RIETI Discussion Paper Series 22-E-086

Trade Disruption and Risk Perception

KASHIWAGI, Yuzuka
National Research Institute for Earth Science and Disaster Resilience

TODO, Yasuyuki
RIETI

The Research Institute of Economy, Trade and Industry
https://www.rieti.go.jp/en/

RIETI Discussion Paper Series 22-E-086
September 2022

Trade Disruption and Risk Perception*

Yuzuka KASHIWAGI
National Research Institute for Earth Science and Disaster Resilience

Yasuyuki TODO
Research Institute of Economy, Trade and Industry and Waseda University

Abstract

In the literature, direct physical damage to individuals caused by natural disasters, such as the destruction of houses, is often found to raise their perception of risks of future disasters. This paper examines whether another type of damage caused by disasters, i.e., indirect economic shocks, also affects the risk perception of individuals who are not directly affected by disasters. For this purpose, we focus on cacao farmers in Indonesia who experienced a disruption in trade with their traders after the 2018 Sulawesi earthquake, and use unique, household-level data collected after the earthquake. We find that when farmers were not directly or physically hit by the earthquake, but could not sell their products to their traders for a longer period of time due to the destruction of transport infrastructure and warehouses, they were more likely to perceive a very high risk of future earthquakes in their vicinity. In addition, farmers facing a longer trade disruption tended to believe that the risk of earthquakes is higher than that of other types of natural disasters. These findings imply that the effect of a disaster on individuals' risk perception propagates geographically through trade networks to regions that are not directly affected by the disaster because of indirect and economic damage.

Keywords: trade disruption, natural disasters, risk perceptions
JEL classification: O12, D91, Q12, Q54

* This study is conducted as a part of the Project entitled "Research on relationships between economic and social networks and globalization" undertaken at the Research Institute of Economy, Trade and Industry (RIETI). The authors are grateful for the helpful comments and suggestions of Asako Iwaki, Petr Matous, Masayuki Morikawa, Eiichi Tomiura, and seminar participants at RIETI. The authors also thank Swisscontact Indonesia and Koltiva, particularly Hiswaty Fahid, Meg Phillips, Imam Wahyudi, and Kristyna Vydrova, for their help in the field survey. Todo is grateful for the financial support of JSPS Kakenhi Grant No. JP18H03642. The opinions expressed and arguments employed in this paper are the sole responsibility of the authors and do not necessarily reflect those of the National Research Institute for Earth Science and Disaster Resilience, the RIETI, Waseda University, or any institution with which the authors are affiliated.

1 Introduction

Disasters have been found to change victims' perception of the background risks of the same types of disasters. As the perception of risks is an important determinant of investment decisions (Giné, Townsend, and Vickery 2015, Raschky et al. 2013, Shaik et al. 2008), risk preferences (Cameron and Shah 2015), and possibly preparedness for future risks, the change in risk perception in the post-disaster period has attracted attention in the literature. Although many past studies find a positive effect of natural disasters on the subjective risk of disasters in the future (Brown et al. 2018, Chantarat, Lertamphainont, and Samphantharak 2016, Chantarat et al. 2019, Wachinger et al. 2013), some studies, such as Cameron and Shah (2015) and Ohtomo, Kimura, and Hirata (2020), who specifically examined the effect of earthquakes, found the subjective likelihood of future earthquakes to be statistically insignificant.

Existing studies have focused on the effect of direct experiences of disasters and the level of direct physical damage caused by disasters, such as damage to houses. However, people who are not directly affected by disasters may suffer from indirect nonphysical damage, e.g., psychological shocks due to the loss of distant relatives and economic shocks due to reduced inputs from and outputs to the directly affected areas through supply chains. If this propagation occurs, disasters lead to changes in the perception of people not directly but indirectly affected in addition to changes in the perception of directly affected people. Thus, the effect of the direct damage of disasters on risk perception estimated by comparing directly affected and unaffected people could be underestimated because of the propagation to the latter. This propagation effect may be more prominent in the case of earthquakes than other types of disasters, as shown in several studies (Carvalho et al. 2020; Inoue and Todo 2019; Kashiwagi, Todo, and Matous 2021). This difference in prominence is probably one reason why the effect of earthquakes is often found to be statistically insignificant in the literature.

Therefore, this study examines the impact of indirect economic shocks due to an earthquake on the degree of risk of future disasters perceived by people not directly affected by the disaster. In particular, we focus on trade disruption as the source of indirect economic shocks. There are three reasons why, rather than the effect of direct shocks on people directly affected, our focus is of great interest. First, by showing its positive effect, we can provide indirect evidence of overestimation of the effect of direct physical shocks due to disasters on the perception of future disasters in the literature. Second, if indirect shocks to people not directly affected by disasters influence their perception and behaviors, the overall effect of disasters can be larger in size than we are currently considering. Finally, as supply chains have recently expanded geographically within and across countries, a disaster in a region results in indirect economic shocks in larger regions than before (Boehm, Flaaen, and Pandalai-Nayer 2019). Therefore, the effect of disasters on risk perception may propagate widely across countries through global supply chains.

To achieve the purpose of this research, we utilize unique household-level data on cacao farmers in Indonesia collected after the 2018 Sulawesi earthquake, a major earthquake in the region. After the earthquake, cacao farmers who were not directly affected by the earthquake could not sell their cacao

beans to traders for 1.5 months on average because of power shortages and the destruction of transport infrastructure and warehouses. Comparing farmers without direct damage but with indirect damage and those without either direct or indirect damage, we find that farmers who experienced a trade disruption for a longer period of time tended to raise their perception of the risk of future earthquakes in their neighborhood. Moreover, a longer trade disruption increased the risk aversion of farmers, a result consistent with the findings of Cameron and Shah (2015), who examined the effect of the direct damage of disasters.

This paper contributes to the literature in the following three ways. First, this paper is most closely related to the growing strand of literature exploring the impact of disasters on individual perceptions and preferences. Past studies have shown that disasters change victims' risk perceptions (Cameron and Shah 2015, Chantarat, Lertamphainont, and Samphantharak 2016, Chantarat et al. 2019), risk preferences (Bchir and Willinger 2013, Cameron and Shah 2015, Cassar, Healy, and Von Kessler 2017, Chantarat et al. 2019, Eckel, El-Gamal, and Wilson 2009, Hanaoka, Shigeoka, and Watanabe 2018, Ingwersen 2014, Page, Savage, and Torgler 2014, Reynaud and Aubert 2014, Van Den Berg, Fort, and Burger 2009, Willinger, Bchir, and Heitz 2013), time preferences (Callen 2015, Cassar, Healy, and Von Kessler 2017, Voors et al. 2012), social capital (Chantarat, Lertamphainont, and Samphantharak 2016, Kashiwagi and Todo 2021), trust (Andrabi and Das 2017, Cassar, Healy, and Von Kessler 2017, Chantarat et al. 2019, Fleming, Chong, and Bejarano 2014, Shoji 2018), and altruism (Cassar, Healy, and Von Kessler 2017, Castillo and Carter 2011, Chantarat et al. 2019, Samphantharak 2014, Voors et al. 2012). We contribute to the literature by providing new evidence showing that indirect economic shocks due to disasters without any direct physical damage have a significant impact on the risk perception of individuals not directly affected by disasters.

Second, this study contributes to the literature on the relationships between disasters and economic development. The literature suggests that subjective expectations influence agricultural investment decisions (Giné, Townsend, and Vickery 2015, Raschky et al. 2013, Shaik et al. 2008), which can further affect the income of farmers. Our results add to the literature by suggesting that the experience of a trade disruption raises farmers' perception of future risks, possibly leading to less willingness to invest and, thus, to lower income. This implication is in line with Crespo Cuaresma, Hlouskova, and Obersteiner (2008), who found a negative effect of country-level disaster risks on knowledge spillovers through trade. Because trade disruptions occur widely and frequently for many other reasons, such as political and military conflicts, in addition to disasters, the potential impact of trade disruptions on income through the channel of risk perception can be quite large in practice.

Third, this study is related to the growing body of literature on the economic effect of supply chain disruptions because of disasters (Barrot and Sauvagnat 2016, Carvalho et al. 2020, Kashiwagi, Todo, and Matous 2021, Lu et al. 2017). While past studies have focused on the geographic propagation of the negative effects of disasters on economic activities and performance in regions not directly affected through supply chains, we extend the literature by exploring the propagation of noneconomic, i.e., psychological, effects. Accordingly, our findings suggest that the total effect of supply chain disruptions

because of disasters can be more substantial and widespread than the current literature shows.

2 Background of the Study Region

This study is based on a survey of cacao farmers in the Sigi and Donggala regencies of Central Sulawesi Province, Indonesia, which were hit by the 2018 Sulawesi earthquake, as we will explain in detail below. First, this section describes the earthquake; then, it discusses the hazard risks predicted by seismic and geological studies; and finally, it explains cacao farming in the region.

2.1 The 2018 Sulawesi Earthquake

The 2018 Sulawesi earthquake struck part of Palu city, i.e., the provincial capital, and the neighboring Sigi and Donggala regencies in Central Sulawesi Province, Indonesia, on 28 September 2018. The moment magnitude scale of the earthquake was 7.5. It triggered an extraordinarily large tsunami and liquefaction in these regions. The earthquake caused 4,340 deaths, affected 1.5 million individuals, and resulted in economic damage amounting to 1.45 billion USD (EM-DAT 2021; OCHA 2018). The earthquake was a lateral-fault-type earthquake, which often concentrates physical damage along earthquake faults. In the case of the 2018 Sulawesi earthquake, the Palu-Koro fault line caused massive physical damage (Geospatial Information Authority of Japan 2019). Accordingly, we observe large variations in the level of damage caused by the earthquake across areas depending on the distance from the fault line. In addition, because of the tsunami after the earthquake, areas along the coast were heavily affected.

The earthquake and tsunami destroyed infrastructure, including roads, sea ports, airports, and power plants, as well as business facilities, including production plants, warehouses, and major shopping centers. For example, the major seaport in Palu used for cacao exports lost its crane for loading and unloading cargo. The power was out for one week until 4 October (OCHA 2018). Because of the damage to the power plants, transport infrastructure, and warehouses, trade within the affected regions and between the affected regions and their neighbors was largely disrupted for several weeks or several months.

2.2 Hazard Risks

According to the World Bank's Global Facility for Disaster Reduction and Recovery (2022), the area of the survey has been exposed to probabilistic risks of several disasters. The risks of urban floods, tsunamis, landslides, and wildfires are projected to be relatively high. For example, the risk of an urban flood that is potentially damaging and life threatening is more than 20 percent in the next 10 years. In contrast, the chance of a potentially-damaging earthquake is estimated to be 10 percent in the coming 50 years, lower than the abovementioned disasters. Other seismic and geological studies, such as Watkinson and Hall (2017) and Cummins (2017), present similar predictions of future earthquakes because of the rupture of the Palu-Koro fault line. In addition, a hazard assessment report by Japan International Cooperation Agency (JICA) (2015) publicizes a hazard map of Indonesia developed by a local insurance company, PT. Asuransi Maipark Indonesia.

Historical experiences also support the presumption that this region has been and will be exposed to probabilistic risks of disasters. Before the 2018 Sulawesi earthquake, this region had suffered from occasional natural disasters. According to the list of disasters from 2008 to 2017 of the Emergency Events Database (EM-DAT) (2021), three floods, one landslide, and one earthquake were observed in Sigi and Donggala. However, all of them were substantially less severe than the 2018 earthquake in terms of the scale of damage and the reading of the Richter magnitude scale.

2.3 Cacao Farming

Globally, Indonesia is a major cacao-producing country, and Indonesia's comparative advantage is its high yield rather than the flavor of its cacao. Cacao beans in Indonesia are produced predominantly by smallholder farmers, who accounted for approximately 96% of all production in 2017 (Ariningsih 2020). The cacao harvest in Sulawesi has two peaks in May and October, accounting for 21 and 10 percent of total production, respectively (Abbate 2007). That is, the earthquake occurred during one of the peak harvest seasons. Thus, the disruption in the trade in cacao beans caused by the 2018 Sulawesi earthquake should have severely affected farmers.

Typically, cacao beans in this province are traded in the following process. First, farmers sell their cacao beans to intermediary traders. Some of these traders visit farmers to collect products, while in other cases, farmers take their products to traders' stores, which are mostly located in the farmers' neighborhoods. Some traders are certified by private organizations, such as UTZ and Rainforest Alliance, for the high quality or environmental friendliness of their products. Farmers can sell their cacao beans to their traders for higher prices if the quality of the beans is high enough to be certified. These intermediary traders sort "good-quality" cacao and others when they buy cacao beans from farmers. Then, they sell the beans to larger collectors, wholesalers, or exporters, often in coastal areas. These intermediary traders sell the beans to larger traders, wholesalers, or exporters often located in Palu city and coastal areas, where the damage caused by the 2018 Sulawesi earthquake and the subsequent tsunami was severe.

In the wake of the 2018 Sulawesi earthquake, transport infrastructure, most notably main roads and the seaport in Palu, and the warehouses of traders were heavily damaged for several months, and hence, the trade of cacao farmers with intermediary traders was disrupted. Moreover, because the earthquake damaged the seaport and warehouses for exporting cacao beans, exporters, who are the largest buyers of cacao beans in the region, stopped buying cacao beans from intermediary traders. In turn, the intermediary traders stopped buying cacao beans from farmers. Because of the reduction in the demand of traders and the destruction of transport infrastructure, farmers who were not directly affected by the earthquake and thus could continue cacao bean production as before were also affected by the trade disruption.

The effect of a trade disruption can be magnified by farmers' liquidity constraints. When farmers face negative economic shocks, they often immediately suffer from a lack of cash for everyday life because they have little savings and cannot receive credit (Karlan and Morduch 2010). Our observation suggests that most farmers in this region face liquidity constraints. If farmers ferment their harvested cacao for

one week, they can receive higher prices for the fermented and, thus, better-quality cacao. Although the one-week fermentation process is not very costly and is quite simple, it is often the case that Indonesian cacao farmers sell their products immediately after they harvest their products because of liquidity constraints (Ariningsih 2020). Consistently, we observe that none of the farmers in our sample fermented cacao beans before selling them, presuming that they face liquidity constraints.

One way to mitigate the negative effect of such liquidity constraints after an economic shock is informal credit from downstream to upstream actors in supply chains to maintain their ties even after the recovery from the shock. In our study region, we observe that some exporters who could not buy cacao beans from smaller traders offered credits to the smaller traders, whereas some intermediate traders offered credits to farmers. According to the in-depth interviews with exporters, traders, and farmers that we conducted, such credits were provided when downstream actors faced financial difficulties and worked well in maintaining supply chain ties and transactions of good-quality cacao beans between exporters, traders, and farmers. Therefore, we consider the provision of such informal credits to be one type of informal insurance that is often observed in developing countries to relieve liquidity constraints (Karlan and Morduch 2010).

3 Data

3.1 Survey

We conducted the post-disaster household survey in the Sigi and Donggala regencies, Central Sulawesi Province, Indonesia, from July to August 2019, 10 months after the 2018 Sulawesi earthquake. Some parts of these regencies, which cover 10,472 km^2 of land, were hit by the 2018 earthquake, while others were not. Our survey targeted all 4,154 cacao farmers in targeted subdistricts (administrative units under regencies) in the two regencies who were universally surveyed by a nongovernmental organization (NGO) in 2017 based on census information. Among them, approximately 90 percent participated in our survey. The survey was administered by local enumerators in the local language, Bahasa Indonesia, using a questionnaire written in Bahasa Indonesia.

The farmers in the survey included those who were directly affected by the earthquake and those who were not. In the present study, we limit our sample to those who were not directly or physically affected by the earthquake, i.e., those who had no damage to their houses or business assets due to the earthquake. The reason is that we estimate the effect of indirect economic damage on farmers' risk perception by comparing those who were not directly affected but were indirectly affected by the earthquake and those who were not affected directly or indirectly. Accordingly, the number of observations in our benchmark estimations is 1,107.

3.2 Variable Construction

Our key dependent variables measure the perception of the risk of natural disasters. In the questionnaire, we asked farmers to choose the probability that an earthquake or another natural disaster would happen

in their neighborhood within 10 years from the following five choices: very large (over 80 percent), large (61-80 percent), moderate (41-60 percent), small (21-40 percent), and very small (0-20 percent). We create a dummy variable for each disaster category that is coded one if the answer of a respondent is "very large" or "large", i.e., if the perceived probability is more than 60 percent, and zero otherwise. We do not directly use the categorical variable in our benchmark estimations to minimize biases due to measurement errors in the categorical variable, although we check the robustness of our benchmark results by directly using the categorical variable. In addition, the survey asked farmers the possible scale of damage by the largest earthquake or the largest other type of disaster that the respondent thought would occur within 10 years using five categories (very small, small, moderate, large, and very large). Combining these two sets of questions, we create two dummy variables indicating farmers who predict that a large or very large earthquake or other disaster would occur within 10 years with a probability of over 60 percent. We also make a dummy variable that takes the value of one if the respondent chose a higher probability of occurrence of an earthquake than the probability of occurrence of another type of natural disaster and zero otherwise. This variable measures whether each farmer subjectively views the risk of earthquakes as being higher than the risk of other disasters.

Our key independent variable is the number of days for which sales of cacao beans from the respondent farmer to any trader were disrupted after the 2018 Sulawesi earthquake, representing the degree of indirect economic damage caused by the earthquake. This information is taken directly from a question in the survey.

The control variables used in this study include dummy variables for gender, household heads, an educational level of middle school or higher, ethnicity, age, the total production of cacao per year in kilograms, the total number of traders prior to the earthquake, and an index of the quality of cacao beans prior to the earthquake. This information is also directly taken from responses to the survey.

3.3 Summary Statistics

The summary statistics are presented in Table 1. Most farmers were linked to only one trader: the mean of the number of traders was 1.022, and its maximum was three. These results indicate that facing a disruption of trade with only one trader, farmers may not easily be able to find substitute suppliers and were thus most likely to suffer from large economic shocks. The average duration of the trade disruption because of the 2018 Sulawesi earthquake was 43 days, whereas its maximum was eight months.

Among the farmers, 7.7 and 4.5 percent of farmers thought that a "large" or "very large" earthquake (i.e., the top two categories among the five), respectively, would occur within 10 years at a probability of more than 60 percent. However, the probability of the occurrence of a large earthquake of 60 percent within 10 years is extremely high compared with the past occurrence of a small earthquake in the last 10 years and the probability of 10 percent in 50 years predicted by seismic and geological studies, as presented in Section 2.2 (Cummins 2017; Watkinson and Hall 2017). Therefore, we conclude that farmers who expect such a high probability overvalue the risk of future earthquakes. Figure 1 presents a more detailed distribution of the degree of risk perception, showing the share of farmers who chose 0-20%,

21-40%, 41-60%, 61-80%, or 81-100% as the probability of the occurrence of an earthquake within 10 years.

In contrast to the risk of earthquakes, 2.2 and 1.5 percent of farmers supposed a higher probability than 60 percent of the occurrence of another type of disaster and another type of large or very large disaster within 10 years. These figures indicate that farmers tended to perceive a higher risk of earthquakes than the risk of other disasters after the 2018 Sulawesi earthquake. Moreover, 19 percent of households believed that the risk of earthquakes was higher than that of other natural disasters. Because existing disaster studies predict that the risk of nonearthquake disasters, such as floods and landslides, is higher than the risk of earthquakes (Section 2.2), we confirm that farmers in this region are likely to overvalue the risk of earthquakes compared with the risk of other disasters.

The bottom half of Table 1 shows the summary statistics of other attributes of farmers. 92 percent of the survey respondents were household heads, nearly 80 percent were men, 53 percent completed at least a middle school, and their average age was 45. The surveyed agricultural households produced 720 kg of cacao beans per year on average. 79 percent of farmers traded good-quality cacao beans. 30 percent had access to informal credit from traders as a consequence of informal insurance (Section 2.3), although not all of them actually accepted the offer.

4 Empirical Strategy

4.1 Conceptual Framework

To explain how individuals update probabilistic beliefs based on states, there are two theoretical frameworks. First, economic models have traditionally assumed that people update their beliefs simply based on Bayes' rule when they receive new information. Second, the recent literature suggests that people may have irrational and mistaken beliefs that do not necessarily follow Bayes' rule because they overvalue or undervalue new information from their own experiences and learning from others (Croson and Sundali 2005, Eil and Rao 2011, Ertac 2011, Möbius et al. 2014).

Therefore, we presume three possibilities regarding our focus, the effect of the duration of a trade disruption or a measure of indirect economic shocks due to the 2018 Sulawesi earthquake on farmers' perception of the risk of future disasters. First, farmers who faced a longer trade disruption due to the earthquake were significantly suffered from the disaster even though they did not experience direct damage, and thus, they updated their risk perception to a higher level according to Bayes' rule. This positive effect of a trade disruption on risk perception may be magnified by a reduction in income because the disruption can cause psychological distress. Meta-analyses by Paul and Moser (2009) found that people tend to be distressed by unemployment, that is, an income shock. Furthermore, it has been found that distress increases the perception of risks of, for example, personal and terrorism threats (Loewenstein et al. 2001; Stevens et al. 2011). These findings imply a possible positive effect of a trade disruption on risk perception through the income-distress channel. Second, farmers may possibly maintain their risk perception after the earthquake because they were not struck directly by the earthquake and thus did not

receive any new signal for information updating. Finally, the effect of a trade disruption on risk perception can be negative. Farmers affected indirectly by the earthquake through a trade disruption but unaffected directly may think that they are quite lucky compared with others who were living nearby but directly and heavily were affected by the earthquake and thus lost houses and property. If this is the case, they may assume that the luck will continue and undervalue the risk of future disasters.

In summary, how a trade disruption affects risk perception is an empirical question.

4.2 Estimation Methodologies

Our benchmark analysis examines the effect of the trade disruption due to the 2018 Sulawesi earthquake experienced by cacao farmers on their perception of risks of future disasters by estimating the following equation:

$$y_{is} = \alpha + \beta_1 DAYSDISRUPTION_i + \beta_2 X_i + \delta_s + \epsilon_{is},$$

where subscripts i and s indicate individuals and subdistricts, respectively. The dependent variable y_{is} indicates one of the measures of the level of risk perception of individual i in subdistrict s, defined in Section 3.2. $DAYSDISRUPTION_i$ represents our key independent variable, defined as the log of the number of days of a disruption in the trade in cacao beans due to the earthquake plus one. The vector of the control variables for individual i, X_i, includes the dummy variables for gender, household heads, an educational level of middle school or higher, ethnicity, age, the total production of cacao beans per year in kilograms, the total number of traders prior to the earthquake, and an index of the quality of cacao beans prior to the earthquake. We also incorporate subdistrict fixed effects, δ_s, to control for unobserved effects at the subdistrict level, such as those of historical events, culture, and geographic and climate conditions.

We estimate this equation using ordinary least squares (OLS) based on the identification strategies explained in detail in the next subsection. We utilize cluster robust standard errors at the subdistrict level to account for possible correlations between error terms in the same subdistrict because of spillovers of perception across neighboring farmers.

4.3 Identification Strategies

Our identification strategy relies on the assumption that the duration of a trade disruption due to the earthquake is exogenous. However, this assumption is violated if unobserved attributes of households that determine post-earthquake perception are also correlated with the duration of the trade disruption.

Notably, we do not observe the risk perception of farmers in the pre-disaster period. Farmers who suffered from a longer trade disruption after the 2018 Sulawesi earthquake may tend to live in areas that have long been exposed to higher risks of disasters. If this is the case, such farmers may have perceived higher risks of disasters even before the 2018 Sulawesi earthquake, and thus, our estimation results could be biased.

We test this possibility using the probabilities of natural disasters before the 2018 Sulawesi earthquake

predicted by seismic and geological studies shown in Section 2.1. In particular, we create two measures of risks of severe earthquakes in the pre-2018 period: the distance from the Palu-Koro fault line, which was predicted to cause a large earthquake before 2018 (Watkinson and Hall 2017; Cummins, 2017) and which in fact caused the 2018 Sulawesi earthquake; and a dummy variable that takes the value of one if the respondent lived in a region with a high risk of severe earthquakes according to the hazard map shown in JICA (2015). If farmers who experienced a longer trade disruption after the 2018 Sulawesi earthquake tended to perceive higher risks of earthquakes prior to the earthquake because of the dissemination of hazard information, the duration of the trade disruption after the 2018 Sulawesi earthquake and the two measures of pre-2018 risks should be correlated.

We simply test the correlation using OLS and present the results in columns (1) and (2) of Table 2. The duration of a trade disruption is not significantly associated with either of the two measures of pre-2018 risks, rejecting the hypothesis that farmers who suffered from a longer trade disruption in 2018 were more likely to live in areas with higher risks of disasters predicted by seismic studies before 2018. Furthermore, as shown in columns (3) and (4) of Table 2, neither of the two measures of pre-2018 risks is significantly correlated with the post-earthquake perception of earthquake risks. These results suggest that seismic predictions of risks in the pre-2018 period did not determine the perception of risks after the earthquake in 2018. Therefore, we conclude that the pre-earthquake differences in risk perception, which could be largely driven by seismic predictions, are unlikely to cause serious biases in our estimations.

In addition, we test whether the duration of a trade disruption is correlated with any observed attribute of farmers, although we cannot test whether it is correlated with unobserved attributes. A review article of the risk perception of natural disasters by Wachinger et al. (2013) argued that the factors that affect risk perception include the individual's personal experience of any natural disaster, trust in authorities and experts, access to media, educational level, gender, age, income, and home ownership. We examine the correlation between the duration of a trade disruption and each of these potential determinants except for access to media and home ownership, for which data are not available. The lack of the two variables may be acceptable because approximately 90 percent of households own their houses in rural areas of Indonesia according to Statistics Indonesia and because the media coverage in the study areas is similar across households. The results in Table 3 indicate no significant correlation between the duration of a trade disruption and any of the farmers' observed attributes, i.e., the respondent's past experience of severe disasters, perception of authorities, gender, age, educational level, and income. Therefore, we conclude that the duration of a trade disruption is randomly distributed across the observed attributes of farmers that affect their risk perception.

5 Results

5.1 Benchmark Results

Table 4 reports the benchmark results. Column (1) shows a positive and significant effect of the duration of a trade disruption due to the 2018 Sulawesi earthquake on the post-earthquake perception of the risk

of future earthquakes. This result indicates that if the duration is doubled, the probability of farmers' perceiving high risks of an earthquake in 10 years (a probability of its occurrence of more than 60 percent) increases by 3.47 percentage points. Because the mean of the outcome variable is 7.68 percent, we regard this result as a large effect. This result holds when we include the control variables and subdistrict dummies, as shown in column (2) of Table 4. Moreover, the result is similar when we change the outcome variable to a dummy variable that indicates whether the respondent expected that a "large" or "very large" earthquake would occur at a probability of more than 60 percent (column [3]). These results are robust when we experiment with an ordered probit model where a categorical variable for five, rather than two, categories of the perceived probability of earthquakes (see Section 3.2 and Figure 1 for details) is used as the dependent variable, as shown in Appendix Table A1. Therefore, producers suffering from a more severe trade disruption due to the earthquake tended to evaluate the risk of earthquakes as being higher, even though they were not directly hit by the earthquake. Notably, a perceived probability of the occurrence of a large earthquake in 10 years of more than 60 percent is quite high compared with the corresponding probability predicted by seismic and geological studies (Watkinson and Hall 2017; Cummins, 2017), that is, 10 percent in 50 years. It is thus suggested that people who experience a large indirect economic shock due to a disaster tend to overvalue the risk of future disasters.

In columns (4)-(6) of Table 4, we experiment with alternative dependent variables for the perception of the risk of other types of disasters. In other words, we test whether a trade disruption due to the 2018 Sulawesi earthquake can change the perception of risks of disasters in general. Unlike the perception of the risk of earthquakes, the perception of the risk of different types of disasters is not significantly affected by a trade disruption. This result suggests that the effect of indirect economic shocks due to an earthquake is limited to the perception of the risk of earthquakes, the same type of disaster. However, when we employ an ordered probit model using a categorical variable with five probability categories, instead of the linear probability model using the dummy variable with only two categories, we find a positive and significant impact of a longer disruption on the perception of risks of other disasters (columns [2] and [4] of Appendix Table A1). These contrasting results from the OLS and ordered probit estimations suggest that the effect of indirect economic shocks due to a disaster on the perception of risks of other types of disasters is unclear. Notably, however, even in the ordered probit estimations, the coefficients in columns (1) and (3) of Appendix Table A1 are larger than those in columns (2) and (4), respectively. Therefore, we conclude that the effect of indirect economic shocks due to an earthquake on the perception of the risk of earthquakes is larger than its effect on the perception of the risks of other disasters.

In column (7) of Table 4, we employ an alternative outcome variable that is coded one if a farmer perceives a higher probability of the occurrence of a large earthquake within 10 years than that of a large disaster of another type. The result indicates that when farmers suffered from a longer trade disruption, their perceived risk of earthquakes was likely to be higher than that of other disasters. According to the disaster studies presented in Section 2.1, the risk of other disasters, such as floods and landslides, is predicted to be higher than the risk of earthquakes. Therefore, we conclude that people suffering from indirect economic shocks due to an earthquake tend to overvalue the risk of future earthquakes compared

with the risk of other disasters. The overvaluation of the risk of a particular type of a disaster because of past experiences may lead to irrational and inefficient behaviors for disaster prevention and management.

5.2 Robustness Checks

We conduct several robustness checks in Table 5, in addition to Appendix Table A1 mentioned above. Because we have already found that the impact on the perception of risks of other types of disasters is not robust to the estimation methods, we will not perform further robustness checks of this effect.

First, although our benchmark analysis restricts the sample to farmers without any reported damage to their houses or business assets, a small tremor that did not cause any explicit physical damage but was felt by farmers may have changed their risk perception. To test this possibility, we include the distance from the epicenter as an additional control variable that measures any possible direct effect of the earthquake and examine whether the results change. The results in columns (1), (3), and (5) of Table 5 indicate that our main results are not driven by the possible direct experience of a small tremor, which is consistent with a psychological study by Ohtomo, Kimura, and Hirata (2020).

Another possible experience related to the earthquake that may be correlated with both perception and a trade disruption is the loss of close people. While farmers in the sample had no damage to either their houses or their business assets, 5.33 percent lost a family member, relative, or close friend. Such tragic experiences may remind people how fearful earthquakes are and change their risk perception. Thus, we add a dummy variable for the loss of any close person as an additional control variable. However, we do not find any significant effect of such psychological shocks, and the significant impact of economic shocks or a trade disruption is robust, as shown in columns (2), (4), and (6) of Table 5. The lack of a positive effect of bereavement on risk perceptions is consistent with Pailing and Reniers (2018) who find no effect of depression on risk perception, because bereavement often results in sadness and depression. Our These results imply that although indirect economic shocks result in the perception of higher risks, indirect psychological shocks do not.

5.3 Heterogeneity

We further explore the possible heterogeneity of the effect of indirect economic shocks due to disasters on risk perception across farmers' attributes. In particular, we focus on the following three attributes: the respondent's gender, educational level, and access to informal credit from traders.

First, the risk preference literature suggests a substantial difference between males and females (Fessler, Pillsworth, and Flamson 2004). Most notably, Hanaoka, Shigeoka, and Watanabe (2018) found gender differences in the impact of a disaster shock on risk preferences. If this is the case, the influence of disaster shocks on risk perceptions may also be different across genders because changes in risk perception are possibly correlated with changes in risk preferences (Cameron and Shah 2015). To date, no consensus on the heterogeneity in risk perception across genders has been reached, although some studies find gender differences (Armaş and Avram 2009, Ho et al. 2008, Ohtomo, Kimura, and Hirata 2020, Wachinger et al. 2013). We test this possibility by including the interaction term between the trade

disruption variable and the female dummy.

The results are presented in columns (1), (4), and (7) of Table 6. We find a significant effect of the interaction term in column (1), while its effect is statistically insignificant in the other columns. These results show weak evidence of gender differences in the effect of indirect economic shocks on risk perception, suggesting that women suffering from a trade disruption due to the earthquake evaluate a higher probability of future earthquakes than men.

Second, we test whether the effect of a trade disruption varies across the educational levels of the respondents. The literature on the relationship between educational level and the degree of risk aversion finds mixed results, as summarized by Ourtreville (2015). Therefore, we are interested in how educational level affects the effect of economic shocks on risk perception and include the interaction term between the duration of a trade disruption and the dummy variable for educational levels of high school or higher in this analysis. Our results in columns (2) and (5) indicate that more educated farmers are more likely to perceive high risks of future earthquakes when they face a trade disruption although the effects are significant at only the 10-percent level. Most likely, the reason is that educated people are more risk averse and thus raise the subjective probability of future disasters more after they experience indirect shocks due to disasters.

Finally, we investigate whether access to informal credit from traders to farmers changes the effect of a trade disruption on risk perception. Because we focus on the effect of economic shocks due to a disaster on risk perception, unlike the effect of physical shocks examined in past studies, a monetary remedy after the disaster may reduce the effect of economic shocks. For this purpose, we create a dummy variable that is coded one if the respondent had access to credit from any of his or her traders after the 2018 Sulawesi earthquake and zero otherwise. If farmers believed that they had access but did not apply for credit, the dummy variable for these farmers is also defined as one. The results using the interaction term between the duration of a trade disruption and the dummy are shown in columns (3), (6), and (9) of Table 6, presenting no significant effect of the interaction term. These findings suggest that, contrary to our theoretical conjecture, post-disaster credit relief does not necessarily weaken the impact of economic shocks on risk perception.

5.4 Impact on Risk Preferences

Finally, we test whether a trade disruption leads to risk aversion because the literature suggests that changes in the perception of risks caused by disasters cause changes in risk preferences (Cameron and Shah 2015).

Our questionnaire included hypothetical lottery questions to measure individuals' risk preferences, following the Indonesian Family Life Survey (IFLS) conducted by the RAND Institute. One notable feature of these lottery questions is that the degree of risk aversion estimated from the responses to these questions was found to be consistent with that estimated by a social experiment in rural Indonesia, according to Cameron and Shah (2015). In addition, the simplicity of the tasks in the field interview was another important feature when we obtained information from respondents, considering the low

educational level in the survey region.

Specifically, in one of the hypothetical lotteries in the survey, we provided two options and asked each respondent to choose one of the two. The first option was to receive the fixed amount of 800,000 Rp. (Indonesian rupiah), i.e., 54 USD, while the second option was to receive either 1.6 million Rp. or 600,000 Rp. with an equal probability of 50 percent. The expected payoff of the second option was 1.1 million Rp., a larger value than the fixed payoff of the first option. Following Sohn (2017), who used these lottery games, we define those individuals who selected the first option in this question as risk-averse individuals. All others are defined as non-risk-averse individuals. Based on this definition, we create a dummy variable that is coded 1 if the respondent is risk averse and 0 otherwise.

The result in column (1) of Table 7 indicates that a longer trade disruption leads to a higher probability of being risk averse. This result is consistent with past studies, such as Brown et al. (2018), Cameron and Shah (2015), Chantarat, Lertamphainont, and Samphantharak (2016), and Chantarat et al. (2019), who examined the impact of direct physical damage caused by disasters on risk aversion.

We further experiment with two variables related to risk aversion that measure the degree of conservativeness in individuals' behaviors. In the survey, we asked each respondent (1) whether they do not like changing their way once they get used to doing things in a certain way and (2) whether they like to try things that they have never done before. When the answer is yes to each of the two questions, we code the corresponding dummy variable one and otherwise zero. The results presented in columns (2) and (3) of Table 7 show no significant effect of a trade disruption on these behaviors at the 5-percent significant level. Therefore, preferences related to general behaviors may not have changed significantly.

6 Discussion and Conclusion

This paper examines whether indirect economic shocks due to natural disasters affect the risk perception of individuals who are not directly affected by disasters. Although the literature often finds a positive effect of direct and physical shocks due to disasters on risk perception, indirect economic shocks have not been considered. For this purpose, we take a disruption in the trade in cacao beans after the 2018 Sulawesi earthquake due to the destruction of transport infrastructure and warehouses as an example of indirect economic shocks and use data on cacao farmers collected after the earthquake.

Our findings can be summarized as follows. First, we find a positive effect of the duration of a trade disruption on farmers' perception of the risk of future earthquakes. Second, regarding the effect of a trade disruption on the perception of the risks of other types of disasters, we find that the effect is either statistically insignificant (in the OLS estimations in Table 4) or significant but smaller than the effect on the perception of the risk of earthquakes (in the ordered probit estimations in Appendix Table A1). Third, farmers facing a longer trade disruption tend to believe that the risk of earthquakes is higher than the risks of other types of natural disasters. Fourth, indirect economic shocks due to disasters raise the degree of risk aversion and conservativeness. Fifth, despite the significant effect of indirect economic shocks, i.e., a trade disruption, on risk perception, the effect of indirect psychological shocks, i.e., the loss of a family member, relative, or close friend, is statistically insignificant. Finally, the effect of a trade

disruption on risk perception is larger for women than for men, but we do not find heterogeneity in the effect depending on educational level or access to informal credit.

These results have several important implications. First, we find that the duration of a trade disruption increases the likelihood that a farmer will perceive a probability of the occurrence of an earthquake in 10 years as being more than 60 percent. However, recent seismic and geological studies predict that the probability of the occurrence of a damaging earthquake in the study region in 50 years is 10 percent (Watkinson and Hall 2017; Cummins, 2017). The substantial difference between the probability perceived by some farmers and predicted by seismic studies suggests that farmers who experience an indirect economic shock tend to overvalue the risk of future earthquakes. In addition, compared to the risk of earthquakes, these farmers are likely to perceive a lower risk of other types of disasters.

From the perspective of disaster risk management, such an unbalanced evaluation of the risks of disasters across different types of disasters may lead to inefficiency. For example, people who have experienced indirect economic shocks due to an earthquake may prepare for future earthquakes using extensive effort, time, and costs and thus pay little attention to preparing for other disasters, such as floods, landslides, and wildfires. Therefore, policy makers should be concerned about this possibility when they construct a disaster risk management plan after a great disaster.

Second, our findings clearly show that the effect of disasters on risk perception and preference propagates to people who are not directly affected by the disasters through trade networks. Although the propagation of the negative economic effects of disasters through supply chains has been extensively examined (Barrot and Sauvagnat 2016, Carvalho et al. 2020, Kashiwagi, Todo, and Matous 2021, Lu et al. 2017), the propagation of the psychological effects of disasters through supply chains is a new finding in the literature. Because supply chains have recently expanded within and across countries, our findings suggest that a disaster in a region may affect the risk perception of people in substantially wider regions, including regions far from the disaster area but linked with it through supply chains, than previously considered. This spatial propagation of risk perception and preference after disasters should also be incorporated into policy making.

Third, it is interesting to find that while indirect economic shocks, or trade disruptions, by the earthquake raise risk perceptions, indirect psychological shocks, or loss of any close person, do not. This finding may be related to the finding of Pailing and Reniers (2018) that depression does not significantly affect risk perception. Their finding implies that although people who lost any close person because of disasters should feel depressed, the depression may not necessarily increase perception of risks of future disasters.

Finally, one of the results should be further explored. Although we presume that the effect of economic shocks, i.e., a reduction in sales of cacao beans, can be alleviated by informal credits from traders, our results are the opposite of this presumption. Therefore, it would be interesting to examine the external validity of these results empirically and the reasons for the empirical results theoretically. We leave these issues for future research.

References

Abbate, Maria. 2007. "The “Sweet Desire” Cacao Cultivation and Its Knowledge Transfer in Central Sulawesi, Indonesia." STORMA Discussion Paper Series 17. University of Gottinggen.

Andrabi, Tahir, and Jishnu Das. 2017. "In Aid We Trust: Hearts and Minds and the Pakistan Earthquake of 2005." *The Review of Economics and Statistics* 99 (3):371-386. doi: 10.1162/REST_a_00638.

Ariningsih, Ening. 2020. Efforts in Improving Indonesian Cocoa Bean Quality Efforts in Improving Indonesian Cocoa Bean Quality. FFTC Agricultural Policy Platform.

Armaş, Iuliana, and Eugen Avram. 2009. "Perception of Flood Risk in Danube Delta, Romania." *Natural Hazards* 50 (2):269-287. doi: 10.1007/s11069-008-9337-0.

Barrot, Jean-Noël, and Julien Sauvagnat. 2016. "Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks." *The Quarterly Journal of Economics* 131 (3):1543-1592.

Bchir, Mohamed A, and Marc Willinger. 2013. "Does the Exposure to Natural Hazards Affect Risk and Time Preferences? Some Insights from a Field Experiment in Perú." LAMETA Document de Recherche, No. 2013-04. Unite Mixte de Recherche.

Boehm, Christoph E, Aaron Flaaen, and Nitya Pandalai-Nayar. 2019. "Input Linkages and the Transmission of Shocks: Firm-Level Evidence from the 2011 Tōhoku Earthquake." *Review of Economics and Statistics* 101 (1):60-75.

Brown, Philip, Adam J. Daigneault, Emilia Tjernström, and Wenbo Zou. 2018. "Natural Disasters, Social Protection, and Risk Perceptions." *World Development* 104:310-325. doi: https://doi.org/10.1016/j.worlddev.2017.12.002.

Callen, Michael. 2015. "Catastrophes and Time Preference: Evidence from the Indian Ocean Earthquake." *Journal of Economic Behavior & Organization* 118:199-214. doi: https://doi.org/10.1016/j.jebo.2015.02.019.

Cameron, Lisa, and Manisha Shah. 2015. "Risk-Taking Behavior in the Wake of Natural Disasters." *Journal of Human Resources* 50 (2):484-515.

Carvalho, Vasco M, Makoto Nirei, Yukiko U Saito, and Alireza Tahbaz-Salehi. 2020. "Supply Chain Disruptions: Evidence from the Great East Japan Earthquake." *The Quarterly Journal of Economics* 136 (2):1255-1321. doi: 10.1093/qje/qjaa044.

Cassar, Alessandra, Andrew Healy, and Carl Von Kessler. 2017. "Trust, Risk, and Time Preferences after a Natural Disaster: Experimental Evidence from Thailand." *World Development* 94:90-105.

Castillo, Marco, and Michael Carter. 2011. "Behavioral Responses to Natural Disasters." Working Papers 1026, George Mason University, Interdisciplinary Center for Economic Science.

Chantarat, Sommarat, Sirikarn Lertamphainont, and Krislert Samphantharak. 2016. Floods and Farmers: Evidence from the Field in Thailand. Puey Ungphakorn Institute for Economic Research.

Chantarat, Sommarat, Sothea Oum, Krislert Samphantharak, and Vathana Sann. 2019. "Natural Disasters, Preferences, and Behaviors: Evidence from the 2011 Mega Flood in Cambodia." *Journal of Asian Economics* 63:44-74.

Crespo Cuaresma, Jesús, Jaroslava Hlouskova, and Michael Obersteiner. 2008. "Natural Disasters as Creative Destruction? Evidence from Developing Countries." *Economic Inquiry* 46 (2):214-226.

Croson, Rachel, and James Sundali. 2005. "The Gambler's Fallacy and the Hot Hand: Empirical Data from Casinos." *Journal of Risk and Uncertainty* 30 (3):195-209. doi: 10.1007/s11166-005-1153-2.

Cummins, Phil R. 2017. "Geohazards in Indonesia: Earth Science for Disaster Risk Reduction–Introduction." Geological Society, London, Special Publications 441 (1):1-7.

Eckel, Catherine C, Mahmoud A El-Gamal, and Rick K Wilson. 2009. "Risk Loving after the Storm: A Bayesian-Network Study of Hurricane Katrina Evacuees." *Journal of Economic Behavior & Organization* 69 (2):110-124.

Eil, David, and Justin M. Rao. 2011. "The Good News-Bad News Effect: Asymmetric Processing of Objective Information About Yourself." *American Economic Journal: Microeconomics* 3 (2):114-38. doi: 10.1257/mic.3.2.114.

EM-DAT. 2021. The International Disaster Database. edited by the Centre for Research on the Epidemiology of Disasters. Brussels, Belgium.

Ertac, Seda. 2011. "Does Self-Relevance Affect Information Processing? Experimental Evidence on the Response to Performance and Non-Performance Feedback." *Journal of Economic Behavior & Organization* 80 (3):532-545. doi: https://doi.org/10.1016/j.jebo.2011.05.012.

Fessler, Daniel M. T., Elizabeth G. Pillsworth, and Thomas J. Flamson. 2004. "Angry Men and Disgusted Women: An Evolutionary Approach to the Influence of Emotions on Risk Taking." *Organizational Behavior and Human Decision Processes* 95 (1):107-123. doi: https://doi.org/10.1016/j.obhdp.2004.06.006.

Fleming, David A., Alberto Chong, and Hernán D. Bejarano. 2014. "Trust and Reciprocity in the Aftermath of Natural Disasters." *The Journal of Development Studies* 50 (11):1482-1493. doi: 10.1080/00220388.2014.936395.

Geospatial Information Authority of Japan. 2019. The 2018 Sulawesi island, Indonesia Earthquake. In The Coordinating Committee for Earthquake Prediction Seasonal Report, edited by The Coordinating Committee for Earthquake Prediction. Japan.

Giné, Xavier, Robert Townsend, and James Vickery. 2015. "Forecasting When It Matters: Evidence from Semi-Arid India." Unpublished manuscript. Available at http://www.robertmtownsend.net/sites/default/files/files/papers/working_papers/dist_art_all_10122015.pdf.

Hanaoka, Chie, Hitoshi Shigeoka, and Yasutora Watanabe. 2018. "Do Risk Preferences Change? Evidence from the Great East Japan Earthquake." *American Economic Journal: Applied Economics* 10 (2):298-330. doi: doi: 10.1257/app.20170048.

Ho, Ming-Chou, Daigee Shaw, Shuyeu Lin, and Yao-Chu Chiu. 2008. "How Do Disaster Characteristics Influence Risk Perception?" *Risk Analysis* 28 (3):635-643. doi: https://doi.org/10.1111/j.1539-6924.2008.01040.x.

Ingwersen, Nicholas. 2014. "Impact of a Natural Disaster on Observed Risk Aversion." Unpublished Manuscript.

Inoue, Hiroyasu, and Yasuyuki Todo. 2019. "Firm-Level Propagation of Shocks through Supply-Chain Networks." *Nature Sustainability* 2:841-847.

Japan International Cooperation Agency (2015), Country Report Indonesia: Natural Disaster Risk Assessment and Area Business Continuity Plan Formulation for Industrial Agglomerated Areas in the ASEAN Region. https://openjicareport.jica.go.jp/pdf/1000023394.pdf

Karlan, Dean S., and Jonathan Morduch. 2010. "Access to Finance." In Handbook of Development Economics, edited by Dani Rodrik and Mark R. Rosenzweig. Amsterdam: Elsevier B.V.

Kashiwagi, Yuzuka , and Yasuyuki Todo. 2021. "How Do Disasters Change Inter-Group Perceptions? Evidence from the 2018 Sulawesi Earthquake." RIETI Discussion Paper Series 21-E-082.

Kashiwagi, Yuzuka, Yasuyuki Todo, and Petr Matous. 2021. "Propagation of Economic Shocks through Global Supply Chains—Evidence from Hurricane Sandy." *Review of International Economics* 29 (5):1186-1220. doi: https://doi.org/10.1111/roie.12541.

Loewenstein, George F, Elke U Weber, Christopher K Hsee, and Ned Welch. 2001. "Risk as feelings." *Psychological Bulletin* 127 (2):267.

Lu, Yi, Yoshiaki Ogura, Yasuyuki Todo, and Lianming Zhu. 2017. "Supply Chain Disruptions and Trade Credit." RIETI Discussion Paper, No. 17-E-054, Research Institute of Economy Trade and Industry.

Möbius, Markus M, Muriel Niederle, Paul Niehaus, and Tanya S Rosenblat. 2014. "Managing Self-Confidence." NBER Working paper 17014.

OCHA. 2018. Central Sulawesi Earthquake Response Plan (Oct2018 - Dec 2018). United Nations Office for the Coordination of Humanitarian Affairs. https://reliefweb.int/report/indonesia/central-sulawesi-earthquake-response-plan-oct-2018-dec-2018

Ohtomo, Shoji, Reo Kimura, and Naoshi Hirata. 2020. "The 2016 Kumamoto Earthquakes' Influence on Residents' Risk Perception." 17th World Conference on Earthquake Engineering Conference Proceedings, Sendai, September 13.

Outreville, J François. 2015. "The Relationship between Relative Risk Aversion and the Level of Education: A Survey and Implications for the Demand for Life Insurance." *Journal of Economic Surveys* 29 (1):97-111.

Page, Lionel, David A. Savage, and Benno Torgler. 2014. "Variation in Risk Seeking Behaviour Following Large Losses: A Natural Experiment." *European Economic Review* 71:121-131. doi: https://doi.org/10.1016/j.euroecorev.2014.04.009.

Pailing, Adam N, and Renate LEP Reniers. 2018. "Depressive and Socially Anxious Symptoms, Psychosocial Maturity, and Risk Perception: Associations with Risk-Taking Behaviour." *PLoS ONE* 13 (8):e0202423.

Paul, Karsten I, and Klaus Moser. 2009. "Unemployment Impairs Mental Health: Meta-Analyses." *Journal of Vocational Behavior* 74 (3):264-282.

Raschky, Paul A., Reimund Schwarze, Manijeh Schwindt, and Ferdinand Zahn. 2013. "Uncertainty of Governmental Relief and the Crowding out of Flood Insurance." *Environmental and Resource Economics* 54 (2):179-200. doi: 10.1007/s10640-012-9586-y.

Reynaud, Arnaud, and Cécile Aubert. 2014. "Do Natural Disasters Modify Risk Preferences? Evidence from a Field Experiment in Vietnam." Unpublished Manuscript.

Samphantharak, Krislert. 2014. "Natural Disasters and the Economy: Some Recent Experiences from Southeast Asia." *Asian-Pacific Economic Literature* 28 (2):33-51. doi: https://doi.org/10.1111/apel.12075.

Shaik, Saleem, Keith H Coble, Thomas O Knight, Alan E Baquet, and George F Patrick. 2008. "Crop Revenue and Yield Insurance Demand: A Subjective Probability Approach." *Journal of Agricultural and Applied Economics* 40 (1379-2016-112787):757-766.

Shoji, Masahiro. 2018. "Incentive for Risk Sharing and Trust Formation: Experimental and Survey Evidence from Bangladesh." *Oxford Economic Papers* 70 (4):1062-1083. doi: 10.1093/oep/gpy019.

Sohn, Kitae. 2017. "The Risk Preferences of Entrepreneurs in Indonesia." *Bulletin of Economic Research* 69 (3):271-287. doi: 10.1111/boer.12088.

Stevens, Garry, Kingsley Agho, Melanie Taylor, Alison L Jones, Jennifer Jacobs, Margo Barr, and Beverley Raphael. 2011. "Alert but Less Alarmed: A Pooled Analysis of Terrorism Threat Perception in Australia." *BMC Public Health* 11 (1):1-11.

Van Den Berg, Marrit, Ricardo Fort, and Kees Burger. 2009. "Natural Hazards and Risk Aversion: Experimental Evidence from Latin America." 2009 Conference, Beijing, China, August 16-22.

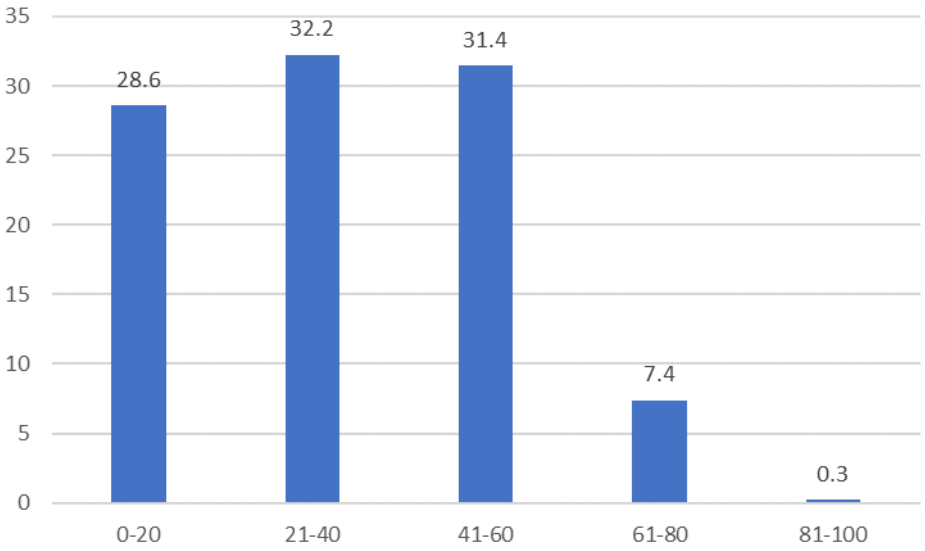
Voors, Maarten J., Eleonora E. M. Nillesen, Philip Verwimp, Erwin H. Bulte, Robert Lensink, and Daan P. Van Soest. 2012. "Violent Conflict and Behavior: A Field Experiment in Burundi." *American Economic Review* 102 (2):941-64. doi: 10.1257/aer.102.2.941.

Wachinger, G., O. Renn, C. Begg, and C. Kuhlicke. 2013. "The Risk Perception Paradox--Implications for Governance and Communication of Natural Hazards." *Risk Analysis* 33 (6):1049-65. doi: 10.1111/j.1539-6924.2012.01942.x.

Watkinson, Ian M, and Robert Hall. 2017. "Fault Systems of the Eastern Indonesian Triple Junction: Evaluation of Quaternary Activity and Implications for Seismic Hazards." Geological Society, London, Special Publications 441 (1):71-120.

Willinger, Marc, Mohamed A Bchir, and Carine Heitz. 2013. "Risk and Time Preferences under the Threat of Background Risk: A Case-Study of Lahars Risk in Central Java." Working Papers No. 13-08. LAMETA, Universtiy of Montpellier. https://EconPapers.repec.org/RePEc:lam:wpaper:13-08.

Figure 1. Distribution of the Degree of Perception of the Risk of Earthquakes



Note: This figure shows the share of farmers who chose 0-20%, 21-40%, 41-60%, 61-80%, or 81-100% as the probability of the occurrence of an earthquake within 10 years.

Table 1. Summary Statistics

Variables	Mean	S.D.	Min	Max
Number of traders (before the earthquake)	1.022	0.152	1	3
Number of days of the trade disruption	43.387	29.320	0	240
Log(number of days of the trade disruption +1)	3.433	1.091	0	5.485
Dummy for the perception of high risks of future disasters:				
Earthquakes	0.077	0.266	0	1
Large or very large earthquakes	0.045	0.208	0	1
Other natural disasters	0.022	0.146	0	1
Other large or very large natural disasters	0.015	0.123	0	1
Dummy for the perception of higher risks of earthquakes than other disasters	0.189	0.392	0	1
Dummy for female	0.185	0.389	0	1
Dummy for an educational level of middle school or higher	0.530	0.499	0	1
Age	44.892	11.097	20	83
Dummy for household heads	0.919	0.273	0	1
Total cacao production (kg/year)	719.754	557.192	0	8595
Dummy for trading good-quality cacao beans	0.786	0.410	0	1
Dummy for access to informal credit from traders	0.298	0.458	0	1
Dummy for fermentation before sales	0.000	0.000	0	0

Table 2. Correlation Between Pre-Disaster Hazard Prediction and a Post-Disaster Trade Disruption and Risk Perception

	(1)	(2)	(3)	(4)
	Dependent variable:			
	Dummy for high risks of earthquakes predicted by seismic studies before 2018	Distance from the fault line (km in log)	Post-earthquake perception of high risks of future earthquakes	
Log(# days of disruption +1)	-0.0272	1.430		
	(0.0196)	(1.0911)		
Dummy for higher risks of earthquakes before 2018			-8.43E-02	
			(0.151)	
Km distance from the fault line				0.000266
				(0.00235)
Observations	1,107	1,107	1,107	1,107
R-squared	0.0074	0.0099	0.0120	0.0002
Control	No	No	No	No
Subdistrict FE	No	No	No	No

Note: *** p<0.01, ** p<0.05, * p<0.1. Clustered robust standard errors are in parentheses.

Table 3. Correlation between a Trade Disruption and Observed Farmer Attributes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable						
Independent variable	Past experience of severe disasters	Participation in policy making	Support from government officials	Female	Age	Education (≥ middle school)	Production
Log(# days of disruption +1)	0.00607	0.00436	0.00567	0.00683	0.362	0.0298	-15.529
	(0.00386)	(0.0102)	(0.00774)	(0.00406)	(0.256)	(0.0171)	(11.0864)
Observations	1,107	1,107	1,107	1,107	1,107	1,107	1,107
R-squared	0.0022	0.0001	0.0005	0.0004	0.9757	0.0042	0.0009
Control	No	No	No	No	No	No	No
Subdistrict FE	No	No	No	No	No	No	No

Note: *** p<0.01, ** p<0.05, * p<0.1. Clustered robust standard errors are in parentheses. The variable "past experience" is a dummy for having experience of disasters in the past. The variable "participation in policy making" is a dummy variable that takes the value of one if the respondent thinks that she or he can influence decisions on Indonesian policies. "Support from government officials" is another dummy variable that indicates whether the respondent believes that she or he can ask for help from government officials in an emergency. In the age regression, we include a dummy for those who do not know their age.

Table 4. Benchmark Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable:						
	Perception of high risks of future disasters of the following type						Perception of higher risks of earthquakes than other disasters
Independent variable	Earthquakes		Large earthquakes	Other disasters		Other large disasters	
Log(# days of disruption +1)	0.0347**	0.0241***	0.0133***	0.00370	0.000786	-0.000277	0.0530***
	(0.0119)	(0.00484)	(0.00315)	(0.00215)	(0.00154)	(0.00227)	(0.0155)
Observations	1,107	1,107	1,107	1,107	1,107	1,107	1,107
R-squared	0.020	0.397	0.404	0.001	0.066	0.081	0.230
Control	No	Yes	Yes	No	Yes	Yes	Yes
Subdistrict FE	No	Yes	Yes	No	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1. Clustered robust standard errors are in parentheses. “Large earthquake” in column (3) is defined as “large” or “very large” earthquakes, i.e., the top two categories among the five in the survey.

Table 5. Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable:					
	Perception of high risks of future disasters of the following type				Perception of higher risks of earthquakes than other disasters	
	Earthquakes		Large earthquakes			
Log(# days of disruption +1)	0.0192***	0.0242***	0.0105***	0.0133***	0.0450***	0.0533**
	(0.00162)	(0.00513)	(0.00165)	(0.00326)	(0.0117)	(0.0165)
−Log(distance from the epicenter)	-0.408		-0.241		-0.614	
	(0.242)		(0.134)		(0.371)	
Dummy for the loss of close people		-0.00346		-0.00515		-0.0207
		(0.0194)		(0.00867)		(0.0868)
Observations	1,107	1,107	1,107	1,107	1,107	1,107
R-squared	0.408	0.397	0.410	0.404	0.243	0.230
Control	Yes	Yes	Yes	Yes	Yes	Yes
Subdistrict FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1. Clustered robust standard errors are in parentheses. “Large earthquake” in columns (3) and (4) is defined as “large” or “very large” earthquakes, i.e., the top two categories among the five in the survey.

Table 6. Heterogeneous Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable:								
	Perception of high risks of future disasters of the following disasters						Perception of higher risks of earthquakes than other disasters		
	Earthquakes			Large earthquakes					
Log(# days of disruption +1)	0.0219***	0.0221***	0.0288**	0.0126***	0.0110***	0.0142*	0.0495**	0.0572***	0.0601***
	(0.00419)	(0.00374)	(0.00962)	(0.00302)	(0.00252)	(0.00746)	(0.0176)	(0.0118)	(0.0159)
– × dummy for female	0.0142***			0.00421			0.0217		
	(0.00270)			(0.00227)			(0.0195)		
– × dummy for high education		0.00481*			0.00833*			-0.0231	
		(0.00252)			(0.00399)			(0.0267)	
– × dummy for access to credit			-0.0181			-0.00647			-0.0305
			(0.0163)			(0.0130)			(0.0183)
Observations	1,107	1,118	1,107	1,107	1,118	1,107	1,107	1,122	1,107
R-squared	0.397	0.401	0.401	0.404	0.405	0.405	0.230	0.224	0.236
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Subdistrict FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1. Clustered robust standard errors are in parentheses. “Large earthquake” in columns (4)-(6) is defined as “large” or “very large” earthquakes, i.e., the top two categories among the five in the survey.

Table 7. Impact of a Trade Disruption on Risk Preferences

	(1)	(2)	(3)
	Dependent variable		
	Risk averse	Conservative	To love trying new things
Log(# days of disruption+1)	0.108***	-0.0107	-0.0413*
	(0.0115)	(0.0190)	(0.0211)
Observations	1,107	1,107	1,107
R-squared	0.222	0.233	0.370
Control	Yes	Yes	Yes
Subdistrict FE	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1. Clustered robust standard errors are in parentheses.

Appendix Table A1. Results of Ordered Probit Estimations

	(1)	(2)	(3)	(4)
	Dependent variable			
	Categorical variable for the level of future disasters		Categorical variable for the perception of high risks of future disasters	
	Earthquakes	Other disasters	Earthquakes	Other disasters
Log(# days of disruption +1)	0.147***	0.0944**	0.194***	0.117***
	(0.0395)	(0.0444)	(0.0587)	(0.0328)
Observations	1,107	1,103	1,107	1,107
Control	Yes	Yes	Yes	Yes
Subdistrict FE	Yes	Yes	Yes	Yes

Note: *** p<0.01, ** p<0.05, * p<0.1. Clustered robust standard errors are in parentheses. Each dependent variable is based on 5-level categories from 1 (very small, i.e., 0-20%) to 5 (very large, i.e., 81-100%).