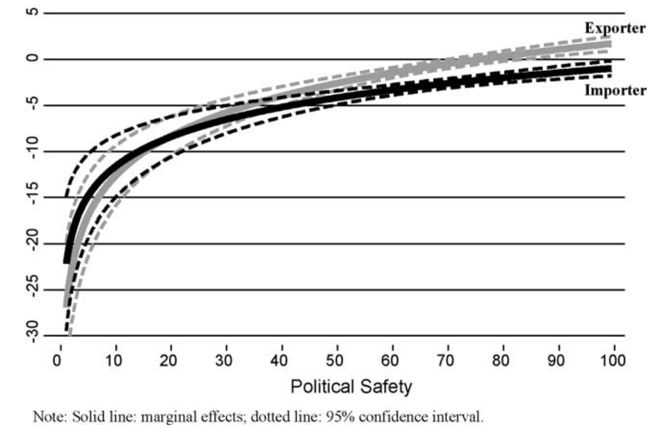

Fig. 1. The marginal effect of climatic disasters as a function of political safety. *Note*: Solid line: marginal effects; dotted line: 95% confidence interval.

climatic disasters variables, respectively. The points along each graphs show how the marginal effect of one variable changes as the other variable changes. The respective 95% confidence intervals show that the marginal effects are always statistically significantly different from zero, except when the political safety score is in the range 70–82 in Fig. 1.

Fig. 1 indicates that climatic disasters are less detrimental to bilateral trade as a country becomes politically safer (or its political risk falls). The marginal effect of a climatic disaster hitting the importer rises by about 10 percentage points when its political safety rises from the lowest value in the sample (13) to its highest value (94.5); for the highest safety in the sample, the effect is −2%. The marginal effect of a climatic disaster hitting the exporter rises by 14 percentage points when its political safety rises from the sample's minimum to the maximum. When the exporter's political safety rises above 77, the marginal effect of a climatic disaster hitting the exporter becomes positive; for the highest safety in the sample, the effect is 2%.

Fig. 2 indicates that a unit decline in the political risk of a country (or a unit rise in safety) has a greater positive effect on the bilateral trade as the number of climatic disasters hitting the importer or the exporter increases. When the number of climatic disasters rises from its smallest value in the sample (0) to its highest value (35), the marginal effect of political safety on the bilateral trade rises from about 0.2% to 1.75% when the disasters hit the importer and from about 0.1% to 2.25% when the disasters hit the exporter.

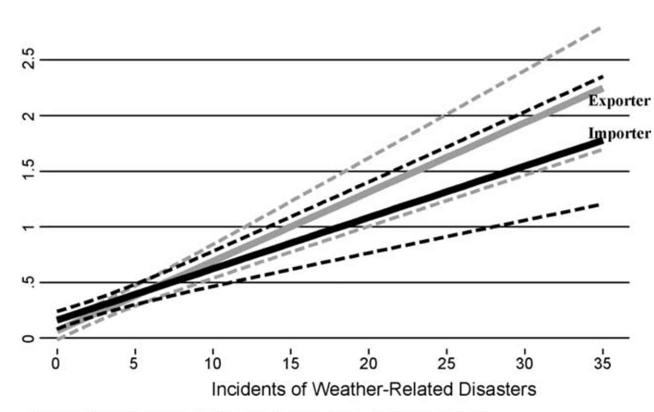

Fig. 2. The marginal effect of political safety as a function of climatic disasters. *Note*: Solid line: marginal effects; dotted line: 95% confidence interval.

6. Additional analyses

This section summarizes findings from additional analyses based on Model 4 in Table 3 (the detailed findings are reported in Appendix A). First, Table 3 used the importer- and exporter-specific fixed effects, not the dyad-specific effects, since the latter model cannot infer the effects of dyadic variables that do not change over time (e.g., distance). Having verified that our model generated the expected results for these variables, Model 1, Appendix A replaced the country-fixed effects with dyad-specific fixed effects (e.g., Glick and Rose, 2002). The results were consistent with those reported in Model 4, Table 3.

Second, Model 4, Table 3 examined the level of bilateral trade based on the trade gravity model. We now include a model of first differences to examine changes in trade using the trade gravity model. This model cannot examine variables that do not change over time, but it may be more efficient and less sensitive than the level model to the possibility of a unit root in the trade or the GDP data (e.g., Baier and Bergstrand, 2007). The results for Model 2, Appendix A were consistent with those reported for Model 4, Table 3 except that the positive coefficients of the exporter PS and the importer interaction term were significant at the one-tail test 0.1 level.

Third, Model 4, Table 3 included interaction terms between disasters and political risk because these factors are our two key explanatory variables in this paper. Model 3, Appendix A examined if the basic results hold when the model includes interaction terms between the climatic disasters and all the variables. The results were consistent with those reported in Table 3, except that the positive coefficient of the exporter political safety was significant at the one test .452 level, and the positive coefficient of the importer interaction term was significant at the one-tail test 0.1 level.[9]

Fourth, the waves and surges component of CD includes the non-climatic tsunamis. This is not necessarily problematic for our purpose, as the lessons of natural disasters that flood coastal systems apply to climate change (IPCC, 2007b). In this vein, Benoist (2007) employs the example of the 2004 tsunami in Southeast Asia in his evaluation of the expected impacts of climate change on personal insurance. Some scientists also expect that climate change will worsen the impacts of tsunamis by raising the sea level on which they occur (e.g., China View, 2005; de la Vega-Leinert and Nicholls, 2008; Sky News, 2004). Model 4, Appendix A excluded tsunamis from CD and added them to GD. The results were consistent with those reported in Model 4, Table 3, except that the positive coefficient of the exporter PS was significant at the one-tail test 0.131 level.

Fifth, Model 4, Table 3 compiled CD and GD as 'e' to the power of the incidents to deal with the ln(0) problem. One may use the ln(incidents + z) to deal with this problem, where $z > 0$. This method replaces the zero disaster cells with z, and the results may change depending on z. It is also worth noting that under this measure, the net effect of the next disaster on trade falls as the incidents rise, whereas our basic measure assumes the net effect remains the same. Following Skidmore and Toya (2002), we set z to 1. The results for Model 5, Appendix A were consistent with those reported for Model 4, Table 3, except that the negative coefficient of the importer CD was significant at the one-tail test 0.116 level, and the positive coefficient of the importer interaction term was significant at the one-tail test 0.326 level. We got similar results for the ln(incidents + 0.5, or +0.1) though other possibilities, of course, also exist.

[9] The lower significance likely reflects the much larger number of variables now in the model, which soaks up more of the variation in the dependent variables. To save space, we reported only the interactions included in Table 3.

Sixth, recalling our discussion in Section 4, we used the number of disaster victims in a country per year, defined as the sum of the number of people affected and killed by the disaster, for both the climatic disasters and the geophysical disasters variables. This measure accounts for differences in disaster strength, though it may exhibit the limitations discussed in Section 4. The results for Model 6, Appendix A were consistent with those presented for Model 4, Table 3.

Seventh, we used the log of the average of real import and export values in a dyad as a dependent variable (e.g., Frankel, 1997). This model is given by the following equation:

$$\begin{aligned}\ln \mathrm{TRADE}_{i,j,t} = {} & \gamma_0 + \lambda_1 \ln(\mathrm{CD}_{i,j,t}) + \lambda_2 \ln(\mathrm{PS}_{i,j,t-1}) + \lambda_3 \ln(\mathrm{PS}_{i,j,t-1}) \\ & \times \mathrm{CD}_{i,j,t} + \gamma_1 \ln(\mathrm{GDP}_{i,j,t-1}) + \gamma_2 \ln(\mathrm{POP}_{i,j,t-1}) \\ & + \gamma_3 \ln(\mathrm{DIST}_{i,j,t}) + \gamma_4 \mathrm{CBORD}_{i,j,t} + \gamma_5 \mathrm{CLANG}_{i,j,t} \\ & + \gamma_6 \mathrm{CCOL}_{i,j,t} + \gamma_7 \mathrm{COLR}_{i,j,t} + \gamma_8 \mathrm{CURU}_{i,j,t-1} \\ & + \gamma_9 \mathrm{RTA}_{i,j,t-1} + \gamma_{10} \mathrm{GD}_{i,j,t} + \mu_i + \nu_j + \varepsilon_{i,j,t}, \qquad (2)\end{aligned}$$

where TRADE is the average of the real imports of i from j and the real export of i to j, CD is the sum of the numbers of climatic disasters in i and j, PS is the product of the political risk scores of i and j, GD is the sum of the numbers of geophysical disasters in i and j, and the other variables in are as in Eq. (1). The sample included the same countries and years as in Table 3, though there were fewer observations since (2) did not distinguish between importers and exporters. The results for Model 7, Appendix A were consistent with those for Model 4, Table 3.[10]

7. Conclusion

This paper studies the effects of climatic disasters and political risk on trade. In the empirical analysis, we estimated statistical models for a large-N sample of countries and years.

Summarizing our key results, an increase in climatic disasters or political risk, for either the importer or exporter countries, reduces their bilateral trade. Countries whose political risk declines (become safer) see a smaller decrease in their trade flows when hit by more disasters. Countries hit by more disasters see an increasingly larger decline in their trade when their political risk increases. These results held in a number of additional analyses that employed different model specifications, disaster measures, and estimators.

Our findings are based on our epistemology and data. While valuable, we think our study could be extended in a number of ways. While we used total trade, future research may seek to discover if some traded goods are more affected by disasters and political risk than others. Other extensions may carry the analysis to other aspects of globalization.

Taking a broader view, recall that projections of the global science suggest more frequent and stronger climatic disasters in the future as climate change progresses. Assuming that the past may tell us something about the future, our results may inform us about the possible effect of climate change-induced natural disasters on trade in the longer term, in the absence of adaptation and mitigation effort.

First, as climate change progresses in the coming decades, trade may decline over time. The impact may spill into the macroeconomy of many countries due to the critical role of international trade in the global system. Second, economic logic and empirical findings suggest that trade allows the world economy to better withstand adverse shocks such as natural disasters, enabling countries to help each other by providing goods and aid during emergencies and facilitating recovery efforts (e.g., Reilly et al., 1994; Strömberg, 2007; Noy, 2009). The expected decline in trade due to more climatic disasters as climate change progresses may reduce the resilience of the world economy to climate change in the longer run.

Third, some officials and analysts expect that the climate change-induced environmental decline may lead to more intrastate and even interstate armed conflict in the longer run. Examples include the Schwartz and Randall (2003) report, which was apparently commissioned by the U.S. Department of Defense (New York Times, 2004), and the assessments of the former U.S. Army Chief of Staff General Sullivan, Commander-in-Chief of the Central Command General Zinni and other former generals and admirals (CNA, 2007), the former U.S. Vice President Al Gore (2007), the IPCC (2007b, Ch. 8, 10, 19), and Reuveny (2007). Our results suggest that the implied rise in political risk will compound the adverse effect of climatic disasters on trade. The impact may be largest in LDCs, as they are expected to be more adversely affected by climate change, but the upshot may be felt globally, as many LDCs export key natural resources.

These effects assumed business as usual, but a series of increasingly stronger and more frequent climatic disasters may lead to longer run adaptation in order to alleviate the growing adverse effect. For example, Kahn (2003) attributes the decline in the average number of people killed by climatic disasters between 1970 and 2001 to better infrastructure, early warning systems, and health care services. In this vein, technological improvements such as building levees to defend ports and other transportation infrastructures against floods and storms, stockpiling goods, or relocating industrial facilities producing for export to safer areas can reduce the vulnerability of trade to climatic disasters. As another example, countries may work to reduce their political risk in order to alleviate the adverse effect of climatic disasters on their trade flows.[11]

The international community may promote climate change adaptation by developing specialized international insurance programs to cover damages caused by climatic disasters. The basic idea has been around for some time. For example, in 1991 the Alliance of Small Island States (AOSIS) called to create a fund financed by the DCs to cover low-lying LDCs from losses due to sea level rise (Bals et al., 2005). This proposal can be readily expanded to cover losses caused by climatic disasters. Similarly, the DCs may expand the Exogenous Shock Facility (ESF), created by the International Monetary Fund in 2005 to help LDCs facing external shocks (IMF, 2009). The Munich Climate Change Insurance Initiative (MCII), a private–public proposal launched by the Munich Re insurance firm in 2005, may eventually sell climatic disaster insurance to countries (MCII, 2009).

Adaptation, however, may not suffice to alleviate the problem, and its effectiveness may vary across countries, depending on factors such as the level of development, the quality of institutions, and the availability and size of foreign aid. Thus, the problem may also require mitigation of climate change. For example, public policy can cap greenhouse gasses and penalize excessive emitters. This effort will be most effective if it will be globally coordinated. Attempts to mitigate climate change through a concerted global effort have so far failed. One obstacle to action has been the refusal of the U.S. to curb its greenhouse emissions. Today, the U.S. seems more eager to act, suggesting that the time may be ripe to strike a

[10] One may argue that epidemics, insect infestations and landslides, which we count as climatic disasters, are not directly related to climate, though the projections of the global science suggest a rise in these events as climate change progresses (IPCC, 2007a,b). Excluding these disasters, the results for Model 4, Table 3 essentially did not change.

[11] Once a decision to adapt is made, one needs to choose an implementation strategy. For example, Hallegatte (2009) suggested choosing strategies used to evaluate possible R&D outcomes, including "no-regret" methods, reversible and flexible methods, safety margin designs, soft- and long-term adaptation, and decision time horizon reductions.

global deal. The private sector may play a positive role in this deal as firms can opt to cap their greenhouse emissions beyond the limits set by public policy. This approach may be profitable because public demand for "greener" goods may rise as climate change progresses.

To be sure, efforts to mitigate climate change will be costly and may not go into full effect any time soon. However, a phased implementation might also make a difference for international trade flows, as it may slow down the rate of climate change and therefore the increase in the frequency and scope of climatic disasters. While climate change may turn out to be a smaller problem in the future than is currently expected, the converse of this outcome is also possible. Thus, a do nothing-approach may eventually prove to be unwise. As the saying goes, it is better to be safe than sorry.

Appendix A. Additional analyses, 1985–2003

	Dyad fixed effects (1)	First difference (2)	All interactions[a] (3)	CD without Tsunamis[b] (4)	Using ln(CD + 1) (5)	Number of victims[c] (6)	Bilateral trade[d] (7)
ln(Importer PS)	0.2133***	0.4123***	0.2348***	0.1599***	0.2516***	0.2476***	
	(0.0453)	(0.0576)	(0.0427)	(0.0495)	(0.0446)	(0.0462)	
ln(Exporter PS)	0.1890***	0.0760	0.0054	0.0658	0.0847*	0.1634***	
	(0.0547)	(0.0602)	(0.0447)	(0.0586)	(0.0468)	(0.0533)	
ln(Dyadic PS)							0.1844***
							(0.0435)
Importer CD	−0.1991***	−0.0750**	−0.3108***	−0.2227***	−0.1626	−0.0016*	
	(0.0390)	(0.0367)	(0.0501)	(0.0423)	(0.1357)	(0.0009)	
Exporter CD	−0.2574***	−0.1434***	−0.4440***	−0.2696***	−0.6493***	−0.0096***	
	(0.0381)	(0.0364)	(0.0492)	(0.0401)	(0.1362)	(0.0007)	
Dyadic CD							−0.1048**
							(0.0487)
ln(Importer PS) × importer CD	0.0409***	0.0126†	0.0159†	0.0463***	0.0147	0.0004*	
	(0.0091)	(0.0087)	(0.0108)	(0.0099)	(0.0325)	(0.0002)	
ln(Exporter PS) × exporter CD	0.0591***	0.0318***	0.0982***	0.0623***	0.1452***	0.0024***	
	(0.0088)	(0.0086)	(0.0104)	(0.0093)	(0.0325)	(0.0002)	
ln(Dyadic PS) × dyadic CD							0.0111*
							(0.0058)
Importer GD	0.0055	0.0035	−0.0030	0.0084	−0.0212	−0.0003	
	(0.0066)	(0.0059)	(0.0114)	(0.0072)	(0.0186)	(0.0007)	
Exporter GD	0.0233***	−0.0278***	−0.0171†	0.0251***	0.0174	0.0027***	
	(0.0062)	(0.0056)	(0.0109)	(0.0067)	(0.0180)	(0.0004)	
Dyadic GD							0.0241***
							(0.0050)
ln(Importer GDP)	0.4017***	0.5982***	0.3440***	0.3556***	0.3482***	0.3493***	
	(0.0232)	(0.0339)	(0.0204)	(0.0249)	(0.0202)	(0.0249)	
ln(Exporter GDP)	0.3368***	0.0102	0.3705***	0.3741***	0.3718***	0.3552***	
	(0.0236)	(0.0340)	(0.0207)	(0.0257)	(0.0205)	(0.0257)	
ln(Importer GDP × exporter GDP)							0.3327***
							(0.0197)
ln(Importer POP)	−0.1892**	1.2437***	−0.4019***	−0.4441***	−0.4528***	−0.5321***	
	(0.0797)	(0.3856)	(0.0646)	(0.0849)	(0.0647)	(0.0837)	
ln(Exporter POP)	0.0206	4.5225***	−0.1739**	−0.1360†	−0.1257*	−0.2766***	
	(0.0963)	(0.4493)	(0.0679)	(0.1020)	(0.0679)	(0.1004)	
ln(Importer POP × importer POP)							−0.0813†
							(0.0604)
ln(Distance)			−1.3812***	−1.3563***	−1.3561***	−1.3568***	−1.3662***
			(0.0106)	(0.0259)	(0.0086)	(0.0259)	(0.0281)
Common border			0.2330***	0.1099	0.1095***	0.1096	0.2184*
			(0.0413)	(0.1246)	(0.0329)	(0.1246)	(0.1141)
Common language			0.3472***	0.3749***	0.3751***	0.3754***	0.3576***
			(0.0186)	(0.0464)	(0.0154)	(0.0464)	(0.0459)
Common colonizer			0.5452***	0.4896***	0.4894***	0.4909***	0.6070***
			(0.0302)	(0.0763)	(0.0247)	(0.0763)	(0.0768)
Colonial relationship			1.1750***	1.0627***	1.0626***	1.0611***	0.9299***
			(0.0437)	(0.1089)	(0.0343)	(0.1089)	(0.0937)
Currency union	−0.1654**	−0.0309	0.3582***	0.1689	0.1764***	0.1710	0.3777**
	(0.0649)	(0.1619)	(0.0742)	(0.1639)	(0.0618)	(0.1643)	(0.1641)
Trade agreements	0.1460***	0.1169	−0.1465***	−0.0097	−0.0095	−0.0110	0.3311***
	(0.0524)	(0.1241)	(0.0403)	(0.1115)	(0.0318)	(0.1114)	(0.1081)
Constant	−7.7549***	−0.4710**	10.3784***	11.0554***	10.8752***	13.4480***	5.8251***
	(1.5130)	(0.2007)	(1.1613)	(1.7146)	(1.0924)	(1.7976)	(1.9469)
N	127,270	127,270	127,270	127,270	127,270	127,270	68,579
R^2	0.4894	0.0084	0.7141	0.7135	0.7133	0.7137	0.7863

Note: CD: climatic disasters; GD: geophysical disasters; PS: political safety; GDP: real GDP; POP: population. * $p < 0.1$; ** if $p < 0.05$; *** if $p < 0.01$; two-tailed. † $p < 0.1$; one-tailed. Country-fixed effects (Models 2–7) and dyad fixed effects (Model 1) estimated but not shown. Robust standard errors clustered per dyad are shown in parentheses. (a) Interactions between disasters and all the controls estimated, but not shown. (b) Tsunamis are excluded from climatic disasters but included in geophysical disasters. (c) victims = number killed + number affected. (d) Dyadic PS = importer PS × exporter PS. Dyadic CD = importer CD + exporter CD. Dyadic GD = importer GD + exporter GD.

Appendix B. Country list

North America	Sub-Saharan Africa	Middle East and North Africa	Eastern Asia
Canada	Angola	Algeria	China
Mexico	Burkina Faso	Bahrain	Hong Kong
USA	Cameroon	Cyprus	Japan
	Congo	Egypt	Republic of Korea
Central America and Caribbean	Congo, Dem. Rep.	Iran	Mongolia
Bahamas	Cote d'Ivoire	Iraq	
Costa Rica	Ethiopia	Israel	**Western Europe**
Dominican Republic	Gabon	Jordan	Austria
El Salvador	Gambia	Kuwait	Belgium-Luxemburg
Guatemala	Ghana	Libya	Denmark
Guyana	Guinea	Morocco	Finland
Haiti	Guinea-Bissau	Oman	France
Honduras	Kenya	Saudi Arabia	Germany
Jamaica	Liberia	Syria	Greece
Nicaragua	Madagascar	Tunisia	Iceland
Panama	Malawi	Turkey	Ireland
Suriname	Mali	United Arab Emirates	Italy
Trinidad and Tobago	Mozambique		Malta
	Niger	**Australia and Pacific Islands**	Netherlands
South America	Nigeria	Australia	Norway
Argentina	Senegal	New Zealand	Portugal
Bolivia	Sierra Leone	Papua N. Guinea	Spain
Brazil	Somalia		Sweden
Chile	South Africa	**South East Asia**	Switzerland
Colombia	Sudan	Indonesia	UK
Ecuador	Tanzania	Malaysia	
Paraguay	Togo	Philippines	**Eastern Europe**
Peru	Uganda	Singapore	Albania
Uruguay	Yemen	Thailand	Bulgaria
Venezuela	Zambia	Vietnam	Former USSR
	Zimbabwe	Bangladesh	Hungary
		India	Poland
		Pakistan	Romania
		Sri Lanka	

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