Nat. Hazards Earth Syst. Sci. Discuss., 3, 2003–2023, 2015
www.nat-hazards-earth-syst-sci-discuss.net/3/2003/2015/
doi:10.5194/nhessd-3-2003-2015


Natural Hazards and Earth System Sciences
Open Access
Discussions



# The asymmetric impact of natural disasters on China's bilateral trade

**Y. Meng[1,2], P. Shi[1,2], S. Yang[1,2], and C. C. Jeager[2,3]**

[1]State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Beijing 100875, China
[2]Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs & Ministry of Education, Beijing 100875, China
[3]Global Climate Forum, 10178 Berlin, Germany

Received: 6 January 2015 – Accepted: 8 March 2015 – Published: 25 March 2015

Correspondence to: P. Shi (spj@bnu.edu.cn)

Published by Copernicus Publications on behalf of the European Geosciences Union.

## Abstract

Globalization and technological revolutions are making the world more interconnected. International trade is one of the major approaches linking the world. Since the 2011 Tohoku earthquake and tsunami in Japan shocked the global supply chain, more attention has been paid to the global impact of large-scale disasters. China is the second largest trader in the world and faces the most frequent natural disasters. Therefore, this study proposes a gravity model for China's bilateral trade tailored to national circumstances, and estimates the impact of natural disasters in China and trading partner countries on Chinese imports and exports. We analyzed Chinese and trading partner statistical data from 1980 to 2012. Study results show that: (1) China's natural disasters have a positive impact on imports, but have no significant impact on exports, (2) trading partner countries' natural disasters reduce Chinese imports and exports, (3) both development level and land area of the partners are important in determining the intensity of natural disaster impacts on China's bilateral trade. The above findings suggest that the impact of natural disasters on trade is asymmetric and significantly affected by other factors, which demand further study.

## 1 Introduction

Globalization and technological revolutions are changing traditional ways of life. Today there is a worldwide exchange of people, goods, money, information, and ideas, which have formed complex global networks and produced many new opportunities, services and benefits for humanity. At the same time, the underlying networks have created pathways along which dangerous and damaging events can spread rapidly and globally (Helbing, 2013). The increasing numbers of international trade flows are undoubtedly an important part of these networks.

Natural disasters, especially large-scale ones, are becoming severe challenges for human society and development. According to historical records, the average number of people affected by natural disasters rose from about 25 million per year in the 1960s to 300 million since 2000 (Guha-Sapir et al., 2013). The effects of large-scale disasters (LSDs) are increasing on the global scale. For instance, the WTO (WTO, 2012) claimed that the 2011 Tohoku earthquake and tsunami in Japan and flooding in Thailand contributed to below average growth in international trade in 2011, because of the damage to global supply chains, especially the electric, semiconductor and automaker chains. An extreme event has effects in every corner of the world. The global impact of LSDs demands global countermeasures for their risk governance (Shi et al., 2011).

Research on the economic impact of disasters is generally categorized into two approaches. One approach, case studies, focus on direct/indirect loss of an actual disaster. There are several widely used models, including before-and-after macroeconomic (Albalabertrand, 1993), input–output (IO) model (Okuyama and Santos, 2014; Akhtar and Santos, 2013; Rose and Wei, 2012; Lin et al., 2012; Haimes et al., 2005; Rose et al., 1997), and general equilibrium models (Xie et al., 2014; Rose et al., 2007). The other approach uses multi-country/disaster statistics models from a macroscopic viewpoint, using econometric statistical models to analyze the impact of per capita income (Kahn, 2005), education attainment, trade openness (Toya and Skidmore, 2007), investment climate (Raschky, 2008), and others on disaster effects. Also analyzed are the effects of disasters on regional economic development (Noy, 2009) and consumption (Auffret and Turk, 2003).

However, research on disaster impacts on regional trade is rare. Gassebner et al. (2006) quantitatively estimated these impacts on international trade at global scale. They found that disasters reduced trade in both exporter and importer countries. Oh and Reuveny (2010) examined the impact of climatic disasters and political risk on international trade from the standpoint of global climate change. They also found that an increase in climatic disasters in either importer or exporter countries reduced their bilateral trade. Both the aforementioned studies used gravity models of global trade. They concluded that disasters had negative impacts on bilateral trade, but neglected regional diversity. The latter means that the impact of a disaster varies significantly by region of the world. Ando et al. (2012) examined the impact of two crises, the 2009 global financial crisis and 2011 Tohoku Earthquake, on Japanese exports from the viewpoint of domestic and international machinery production network. Li et al. (2014) compared the impacts of these two crises on the exports out of Japan to China from the angle of multi-industry trade. Both studies compared intensities and durations of the impacts, which revealed a part of the impact of external shocks on China's bilateral trade, but not the full picture.

According to leading exporters and importers of merchandise trade in 2012 as listed by the WTO (WTO, 2013), the import value of China in 2012 was 1.814 trillion USD, which makes it the second largest importer after the United States. China is the largest exporter, with export value for 2012 of 2.049 trillion USD. There is no denying that China is extremely important in the network of international trade. It is also the country affected by the most natural disasters over the last decade, followed by the United States, Philippines, India, and Indonesia (Guha-Sapir et al., 2013). China has a vast, diverse landscape and the largest population in the world. It is at the intersection of two of the world's major natural disaster zones, the Pacific Rim and mid–northern latitude zones. Therefore, various hazards, complex environments, and rapid economic growth caused by reform and opening-up policies further complicate the assessment of the impact of natural disasters on China's bilateral trade.

Do natural disasters have significant impact on China's bilateral trade? Are the effects of disasters in China the same as those outside China? This study proposes a trade gravity model based on the national situation, introduces a natural disaster variable, and quantitatively estimates the impact of those disasters on the nation's imports and exports to answer those two key questions.





NHESSD
3, 2003–2023, 2015

## 2 Gravity model

### 2.1 Theory

From a global perspective, natural disasters have negative trade effects (Oh and Reuveny, 2010; Gassebner et al., 2006). However, if we focus on a specific country or region, the result may be totally different. Figure 1 shows interactions between trade system and disasters. We assume three regions, A, B and C. Region B has trade relationships with both A and C. Each region consists of four components, production ($P$), demand ($D$), import ($I$) and export ($E$). The three regions are in an equilibrium state with these four components, and disasters are external shocks to them.

When a disaster strikes region A, it may damage infrastructure, production equipment, and cause loss of life, thus directly reducing production. The production of region A, $P_A$, links with three components, $E_A$, $I_A$ and $D_A$. Starting from $E_A$, the fall of $P_A$ may lead to a drop in $E_A$ and shrink imports of region B. Region B may increase domestic production or import more from region C. Regarding $I_A$, the fall of $P_A$ may lead to the decline of $I_A$, which means that the intermediate demand of A from B may decrease and the exports from region B will decrease. Finally, for $D_A$, the flow from $P_A$ to $D_A$ decreases while $D_A$ remains constant. To meet the demand of region A, $I_A$ should be increased, which results in increasing exports from region B.

The above impacts are all triggered by the fall of $P_A$. However, the disaster may also have impacts on $D_A$; it may increase $D_A$ because of reconstruction needs, which may increase $P_A$, $I_A$, or both. The disaster may also reduce $D_A$ by exhausting people and reducing their willingness to engage in normal economic activities, such as consumption. When $D_A$ decreases, $P_A$ and $I_A$ may automatically decrease but, in such a case, the decrease in $P_A$ will not ripple to $E_A$.

The dashed arrow in Fig. 1 between *Disasters* and $D_A$ is a double arrow. This indicates that the trade can have feedbacks to the disaster through the demand side. If the post-disaster demand can be met by increase of $I_A$, reconstruction and lives of the people in a disaster area can benefit from the trade. In other words, regional trade makes the regional economic system resilient to disasters.

Disaster in region A may also contribute directly to variations of bilateral trade between regions B and A. Region A may choose policies aimed at increasing its bilateral trade flows. For instance, reconstruction efforts for damaged infrastructure in that region may rely on imports of materials, technology, and skills. External aid may intensify this effect by providing foreign currency. Seeking to rebuild areas affected by the disaster, the region may increase exports to obtain foreign currency and even liberalize its export and import markets, which will likely further promote its trade flows. However, direct negative impacts of the disaster in region A may increase the cost and risk of trade. Consequently, traders in region B are likely to exit markets of region A or reduce trade flow.

The contradictory effects of natural disasters on trade can lead to various combined effects in different countries and regions, and some of those effects are mainly driven by positive ones, and some mainly driven by negative ones. These combined effects can be estimated by empirical analysis. The trade gravity model is one of the most widely used methods, which is analogized from the law of universal gravitation and can estimate the impacts of various factors on trade.

The basic form of this model is

$$\mathrm{Trade}_{ij} = C \times \frac{\mathrm{GDP}_i \mathrm{GDP}_j}{D_{ij}} \tag{1}$$

That is, bilateral trade flow ($\mathrm{Trade}_{ij}$) is in proportion to gross domestic product ($\mathrm{GDP}_i, \mathrm{GDP}_j$) of two countries ($i, j$) and in inverse proportion to the distance ($D_{ij}$) between them. Other factors that impact bilateral trade can be introduced to this model, such as population, tariffs, exchange rates, language, common borders, colonial relationships, and regional free trade. In this way, the gravity model can give reasonable explanations of impacts of various factors on bilateral trade.





NHESSD
3, 2003–2023, 2015

### 2.2 Model, variables and data

In research into trade gravity models, widely used variables are institutional, such as tariffs, laws and political risks, geographic variables like boundaries, lands and oceans, and social variables like language, history and culture. However, the present study focuses on impacts of disasters on bilateral trade of China, and its national situation is taken into account. Variables such as population, Asia–Pacific Economic Cooperation (APEC), World Trade Organization (WTO), borders, and disasters are incorporated in the basic trade gravity model. Undoubtedly, the population problem is a great challenge for China's social and economic development. APEC is the most important economic cooperation organization that the country has joined. The WTO has significant impact on its member countries. A common border can reduce trade cost significantly. It is widely accepted that developed countries are more resilient to natural disasters; however, whether trade between them and China is also more resilient is inconclusive. In addition, Gassebner et al. (2006) claims that the physical size of a country appears to play a role in terms of natural disaster trade effects. Consequently, our model is built as

$$\begin{aligned} \ln Y_{it} = {} & \alpha_0 + \alpha_1 \ln(\mathrm{GDP}_t) + \alpha_2 \ln(\mathrm{GDP}_{it}) + \alpha_3 \ln(\mathrm{Dist}_{it}) + \alpha_4 \ln(\mathrm{Pop}_t) + \alpha_5 \ln(\mathrm{Pop}_{it}) \\ & + \alpha_6 \ln(\mathrm{Disa}_t) + \alpha_7 \ln(\mathrm{Disa}_{it}) + \alpha_8 \ln(\mathrm{Disa}_{it}) \times \mathrm{Developed}_i + \alpha_9 \ln(\mathrm{Disa}_{it}) \\ & \times \ln(\mathrm{Area}_{it}) + \alpha_{10}\mathrm{APEC}_{it} + \alpha_{11}\mathrm{WTO}_{it} + \alpha_{12}\mathrm{Bd}_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

Here, subscript $i$ denotes the trading partner of China, $t$ the year, and Greek symbols coefficients to be estimated empirically. The dependent variable $Y_{it}$ is the real value of trade flow between country $i$ and China. If $Y$ designates the import value of China from country $i$, Eq. (2) represents the Chinese import model; if $Y$ is instead its export value to country $i$, Eq. (2) represents the export model. $\mathrm{GDP}_t$, $\mathrm{Pop}_t$, $\mathrm{GDP}_{it}$ and $\mathrm{Pop}_{it}$ are China's and $i$'s real GDP and population size in year $t$. $\mathrm{Dist}_{it}$ is the distance between China and $i$. $\mathrm{Disa}_t$ and $\mathrm{Disa}_{it}$ measure natural disasters in China and $i$ during $t$, respectively. $\mathrm{Area}_{it}$ is the land area of $i$ in $t$. $\mathrm{Developed}_i$ is set to 1 if $i$ is a developed country, and $\mathrm{APEC}_{it}$, $\mathrm{WTO}_{it}$ and $\mathrm{Bd}_{it}$ are set to 1 if China and $i$ belong to APEC, WTO, or share a common border in $t$. Otherwise, they are set to 0. Finally, $\varepsilon_{it}$ is a residual term.

In the classical trade gravity model, only countries having bilateral trade relationships are incorporated in the sample. There are countries with no bilateral relationship with China or only a unilateral trade relationship. This means the trade flows between China and other countries may be zero, which poses a problem for the log-linearization gravity model, since ln(0) is undefined. Therefore, the present study ignores zero trade flow and only takes non-zero flow country pair data into the sample, which were used to estimate the coefficients in Eq. (2).

Trade data were from the Direction of Trade Statistics of the International Monetary Fund. This source provides data in millions of current USD. Data of GDP (in million USD), population (in million) and land area (in $km^2$) were from the World Bank. Distance between two countries (in km) was represented by that between two corresponding most populous cities. The list of developed countries was from the Central Intelligence Agency's World Fact Book. The data of trade and GDP are deflated using the US GDP deflator from the World Bank.

Data on natural disasters were from the Emergency Events Database (EM-DAT) maintained by the Centre for Research on the Epidemiology of Disasters (CRED) of the Catholic University of Louvain (Guha-Sapir et al., 2013). EM-DAT contains data from a wide array of national sources that report natural disaster events, including geophysical, meteorological, hydrological, climatological and biological. For a disaster to be entered into the database, at least one of the following criteria must be fulfilled: (1) 10 or more reported fatalities, (2) 100 or more affected, (3) declaration of a state of emergency, (4) a call for international assistance. Technological disasters, like industrial and transport accidents, are also included in EM-DATA, which are not within the scope of this study.

There are several ways to describe the impact intensity of natural disasters, including occurrence, number of people killed or affected, and monetary cost. However, some of the data on fatalities and those affected were unavailable, as was the case for damage





NHESSD
3, 2003–2023, 2015

data. Worse, observation data always involve uncertainty and competing assessments, whereas disaster occurrence is very clear. In light of the above considerations, we measured natural disasters based on their annual total number in a country, as did Gassebner and Oh (Oh and Reuveny, 2010; Gassebner et al., 2006). In some cases, however, there were no disasters (zero number), which also causes the ln(0) problem. One simple solution to this problem is adding 1 to the disaster count.

## 3 Results and analysis

Coefficients of variables were estimated by stepwise regression for the sake of coping with the multicollinearity problem. The results of import models of China are shown in Table 1. Model 2 adds natural disaster indices on the basis of Model 1, which is the standard gravity model for China's imports. Model 3 adds an interaction term between exporter disasters and development levels and Model 4 adds such a term between exporter disaster and land area. Model 5 includes disasters and both interaction terms. In the estimation, sample sizes were 4553, and $R^2$ values were all about 0.69, suggesting a good fit of the sample. In addition, signs and values of coefficients were consistent across the models, and all variables had statistical significances exceeding the 0.1 level. Taken together, these diagnostics suggest that our modeling platform is robust and statistically reliable.

Results of the export models of China are shown in Table 2. Models 6–10 had the same compositions of variables as the five models shown in Table 1, except that China was the exporter and its partner the importer. Sample sizes were 5170 and $R^2$ all about 0.82, suggesting an even better fit of the sample than import models. Variables like China's disasters and common borders, however, did not enter the export models. But other variables were all statistically significant, their signs and values were strongly consistent across the models, except that for importer disasters. Overall, these diagnostics again suggest a robust and statistically reliable modeling platform.

As the results of import and export models show, China's GDP and trade partners' both had significantly positive impacts on the country's bilateral trade values. Distance and China's population are negative factors, consistent with theoretically expected effects of the gravity model. Moreover, APEC and WTO both increased bilateral trade of the country. This fits the facts very well, since its major trading partners such as the United States and Japan are members of those two organizations. A common boundary promoted national imports, but had no significant impact on exports. These results again suggest the robustness and statistical reliability of the model platform.

We further analyzed the key variables, natural disasters in China and its partner countries, and interaction terms between partner natural disasters with development levels and land areas. In Model 2, the coefficient of disasters in China was significant and positive, indicating that an increase in disasters raises bilateral imports of the country. The coefficient of disasters in partner countries is significant and negative, indicating that increased disasters in partner countries reduces that import. Model 3 shows that the interaction term of exporter natural disasters and development level is significant and negative. Thus, the marginal effect of natural disasters decreases when the exporter is a developed country. Model 4 shows a significant and positive interaction term of exporter natural disasters and land area. Thus the marginal effect of natural disasters increases with exporter land area. Model 5 includes both the interaction terms in Models 3 and 4. Its result shows that natural disasters in partner countries had a negative effect on China's imports. High development levels intensify this effect, but large land areas restrain it.

From the perspective of exports, Model 7 shows that disasters in China had no significant impact on its bilateral exports. The coefficient of disasters in partner countries is significant and negative, indicating that an increase in those countries' disasters reduced bilateral exports from China. In Model 8, the interaction term of importer natural disasters and development level is significant and positive. Thus, the marginal effect of natural disasters increased when the importer was a developed country. Model 9 shows that the interaction term of importer natural disasters and land area is significant and





NHESSD
3, 2003–2023, 2015

negative. Thus, the marginal effect of natural disasters amplified with importer land area. The sign of the variable importer disasters is positive, opposite that from Models 7 and 8. This indicates that disasters in importer countries increased the export value of China, but importer land area reduced positive disaster effects even to the point of becoming negative. Model 10 includes both the interaction terms in Models 8 and 9, and its result is consistent with those of Models 6–9.

Figure 2 indicates that natural disasters in partner countries had more negative effects on Chinese imports when the partner was a developed country, but less negative for exports. The marginal effect of partner natural disasters on China's imports decreased about 27 % when the partner was a developed country, relative to a developing one. The corresponding difference for Chinese exports was an increase of 9 %.

Figure 3 indicates that land area and development level are very important factors when a natural disaster strikes a trading partner of China. Figure 3a suggests that these disasters are less detrimental to the country's imports as partner land area increases. When that area exceeds 7.35 million $km^2$, the marginal effect of the disasters on those imports becomes positive. Figure 3b suggests that the disasters are more detrimental to China's exports as partner land area swells. If that area is smaller than 30 000 $km^2$, the marginal effect of the disasters on those exports is positive. Figure 3b may explain the change in sign in models (9) and (10) for importer's disaster variable. It implies that the importer's disasters have a positive impact on China's export when extracting the land area effect.

The above results are not completely consistent with those from Gassebner and Oh (Oh and Reuveny, 2010; Gassebner et al., 2006), indicating that the impact of disasters on China is significantly different from that on the entire world. Disaster impacts on exports are greater than on imports relative to China's bilateral trade, (Tables 1 and 2), especially when the disasters are in developed countries. In other words, China's bilateral export is more resilient to natural disasters than bilateral import. Moreover, disaster impacts are significant but weaker than those of other variables, such as GDP, population and distance. This suggests that Chinese bilateral trade is relatively resilient to natural disasters, considering several variables.

It is easy to interpret the increase of Chinese import value caused by domestic disasters. Because of reconstruction efforts for damaged infrastructure, increased domestic demand turns to foreign markets to some degree. Further, the robust export capacity of China is generally acknowledged, which makes it likely that domestic disasters have no significant impact on its exports.

The impact of disasters in partner countries is complex, and interactions with development levels and land areas make it more difficult to interpret. First, if a natural disaster affects a developed partner of China, it faces a larger decline in imports from that partner but a smaller decrease in exports to that partner. The larger decrease in imports may be attributed to the structure of the Chinese import system. Products mainly imported from developed countries, such as electrical equipment, machinery and vehicles, are easy for China to find substitutes from other countries and regions. The smaller decrease in exports may be associated with the stable demand market of developed countries and stable export capacity of China. But why do Chinese exports not rise because of the demand of partner reconstruction? Manufacturing industries are the major Chinese export industries but are not needed for post-disaster reconstruction, which may adequately answer this question. Second, land area of China's partners is crucial to its bilateral trade. Because larger land area means a larger buffer pool for natural disasters, a partner with more area presumably has a greater capacity to meet Chinese import demand when struck by disaster. However, the situation is different if China is the exporter. The partner with greater area may focus on dealing with domestic demand in the aftermath of a natural disaster with less help from imports, which may reduce its own exports. The partner would also choose policies aimed at keeping the balance of trade by reducing imports. Consequently, China's exports to this partner would be reduced because most of its export products are not necessities of life in a post-disaster period. Overall, from the perspective of reducing disaster risk





NHESSD
3, 2003–2023, 2015

of trade, it is favorable for China to import more from large developing countries and to export more to small developed countries.

## 4 Conclusions and discussion

This study examines the impact of natural disasters on China's bilateral trade, using the gravity model. The results show that this model can explain well the total value of this trade. The impact of natural disasters on this trade is asymmetric, in contrast with the impact on global bilateral trade. An increase in China's disasters increases its imports but has no significant impact on exports. An increase of disasters in China's trading partner countries reduces both its imports and exports. Both development levels and land areas of the partners are important in determining the magnitude of disaster impacts on China's bilateral trade. If the partner struck by disaster is a developed country, the decrease of Chinese imports is significant, but the decrease of exports is insignificant. Moreover, if the affected partner has a larger land area, the decrease of Chinese imports is less, but the decrease of exports is greater.

Based on the research framework of this study, future investigations can be extended in two ways. Although the present study used total trade value, future research could focus on specific traded commodities and analyze their sensitivity to specific disasters, such as geologic disaster impacts on oil trade and climatic disaster effects on food trade. Since the global distribution of natural disasters has rules, as does the global pattern of imports and exports, various regions may be vulnerable to different disasters. In addition, disaster effects on a country's bilateral trade can be examined. We believe that the impacts of disasters vary significantly by country and that their spatial pattern at a global scale is critical to integrated natural disaster risk management.

However, there are limitations of the research framework. Since natural disasters impact international trade through different ways, the trade gravity model exactly fails to exact the corresponding impact. In other words, we cannot know the mechanism of





NHESSD
3, 2003–2023, 2015

natural disasters' impact on international trade from this research framework, but can only get an aggregate result.

The disaster variable used herein is number of occurrences, which can hardly measure the disaster intensity accurately. Thus, the measurement of integrated intensity of disasters from the perspective of multi-disaster theory requires further study. Development level and land area of trading partners undoubtedly alter natural disaster impacts on China's bilateral trade, but more factors should be examined.

Although it is crucial to probe disaster impacts on regional and international trade from the macroscopic angle, studying the global impact of a specific LSD from a microscopic perspective is also important. For example, the 2010 Iceland volcanic event and 2011 Great East Japan Earthquake and tsunami produced economic losses and social-ecological effects. It is of great urgency and significance to rethink and reassess the complexity of socio-ecological systems, to analyze interactions among subsystems of institutions, society, the economy and ecology, and to determine the transformation, diffusion, and cascading effects of natural disasters.

*Acknowledgements.* This work was supported by the 111 project "Hazard and Risk Science Base at Beijing Normal University" under Grant B08008, Ministry of Education and State Administration of Foreign Experts Affairs, People's Republic of China.

## References

Akhtar, R. and Santos, J. R.: Risk-based input-output analysis of hurricane impacts on interdependent regional workforce systems, Nat. Hazards, 65, 391–405, doi:10.1007/s11069-012-0369-0, 2013.

Albalabertrand, J. M.: Natural disaster situations and growth – a macroeconomic model for sudden disaster impacts, World Dev., 21, 1417–1434, doi:10.1016/0305-750x(93)90122-p, 1993.

Ando, M. and Kimura, F.: How did the Japanese exports respond to two crises in the international production networks? The global financial crisis and the great east Japan earthquake, Asian Econ. J., 26, 261–287, doi:10.1111/j.1467-8381.2012.02085.x, 2012.

Auffret, P. and Turk, C.: High Consumption Volatility: the Impact of Natural Disasters?, World Bank, Latin America and the Caribbean Region, Economic Policy Sector Unit, Washington DC, USA, 2003.

Gassebner, M., Keck, A., and Teh, R.: The Impact of Disasters on International Trade, WTO Staff Working Paper, Geneva, Switzerland, 2006.

Guha-Sapir, D., Below, R., and Hoyois, P.: EM-DAT: International Disaster Database, Université Catholique de Louvain, available at: www.emdat.be (last access: 2013), Brussels, Belgium, 2013.

Guha-Sapir, D., Hoyois, P., and Below, R.: Annual Disaster Statistical Review 2012: The Numbers and Trends, CRED, Brussels, 2013.

Haimes, Y. Y., Horowitz, B. M., Lambert, J. H., Santos, J. R., Lian, C. Y., and Crowther, K. G.: Inoperability input-output model for interdependent infrastructure sectors, I: theory and methodology, J. Infrastruct. Syst., 11, 67–79, doi:10.1061/(Asce)1076-0342(2005)11:2(67), 2005.

Helbing, D.: Globally networked risks and how to respond, Nature, 497, 51–59, doi:10.1038/nature12047, 2013.

Kahn, M. E.: The death toll from natural disasters: the role of income, geography, and institutions, Rev. Econ. Stat., 87, 271–284, doi:10.1162/0034653053970339, 2005.

Li, M., Ye, T., Shi, P., and Fang, J.: Impacts of the global economic crisis and Tohoku earthquake on Sino-Japan trade: a comparative perspective, Nat. Hazards, 75, 541–556, doi:10.1007/s11069-014-1335-9, 2015.

Lin, H. C., Kuo, Y. L., Shaw, D., Chang, M. C., and Kao, T. M.: Regional economic impact analysis of earthquakes in northern Taiwan and its implications for disaster reduction policies, Nat. Hazards, 61, 603–620, doi:10.1007/s11069-011-0049-5, 2012.

Noy, I.: The macroeconomic consequences of disasters, J. Dev. Econ., 88, 221–231, doi:10.1016/j.jdeveco.2008.02.005, 2009.

Oh, C. H. and Reuveny, R.: Climatic natural disasters, political risk, and international trade, Global Environ. Chang., 20, 243–254, doi:10.1016/j.gloenvcha.2009.11.005, 2010.

Okuyama, Y. and Santos, J. R.: Disaster impact and input-output analysis, Econ. Syst. Res., 26, 1–12, doi:10.1080/09535314.2013.871505, 2014.

Raschky, P. A.: Institutions and the losses from natural disasters, Nat. Hazards Earth Syst. Sci., 8, 627–634, doi:10.5194/nhess-8-627-2008, 2008.

Rose, A. and Wei, D.: Estimating the economic consequences of a port shutdown: the special role of resilience, Econ. Syst. Res., 25, 212–232, doi:10.1080/09535314.2012.731379, 2012.
Rose, A., Benavides, J., Chang, S. E., Szczesniak, P., and Lim, D.: The regional economic impact of an earthquake: direct and indirect effects of electricity lifeline disruptions, J. Regional Sci., 37, 437–458, doi:10.1111/0022-4146.00063, 1997.
Rose, A., Adosu, G., and Liao, S. Y.: Business interruption impacts on the electric power system resilience to a total blackout of a terrorist attack of Los Angeles: customer, Risk Anal., 27, 513–531, doi:10.1111/j.1539-6924.2007.00912.x, 2007.
Shi, P., Wang, M., Liu, J., Ye, T., Nie, J., Kong, F., and Shi, Q.: An integrated large scale disaster risk governance paradigm: experiences and lessons in human responses, The 12th Biennial Aon Benfield Hazards Conference, 29 September 2011–1 October 2011, Surfers Paradise, Australia, 55–65, 2011,
Toya, H. and Skidmore, M.: Economic development and the impacts of natural disasters, Econ. Lett., 94, 20–25, doi:10.1016/j.econlet.2006.06.020, 2007.
WTO: World Trade Report 2012, World Trade Organization, 55–65, 2012.
WTO: World Trade Report 2013, World Trade Organization, Geneva, Switzerland, 2013.
Xie, W., Li, N., Wu, J.-D., and Hao, X.-L.: Modeling the economic costs of disasters and recovery: analysis using a dynamic computable general equilibrium model, Nat. Hazards Earth Syst. Sci., 14, 757–772, doi:10.5194/nhess-14-757-2014, 2014.

**Table 1.** Regression results for China as an importer (1980–2012).

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| ln (China's disasters) | | 0.460*** | 0.460*** | 0.423** | 0.419** |
| | | (0.178) | (0.178) | (0.178) | (0.177) |
| ln (Exporter's disasters) | | −0.298*** | −0.234*** | −1.581** | −1.647*** |
| | | (0.056) | (0.059) | (0.264) | (0.264) |
| ln (Exporter's disasters) × Developed | | | −0.273*** | | −0.344*** |
| | | | (0.088) | | (0.089) |
| ln (Exporter's disasters) × ln (Exporter's Area) | | | | 0.100** | 0.111*** |
| | | | | (0.02) | (0.020) |
| ln (China's GDP) | 0.857*** | 0.946*** | 0.928*** | 0.929** | 0.904*** |
| | (0.085) | (0.094) | (0.094) | (0.094) | (0.094) |
| ln (Exporter's GDP) | 1.130*** | 1.120*** | 1.159*** | 1.103** | 1.151*** |
| | (0.022) | (0.022) | (0.025) | (0.022) | (0.025) |
| ln (China's population) | −7.698*** | −10.181*** | −10.193*** | −9.782** | −9.751*** |
| | (1.001) | (1.507) | (1.506) | (1.506) | (1.503) |
| ln (Exporter's population) | 0.135*** | 0.211*** | 0.179*** | 0.183** | 0.140*** |
| | (0.025) | (0.029) | (0.031) | (0.029) | (0.031) |
| ln (Distance) | −0.773*** | −0.729*** | −0.720*** | −0.850** | −0.853*** |
| | (0.073) | (0.073) | (0.073) | (0.077) | (0.077) |
| APEC | 1.164*** | 1.354*** | 1.377*** | 1.154** | 1.160*** |
| | (0.130) | (0.134) | (0.134) | (0.139) | (0.139) |
| WTO | 0.919*** | 0.905*** | 0.897*** | 0.959** | 0.956*** |
| | (0.093) | (0.095) | (0.095) | (0.096) | (0.096) |
| Border | 0.386*** | 0.485*** | 0.468*** | 0.302** | 0.259* |
| | (0.148) | (0.148) | (0.148) | −0.148 | (0.153) |
| Constant term | 46.726*** | 61.174*** | 61.028*** | 60.847** | 60.626*** |
| | (6.200) | (9.252) | (9.243) | (9.228) | (9.214) |
| $N$ | 4553 | 4553 | 4553 | 4553 | 4553 |
| $R^2$ | 0.690 | 0.692 | 0.693 | 0.694 | 0.695 |

*/**/*** indicates significance at 0.1/0.05/0.01 levels (two-tailed test). – indicates variables removed from the model by stepwise regression. Standard errors shown in parentheses.





NHESSD
3, 2003–2023, 2015

**Table 2.** Regression results for China as an exporter (1980–2012).

| | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|
| ln (China's disasters) | | – | – | – | – |
| ln (Importer's disasters) | | −0.113*** | −0.133*** | 0.433*** | 0.454*** |
| | | (0.032) | (0.033) | (0.144) | (0.144) |
| ln (Importer's disasters) × Developed | | | 0.090* | | 0.121** |
| | | | (0.052) | | (0.052) |
| ln (Importer's disasters) × ln (Importer's Area) | | | | −0.042*** | −0.046*** |
| | | | | (0.011) | (0.011) |
| ln (China's GDP) | 1.069*** | 1.063*** | 1.069*** | 1.069*** | 1.078*** |
| | (0.048) | (0.048) | (0.048) | (0.048) | (0.048) |
| ln (Importer's GDP) | 0.738*** | 0.733*** | 0.721*** | 0.737*** | 0.721*** |
| | (0.012) | (0.012) | (0.014) | (0.012) | (0.014) |
| ln (China's population) | −2.294*** | −2.131*** | −2.127*** | −2.210*** | −2.211*** |
| | (0.544) | (0.545) | (0.545) | (0.545) | (0.545) |
| ln (Importer's population) | 0.201*** | 0.228*** | 0.238*** | 0.240** | 0.255*** |
| | (0.013) | (0.015) | (0.016) | (0.016) | (0.017) |
| ln (Distance) | −0.676*** | −0.671*** | −0.675*** | −0.641** | −0.644*** |
| | (0.038) | (0.038) | (0.038) | (0.038) | (0.038) |
| APEC | 0.488*** | 0.553*** | 0.543*** | 0.630** | 0.623*** |
| | (0.076) | (0.078) | (0.078) | (0.08) | (0.08) |
| WTO | 0.517*** | 0.530*** | 0.532*** | 0.506*** | 0.506*** |
| | (0.054) | (0.054) | (0.054) | (0.054) | (0.054) |
| Border | – | – | – | – | – |
| Constant term | 8.970*** | 7.894** | 7.948*** | 7.823** | 7.890** |
| | (3.342) | (3.351) | (3.351) | (3.347) | (3.345) |
| $N$ | 5170 | 5170 | 5170 | 5170 | 5170 |
| $R^2$ | 0.822 | 0.822 | 0.823 | 0.823 | 0.823 |

*/**/*** indicates significance at 0.1/0.05/0.01 levels (two-tailed test). – indicates variables removed from the model by stepwise regression. Standard errors shown in parentheses.





NHESSD

3, 2003–2023, 2015

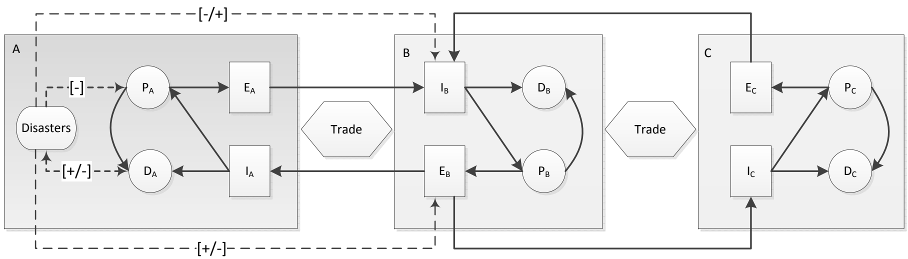


**Figure 1.** Interactions between disasters and trade system. $P_i$ denotes production of region $i$, $D_i$ demand, $I_i$ import value, and $E_i$ export value. Solid arrows indicate flow between two components and dashed arrows indicate the impact.

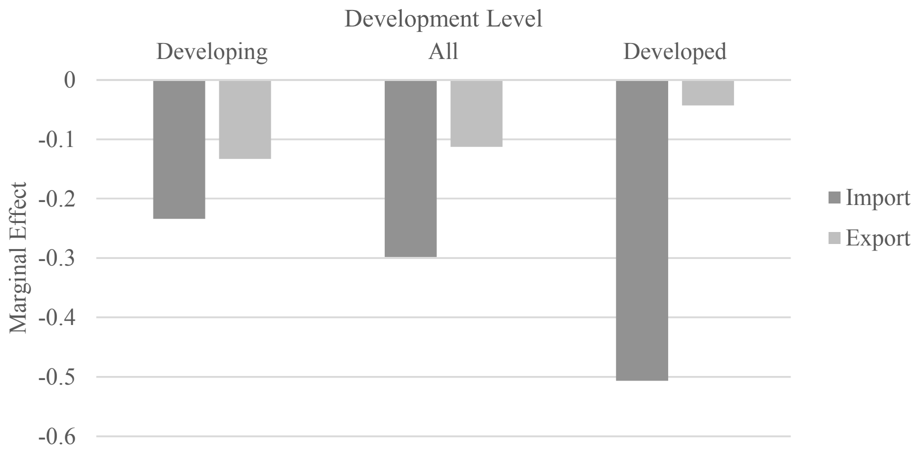


**Figure 2.** Marginal effects of natural disasters in partner countries on China's bilateral trade versus development levels.





NHESSD
3, 2003–2023, 2015

The asymmetric impact of natural disasters on China's bilateral trade

Y. Meng et al.

Title Page
Abstract Introduction
Conclusions References
Tables Figures
◀ ▶
Back Close
Full Screen / Esc
Printer-friendly Version
Interactive Discussion

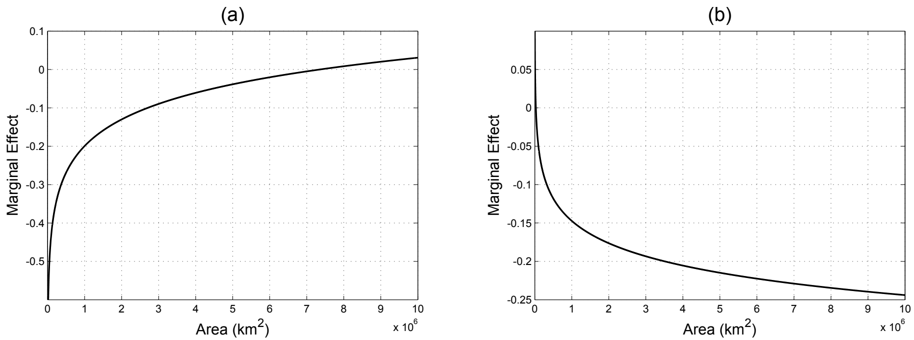


**Figure 3.** Marginal effect of natural disasters in partner countries on China's bilateral trade as a function of land area. **(a)** is for Chinese imports; **(b)** is for its exports.





NHESSD
3, 2003–2023, 2015