The Nexus between Natural disasters, Supply Chains and Trade – Revisiting the Role of FTAs in Disaster Risk Reduction

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Abstract

Taking into account global phenomena such as the increased frequency of natural disasters as well as the proliferation of the 'deep' preferential trade agreements (PTAs), this study explores the nexus between natural disasters, supply chains and trade. Using recent international longitudinal data, the study presents a gravity model to understand the impacts of natural disasters on global value chain participation, and to assess whether a country's FTA with its trading partners and the "depth" of those agreements could cushion or magnify the GVC effects of natural disasters. The empirical results and policy discussions presented in this study provide insights into how international commitments should better address ways to minimise the loss, and promote disaster management in agriculture and beyond.

Keywords: natural disasters, supply chains, trade, agriculture

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1. Introduction

Earthquakes, tsunamis, bushfires and other extreme natural disasters have brought devastating implications for communities across the globe. There has been a significant increase in the average number of natural disasters from about 30 per year in the 1950s to more than 400 since 2000 (Oh and Reuveny 2010). As summarised by Oh and Reuveny (2010), in addition to more complete documentation of and spread of information about disaster events (Peduzzi 2005), this rising trend has been driven by multiple factors such as population growth and housing development (Strömberg 2007) including those in vulnerable areas such as hurricane-prone coastal areas in the US (Pielke et al. 2008), as well as the increased number of extreme weather events (IPCC 2007).

The rising economic loss experienced by disaster-hit countries is also of a significant concern. Between 1998 and 2017 climate-related and geophysical disasters killed 1.3 million people and caused a further 4.4 billion injured with direct economic losses valued at US$ 2.2 trillion up from US$1.3 billion in 1978-1997 (UNDRR 2018). The UNDRR also highlights a possible under-reporting by low-income countries that only reported 13% of disasters compared to over half of the disasters reported by high-income countries.

There is an increasing number of studies that look at the impacts of natural disasters and climatic events on the affected countries' participation in international trade and global value chains (GVCs). Gassebner et al. (2010) using data from 1962 to 2003 and a gravity model suggest that an additional disaster reduces imports on average by 0.2% and exports by 0.1%. Studies also find differing impacts of natural disasters and climatic events with smaller and poorer countries more severely affected (Da Silva and Cernat 2012, Jones and Olken 2010, Klomp and Valckx 2014). It is argued that the natural disasters affect the exports of small developing countries more significantly than those of large developing countries (Da Silva and Cernat 2012). Meanwhile, one degree Celsius increase reduces the growth of a poor country's exports by 2.0-5.7 percentage points while no significant effect is found on rich countries (Jones and Olken 2010).

The increased interconnectedness between countries including through the proliferation of trade agreements and the forming of global value chains implies that local natural disasters can cause 'global effects'. Failures in supply chains is widely seen as a potential transmission mechanism especially in the event of large natural disasters (Puzzello and Raschky 2014). On the other hand, the existence of economic ties including those achieved through free trade agreements (FTAs) could facilitate coordination and implementation of responses to disasters. This highlights a possibility that the disaster effects vary between the different degrees of trade commitments.

Discussions on the cross-border effects of natural disasters are typically centred around two themes. First, there is a concern regarding the disaster-hit nations' capacity to meet their international obligations. At the 11th World Trade Organization (WTO) Ministerial Conference in Buenos Aires a discussion on Special and Differential Treatment took place. If agreed, this SDT provision would allow developing countries to deviate from GATT obligations at the aftermath of the natural disasters. However, the discussion failed to reach a consensus. Secondly, in addition to continued efforts to improve coordination in humanitarian work, there is also an increased interest in revisiting the role of FTAs. Many view that trade agreements can serve as a platform to facilitate freer movements of goods and services during the recovery stage for example through simplified customs clearance, economic and technical cooperation. Addressing these topics, a series of workshops on linking the natural disasters to the trade

domain were organised by the WTO[2]. One policy question is whether 'deep trade agreements', which refer to preferential trade agreements (PTAs) involving deeper level commitments than those agreed at WTO (WTO^{+}) and new areas not covered in the WTO agreements (WTO^{X}) (Horn et al. 2010), could cushion the natural disaster effects on global value chains and international trade. On the other hand, deeper trade commitments also mean stronger trading relationships hence vulnerability of a country to a disaster occurred in its trading partner.

Despite those increased interests, studies that simultaneously look at the nexus between natural disasters, supply chains, and FTAs remain lacking. Much literature focuses on *either* the relief supply chain (Afshar and Haghani 2012, Day et al. 2012, Gatignon et al. 2010), climate-related risks and resilience of supply chains (Fleming et al. 2014, Mwongera et al. 2019, Vermeulen 2015), or the link between natural disasters and political-socio-macroeconomic performance aspects such economic growth, political risks, and international trade (Adam 2013, Bergholt and Lujala 2012, Felbermayr and Gröschl 2013, Klomp and Valckx 2014, Oh and Reuveny 2010, Skidmore and Toya 2002). An exception is Puzzello and Raschky (2014) who use measures of the vulnerability of global value chains to natural disasters in order to analyse the effects of large natural disasters on the trade volume and take into account the General Agreement on Tariffs and Trade (GATT) membership. Much information is still needed to understand the role of both bilateral and regional preferential trade agreements (PTAs) in moderating the disaster effects.

This study tests two hypotheses using modified gravity models. First, it aims to investigate the effects of (i) bilateral and regional PTAs and their depth; and ii) natural disasters on global value chain participation. Second, the study also looks at whether these PTAs could minimise the GVC effects of natural disasters by using the interaction terms between the PTA and disaster variables. This study uses data from multiple data sources. The dependent variable i.e. GVC participation is derived from the 2016 version of the World Input-Output Database (WIOD), while disasters data are from the EM-DAT database. Several PTA-related variables are used, namely a dummy variable; the number of years since the first PTA between two trading partners came into effect; and "PTA depth" variables derived from the World Bank's Content of Deep Trade Agreements Database at the World Bank i.e. the number of legally enforceable provisions in the PTA; the number of core provisions; the number of WTO+ and WTOX provisions. Other variables such as GDP, population, bilateral distance, dummies on colonial relationship, common language and whether at least one trading partner is landlocked, and agricultural land are also included. An agriculture-specific analysis is also presented to provide an improved understanding of the economic loss from natural disasters. While few studies have looked at the impacts of PTAs on agricultural trade (Koo et al. 2006, Serrano and Pinilla 2012, Sun and Reed 2010), little is known about the association between the depth of PTAs, GVC participation and disaster effects.

Results from our empirical work show that while the depth of trade agreements matter for promoting GVC participation, the disaster effects on the GVC participation are stronger when there is a trade agreement between the trading partners. This finding supports the earlier argument that the forming of regional and bilateral trade agreements has contributed to the development of regional and global supply chains, hence a risk profile that increases economic vulnerability of a region with high economic interconnectedness. Policy discussions in this article include recommendations on how disaster risk management including responses to disaster emergency, recovery and redevelopment as well as mitigation and preparedness can

[2] More information accessible here:
https://www.wto.org/english/tratop_e/devel_e/sympnaturaldisaster10052019_e.htm

be better facilitated by trade agreements, which would be useful to aid future trade agreements and during the review process of existing trade agreements.

2. Literature Review

There are at least two streams in the existing literature that addresses the link between natural disasters and supply chains. First is on the relief supply chains. Making reference to the multiple stages of disaster management (e.g. preparedness, impact, response, recovery, development and mitigation (Carter 2008)), vast literature on this theme focuses on topics such as key principles in humanitarian logistics such as leanness and agility, the importance of coordination, and differences between relief and commercial chains (Balcik et al. 2010, Cozzolino et al. 2012, Oloruntoba and Gray 2006, Russell 2005).

Another stream in the literature is the supply chain vulnerability to disasters (Balcik et al. 2010, Wagner and Bode 2006). Firms might lose their workers due to death, injury, or sickness. Disasters can cause a shift in priorities to recovery assistance, which may mean the lack of available transport and logistic facilities to operate commercial supply chains. Moreover, the prices of fuel and other production inputs may increase following the post-disaster major reconstruction. Disaster effects can also spread beyond the affected sectors and regions. Analysing the effects of over 3,500 disasters on more than 100,000 firm-year observations over 15 year, for instance, a study finds that disasters impact all sectors within a supply chain (Altay and Ramirez 2010). There is obviously variations in the supply chain vulnerability to disasters. At the firm level, firm's exposure to supply chain risks are related to its dependence on specific customers and suppliers, the degree of single sourcing, and reliance on global supply sources are related to (Wagner and Bode 2006).

The growth of global and regional supply chains raises over the cross-border effects of natural disaster. This is where the role of international trade in supply chain operations comes into play. The link between the topics of supply chains and trade has been addressed by a relatively large volume of literature with many focusing on the regional production network in East Asia. It is perceived that the cross-border flows of goods, services, investment, know-how and people involved in the production networks or labelled as 'supply-chain trade' by Baldwin (2012) has led to the world transformation. The opening up of economies presents opportunities for firms to source inputs from overseas, and breakdowns the production process into multiple tasks and relocate these tasks to other countries.

The increased frequency of natural disasters and other shocks including the COVID-19 pandemic challenge whether our earlier understanding of potentials from global value chain (GVC) network remains valid. **Figure 1** shows that the occurrence of natural disasters had generally decreased between 2000 and 2014. Globally, excluding the number of biological and technological disasters, the total number of disasters in a year reached its peak in 2005 with 433 disasters recorded in the EM-DAT database.[3] Of these, about 8% were "major disasters", which refer to disasters that meet at least one of the following criteria adopted by Gassebner et al. (2010): (i) the number of killed is no fewer than 1000; (ii) the number of injured is no fewer

[3] See further explanation about the dataset in the next section.

than 1000; (iii) the number of affected is no fewer than 100,000; or (iv) the amount of damages is no less than $1 billion.

Despite the decreasing trend in the number of major disasters, there is no sign of decreasing total damage as shown in **Figure 2**. For instance, in 2005 when the US was hit by Hurricane Katrina, the country's total damage was $158 billion. In 2011, devastatingly affected by tsunami and earthquakes, Japan's total damage was recorded at $210 billion. At the global level, the average total damage between 2000 and 2014 was estimated at $400 million per disaster. This substantial cost highlights the importance of continued work toward disaster risk reduction.

[INSERT FIGURES 1 AND 2 HERE]

Meanwhile, limiting to legally binding provisions, **Figure 3** suggests that countries continue to increase their trade commitments as indicated by the increased in number of legally binding provisions as well as legally binding WTO^{+}, WTO^{X}, and core provisions.[4] If these increased international obligations are seen as an asset towards international cooperation on disaster risk reduction, a key question is on whether and the extent to which the trade agreements help cushion the disasters effects.

[INSERT FIGURE 3 HERE]

Connecting the dots, the present study looks at the nexus between trade, supply chain and natural disasters. It is mostly relevant to the literature on the impacts of natural disasters on trade and global value chain participation. Natural disasters might be negatively associated with trade volume given their impacts on human and physical capitals which could to a decrease in production, increased in trade costs following the increased in transportation costs due to longer routes to reach markets, increased premiums; or could lead to an increase in trade volume driven by the reconstruction of the affected areas, inflows of development assistance and a price increase (despite a decrease in the quantity). The magnitude of the trade effects of natural disasters, however, is an empirical matter.

Using international data from 1950 to 2005, a study finds that large disasters that hit the trade partners are negatively associated with bilateral openness with 1% increase in the number of disasters associated with 0.8% reduction in bilateral openness (Felbermayr and Gröschl 2013). Meanwhile, another study using data from 1962 to 2003, suggests that an additional disaster is associated with a decline in both imports and exports on average by 0.2% and 0.1%, respectively (Gassebner et al. 2010). What is not very clear is that in the event of natural disasters, whether the trade agreements could play a role in disaster risk reduction, whether their 'depths' and what aspects of the agreements that matter most.

[4] The core provisions include 18 areas: Anti-dumping (AD); Customs; Countervailing measures (CVM); Export taxes; FTA agriculture; FTA industrial or customs; General agreement on trade in services (GATS); Public procurement; Sanitary and phytosanitary measures (SPS); State aid; State trading enterprise (STE); Technical barriers to trade (TBT); The Agreement on Trade-Related Investment Measures (TRIMs); The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs); Competition policy; Intellectual property right (IPR); Investment; and Movement of capital.

Today's PTAs that are more plentiful and deeper have increasingly become more relevant to the global value chain (GVC) context. Going beyond traditional market access, deep PTAs also cover provisions on investment, competition policy, standards, economic and technical cooperation and many others. Studies find that trade agreements could drive foreign direct investment through the reduction or removal of trade barriers between parent firms and their affiliates, and freer flows of capital allowing business expansion in the host countries (Thangavelu and Findlay 2011, Thangavelu and Narjoko 2014), while provisions on trade in services are relevant to transport, logistics, information and communication services, and finance aspects of the GVC (Findlay 2011).

Only few studies link between natural disasters and trade agreements. One of these is Puzzello and Raschky (2014) that include both natural disasters variable and GATT membership. There is room to improve the analysis presented by Puzzello and Raschky (2014) by two-fold. First is to include PTAs and consider their variations in the depth. To address the heterogeneity of trade agreements, recent studies look at the depth of various PTAs as proxied by the number of WTO^{+} and WTO^{X} provisions covered, and how this affects various economic indicators including GVC participation (Horn et al. 2010, Laget et al. 2018). The availability of a new database at the World Bank which provides information about the policy areas covered in each agreement based on a list of 52 policy areas, and whether each provision is legally enforceable allows further studies on addressing the possible association between the PTA and macroeconomic performance beyond that presented by the significance of a dummy on PTA.

Second is to consider a possible interaction effect that the effects of natural disasters on trade and GVC participation are less when the affected country and its bilateral partner have a trade agreement in effect. **Figure 4** shows some possible links between disaster management, supply chain perspectives and trade aspects and the three hypotheses to be tested in this study.

[INSERT FIGURE 4 HERE]

3. Empirical Model and Data

The objective of the empirical work in this study is to assess the heterogeneity of PTAs and whether this affects GVP participation, and minimises disaster effects. This study most relates to those applying a panel data and gravity model approach to study trade and other economic variables such as income per capita that incorporates natural disasters (Felbermayr and Gröschl 2013, Gassebner et al. 2010, Laget et al. 2018, Oh and Reuveny 2010).

To assess the impacts of disasters and PTA on GVC participation, the following baseline specification is tested:

$$GVC_{eit}^{k} = \beta_0 + \beta_1 PTA_{eit} + \beta_2 DISASTER_{et} + \beta_3 DISASTER_{it} + +\beta_4 DISASTER_{et} \times PTA_{eit} + \beta_5 DISASTER_{it} \times PTA_{eit} + +\gamma_1^{'} X_{et} + \gamma_2^{'} X_{it} + \gamma_3^{'} Z_{ei} + \alpha_e + \alpha_i + \alpha_t + \varepsilon_{eit} \quad (1)$$

Two dependent variables ($k = 1,2$) are tested for each of the exporting e and importing country i, namely DVA_{eit} and FVA_{eit}. These variables are derived from the World Input-Output Database (WIOD) (Timmer et al. 2015, Timmer et al. 2016) which has been used by studies such as Laget et al. (2018). The 2016 version of the WIOD is used in this study covering data from 2000 to 2014 for 43 countries. Following the accounting framework applied by

earlier studies (Borin and Mancini 2019, Koopman et al. 2014), trade data are decomposed into two parts, namely domestic content (DC) that is originally produced by the exporting country, and foreign content (FC), which is produced abroad. Each of the DC and FC is further split into two parts of value added item –that is domestic value added (DVA) and foreign value added (FVA)— and a double counting item. The analysis therefore uses these two variables DVA_{eit} and FVA_{eit}, which capture forward and backward linkages, respectively.

As illustrated in Figure 1, this study looks at two main explanatory variables. First is the disaster variables $DISASTER_{et}$ and $DISASTER_{it}$, which are the total number of large disasters affecting the exporting and importing countries, respectively. Disasters data are from a global database on natural and technological disasters, namely the "Emergency Events Database" maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université catholique de Louvain in Brussels, Belgium (EM-DAT n.d.). This EM-DAT database has been widely used by studies investigating the disaster effects on economic performance (Auffret 2003, Kahn 2005, Neumayer and Plümper 2007, Puzzello and Raschky 2014, Rasmussen et al. 2004, Skidmore 2001, Yang 2008). At the time of preparing this article, disasters data are available from 1900 to 2019, covering 224 countries.

The EM-DAT database classifies the natural and technological disasters into several categories: (i) biological (animal accident, epidemic, insect infestation); (ii) climatological (wildfire, drought); (iii) extra-terrestrial (impact); (iv) geophysical (volcanic activity, earthquake, mass movement); (v) hydrological (flood, landslide); (vi) meteorological (extreme temperature, storm, fog); and (vi) technological (transport accident, industrial accident, etc.). It is important to note that the inclusion of a disaster into the EM-DAT database must meet one of the following criteria: (i) 10 or more people dead; (ii) 100 or more people affected; (iii) the declaration of a state of emergency; or (iv) a call for international assistance. We therefore refer the disasters included in this analysis as "major disasters".

We set two inclusion criteria. First, biological and technological disasters are excluded. Secondly, to focus on the impact of large-scale disasters, from which cross-border effects on GVC participation most likely occur, this study limits to disasters that meet *at least one* of the following criteria adopted by Gassebner et al. (2010): (i) the number of killed is no fewer than 1000; (ii) the number of injured is no fewer than 1000; (iii) the number of affected is no fewer than 100,000; or (iv) the amount of damages is no less than $1 billion. To allow comparisons over time, the dollar values are converted into constant 2000 dollars using the US GDP deflator[5]. The analysis looks at the number of large disasters in both exporting and importing countries denoted by $DISASTER_{et}$ and $DISASTER_{it}$, respectively.

The second main explanatory variable in participation in PTAs. Several PTA-related variables are used to better understand what aspect of PTA that is correlated with GVC participation and disaster effects. First, similar to what commonly used in studies looking at the effects of PTAs on economic performance, a dummy variable PTA_{eit} is used and equals to one if the exporting country e and importing country i are parties of at least one PTA at period t. One may concern about the endogeneity of this PTA dummy variable. A study finds that while the cross-section techniques using instrumental variables and control functions are not able to provide stable estimates of the average treatment effects of the PTA, the use of panel data presents convincing empirical evidence (Baier and Bergstrand 2007). Specifically, to capture unobserved time-invariant variables that are likely correlated with PTAs, the estimates are best controlled using

[5] The GDP Implicit Price Deflator in United States is from Federal Reserve Bank of St. Louis Economic Research. See the website https://fred.stlouisfed.org/series/USAGDPDEFAISMEI.

"fixed effects" compared to the random effects which assume zero correlation between those unobserved variables and PTA. Despite its usefulness, the drawback of this variable is evident that it does not acknowledge that PTAs are heteregenous.

Second, this study introduces $PTAyr_{eit}$ which is the number of years since the first PTA between two trading partners came into effect. It proxies the intensity of trade agreements where the longer a PTA has been in effect the stronger incentives to deepen GVC participation of the participating countries. This variable is also to reflect results from a review process of a PTA. Most PTAs go through a review process after several years of implementation to ensure the suitability of provisions included in PTAs to their current economic circumstances. Many of these review processes lead to improved provisions (e.g. new areas to be covered or stronger commitments within the agreed areas). Such an improvement is not captured by information in the Content of Deep Trade Agreements Database.

Thirdly, following Laget et al (2018), this study exploits data from the Content of Deep Trade Agreements Database at the World Bank (Hofmann et al. 2017). The database maps 52 provisions in 279 PTAs notified at the WTO signed between 1958 and 2015, and covers 189 economies. Four variables derived from the database are included: (i) $PTAlegal_{eit}$, which is the number of legally enforceable provisions included in an agreement between exporting country e and importing country i at time t; (ii) $PTAcore_{eit}$, which is the number of core provisions (out of 18 core provisions that have a clear economic content) in an agreement between exporting country e and importing country i at time t; (iii) $PTAWTOplus_{eit}$ and $PTAWTOextra_{eit}$ which are the number of WTO^{+} and WTO^{X} provisions in an agreement between exporting country e and importing country i at time t.

In addition to disasters and PTA data, the analysis also other including time varying country-specific variables such as gross domestic product (GDP_{et} and GDP_{it}), population (POP_{et} and POP_{it}) taken from the World Development Indicator database (The World Bank n.d.) and time invariant pair-specific variables such as bilateral distance $DISTANCE_{ei}$, dummies on colonial relationship ($COLONIAL_{ei}$), common language ($LANGUAGE_{ei}$), and whether at least one trading partner is landlocked ($LANDLOCKED_{ei}$) taken from the CEPII GeoDist database (Mayer and Zignago 2011). These variables have been widely used by studies applying gravity models (Gassebner et al. 2010). **Table 1** lists down descriptions and sources of all variables used in this study. We also include exporting country-specific (α_e), importing country-specific (α_i), and time fixed effects (α_t). Given the availability of different databases, this study uses data from 39 countries (the list of which is shown in **Appendix 1**) covering the years 2000 to 2014. It is important to note many countries included in this analysis are advanced economies, hence differences in variables such as GDP compared to the world average.

Table 2 presents the descriptive statistics. Between 2000 and 2014, the average GVC participation of the sample countries as indicated by variables DVA and FVA more than doubled and tripled, respectively. The dummy variable of involvement in trade agreements increased from 0.2 in 2000 to 0.6 in 2014. The depth of trade agreements that these countries are involved in also increased by five-fold as indicated by variables WTO^{X}, WTO^{+} and $CORE$.

[INSERT TABLE 2 HERE]

4. Results

Table 3 presents results from the basic specification based on Equation 1. Two dependent variables, DVA and FVA in their natural logarithm forms are estimated. With regard to the

standard gravity models such GDP, population, distance, and colonial relationship, the results show the expected sign. For brevity, we focus our discussion on the disaster and PTA variables. Across the two dependent variables and different specifications, PTA_{ei} coefficients are highly significant. Deriving the average marginal effects, the GVC participation as indicated by forward (DVA) and backward (FVA) linkages will be 22-23% and 20-22%%higher for country pairs with trade agreements in place than those who have no PTA, respectively.

As shown in Columns (1) and (2) for DVA_{ei} and Columns (5) and (6) for FVA_{ei}, the simple disaster count variable is neither significant for the importing nor for the exporting country. This finding is similar to that of Gassebner et al (2010). We therefore follow their next step by 'scaling' the number of major disasters by the area of the affected country to produce $DISASTERAREA_e$ and $DISASTERAREA_i$ as shown in Columns (3) and (4) for DVA_{ei} and Columns (7) and (8) for FVA_{ei}. The significance and magnitude of other variables are unchanged despite the inclusion of these rescaled variables. In Columns (3) and (7), we find that these variables for both exporting and importing countries are significant at 5% level of significance. While a disaster in the exporting country is negatively associated with both DVA_{ei} and FVA_{ei}, the occurrence of a disaster in the importing country is positively associated with both DVA_{ei} and FVA_{ei}. However, when the interaction terms between these rescaled disaster variables and the PTA dummy are included in Columns (4) and (8), the coefficients for $DISASTERAREA_e$ are no longer significant. In contrast, the rescaled disaster variable in the importing country remains positive and significant.

The results suggest the following. First, to answer the third hypothesis listed in Figure 4, we find a consistent evidence of the positive and significant association between PTA participation and the GVC measures, both forward and backward linkages using different specifications including various disaster variables and interaction terms. Countries take advantage of the PTA participation to strengthen their roles in the global and regional supply chains through the use of both domestic and imported intermediate goods in the production of their export products.

[INSERT TABLE 3 HERE]

Addressing the first and second hypotheses, however, is not straightforward especially when the interaction term between the natural disaster and PTA variables is taken into account. We therefore derive the marginal effects at means of natural disasters on GVC (**Table 4**). One unit increase in the rescaled disaster variable experienced by an exporting country ($DISASTERAREA_e$) is associated with about three-fold and 2.6 times reduction in its DVA and FVA. Meanwhile, we find no significant effect of the rescaled disaster variable of the importing country. Noting a possibility that such disaster effects are influenced by PTA participation, we look at the marginal effects of the rescaled disaster variables by PTA participation as shown in **Figure 5**. On its effect on the forward linkage as indicated by DVA, we find that the GVC participation of country pairs engaged in a PTA are more affected by disasters than those with no PTA put in place. This observation applies to both forward and backward GVC activities as proxied by DVA and FVA, respectively. This finding may imply that the close economic relationships between two trading partners as resulted from and further improved by the implementation of PTAs mean more direct transmission channels of the impacts of a disaster especially when the disaster hits the exporting country. The results also suggests room for improvement in terms of how the PTA should address this close interconnectedness as part of the disaster risk reduction efforts.

[INSERT TABLE 4 HERE]

[INSERT FIGURE 5 HERE]

Next, we take into account the possible heterogeneity of PTAs. **Table 5** presents the estimates. All of the PTA variables being tested have positive coefficients implying the GVC-enhancing effects of those PTAs. While the magnitude of these coefficients are very similar, we note that the coefficients for $CORE_{ei}$ and WTO_{ei}^{+} variable as shown in Columns (1), Columns (5) and (6) are the highest. On the disaster variable, the significance and positive signs of the $DISASTERAREA_i$ variable are relatively consistent throughout different specifications. Taking into account the interaction term between the depth of trade agreements and disaster variables, based on the average marginal effects at different levels of trade commitments, overall we find similar interpretation as that of results from Table 3. Despite the positive and significant effects of 'deeper' trade agreements, these close economic ties position trading partners in more vulnerable position when a disaster occurs especially in the exporting country.

[INSERT TABLE 5 HERE]

Finally, we focus on agricultural trade to assess the impact of natural disasters and how PTA could 'cushion' such effects. Agricultural production's reliability on natural resources implies its vulnerability to disasters, and disturbance in agricultural trade could impact not only the income of producing countries but also the food security status of both disaster-affected and food importing countries. Despite this vulnerability and possible widespread effects, humanitarian aid and official development assistance to the agriculture sector is small when compared with its economic contribution and the industry needs. It is therefore important to revisit the sector contribution particularly within the context of GVC participation.

The application of a gravity model has been used by a large number of studies to assess factors affecting agricultural trade flows between two countries including the impacts of FTAs (Koo et al. 2006, Natale et al. 2015, Parra et al. 2016, Serrano and Pinilla 2014, Serrano and Pinilla 2012, Sun and Reed 2010). Differences in in the effects of FTAs by different FTAs, product types, and membership are observed from their findings. Serrano and Pinilla (2012), for instance, find significant and positives effects of regional trade agreements, albeit at varying degrees, on agricultural trade and argue that given the high degree of protectionism in the sector, trade liberalisation effects in agriculture have been greater than in other sectors.

Table 6 presents the estimates for the agriculture sector, which includes the following: (1) Crop and animal production, hunting and related service activities; (2) Forestry and logging; and (3) Fishing and aquaculture. Similar to results in Table 3, all of the PTA variables being tested have positive coefficients implying the GVC-enhancing effects of those PTAs. On the depth of trade agreements, while the magnitude of these coefficients are very similar, we note that the coefficient for WTO_{ei}^{+} variable as shown in Columns (4) and (8) are the highest. Our interpretation of the disaster effects across different degrees of trade commitments remain the same as that from using cross-sectoral datasets presented earlier. Despite the overwhelmingly positive impacts of a PTA, this close economic tie increases a country's exposure to the effects of a disaster occured its trading partner.

[INSERT TABLE 6 HERE]

5. Policy discussions

The empirical results warrant a further consideration over how disaster risk management including responses to disaster emergency, recovery and redevelopment as well as mitigation

and preparedness should be better facilitated by trade agreements. Such consideration should be taken into account for future trade agreements and during the review process of existing trade agreements.

While identifying which specific aspects of a trade agreement matters for enhancing GVC participation during and in the post-disaster period is beyond the scope of the analysis presented here, there are some possible linkages between disaster stages, supply chain operations and relevant areas in trade agreements that future studies can investigate. **Figure 6** presents the summary. Our discussion focuses on aspects, namely trade facilitation, various trade-related aspects, transparency, equity and effects on agriculture.

[INSERT FIGURE 6 HERE]

First, current policy discussions and existing standards and guidelines[6] put much emphasis on the role of trade facilitation, which as shown by Figure 5 affects all stages of disaster management. The World Bank, for instance, highlights some issues at border management that impede the rapid entry of relief goods and personnel into the affected area including differences in standards between the sending, transit, and receiving countries; imposition of taxes on humanitarian consignments, and the overall burdensome processes (The World Bank 2014).

Noting these issues, while the WTO Trade Facilitation Agreement does not explicitly address humanitarian emergencies, the full implementation of its provisions could assist the countries' responses to these emergencies particularly with regard to transparency, coordinated border management, applying risk based approaches, pre-arrival processing, and priority treatment of perishable goods. and risk management (The World Bank 2014).

The second important aspect is transparency. Under Article 1 of the TFA WTO members shall promptly make available specific information related to procedures for clearing goods for import or export. To this end, the availability of information on relief procedures could assist humanitarian organisations to prepare before the disaster strikes. A publication by the Indonesian customs agency at the World Customs Organisation (WCO) website, for example, provides information that under its Customs Law Number 17/2006 and the Minister of Finance Regulation Number 11/1997 (as amended by Regulation Number 64/2007) donated goods are exempt from import duty and other import taxes (Directorate General of Indonesian Customs & Excise 2010). The formalities to obtain such an exemption, however, require multi-layer processes at local offices, customs headquarters, and the finance minister. Problems such as the shortage of customs officers and the lack awareness of sending countries about customs formalities for donated goods have been identified by the Indonesian customs agency.

Thirdly, beyond transparency, customs procedures and trade facilitation, trade aspects related to disaster management cover other dimensions as shown in Table 3. Enhancing disaster preparedness may require investments in initiatives using advanced technologies and involving

[6] For example, the Recommendations of the WCO to Expedite the Forwarding of Relief Consignments in the Event of Disasters (1970); the Special Annexes of the revised International Convention on the Simplification and Harmonization of Customs Procedures (Revised Kyoto Convention) i.e. Annex B.3 and J.5; the WCO Convention on Temporary Admission (1990); and Guidelines for the domestic facilitation and regulation of international disaster relief and initial recovery assistance (2007), among others.

cross-border transfer of information (for example to develop early warning systems). FTA provisions in intellectual property and e-commerce, respectively may therefore be relevant.

The fourth aspect is on equity. More vulnerable groups of the population should be given more attention. Small and medium enterprises are more susceptible to disaster effects. Taking lessons from the Japan earthquake and Thailand floods, natural disasters have inhibited the development of SMEs and creating high levels of unemployment (Ye and Abe 2012). Likewise, those working in agriculture, for example are most likely to experience more adverse effects of natural disasters than those operation in other sectors. Capacity building programs through provisions under the Cooperation chapter of an FTA may be strategic to address the needs for FTA partners to enhance their disaster preparedness so that they can continue their journey towards deeper economic integration.

Lastly, we view the importance of further work on disaster effects on the agricultural sector both within research and policy domains. Despite its importance, humanitarian aid and official development assistance to the agriculture sector is small when compared with its economic contribution and the industry needs. Between 2003 and 2013, about US$ 4 billion had been spent on humanitarian assistance to the agriculture sector or in average US$ 375 million per annum (FAO 2015). This share for agriculture represents only 3.4% of all humanitarian aid despite the devastating impacts on the sector accounting 22% of total damage and losses caused by natural hazards (FAO 2015).

6. Concluding remarks

It is within all countries' national interest to dedicate more focus on further enhancing its relief supply chain as well better understanding the nexus between trade, supply chain, and natural disasters within the contexts of its current response to natural disasters—both at home yard as well as those affecting the trading partners. The development of regional and even global supply chains have also formed a risk profile that can increase economic vulnerability in a region with high economic interconnectedness through direct and indirect disaster risks (Ye and Abe 2012).

Results from our empirical work show a strong evidence of the association between the depth of trade agreements and GVC. However, this strong trade commitments also increases a country's exposure to the disaster effects occurred in its trading partner. Consideration over the risks of natural disasters should therefore be taken into account in the trade negotiations and future reviews of the existing FTAs. We suggest that future work should further look into topics such as trade facilitation, various trade-related aspects, transparency, equity and effects on agriculture.

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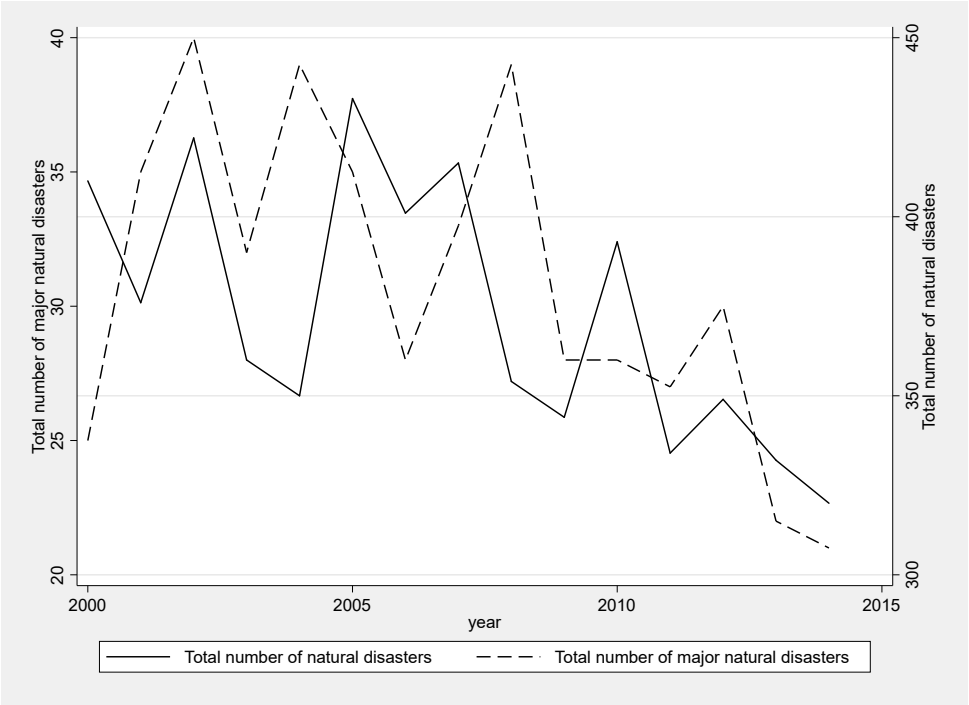
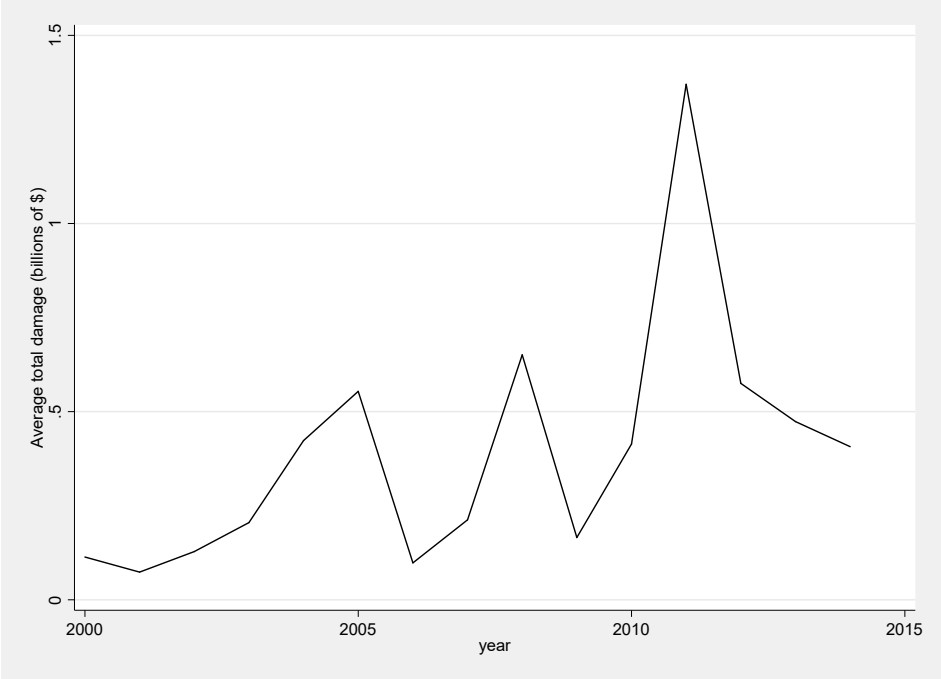
Figure 1. The frequency of natural disasters, 2000-2014



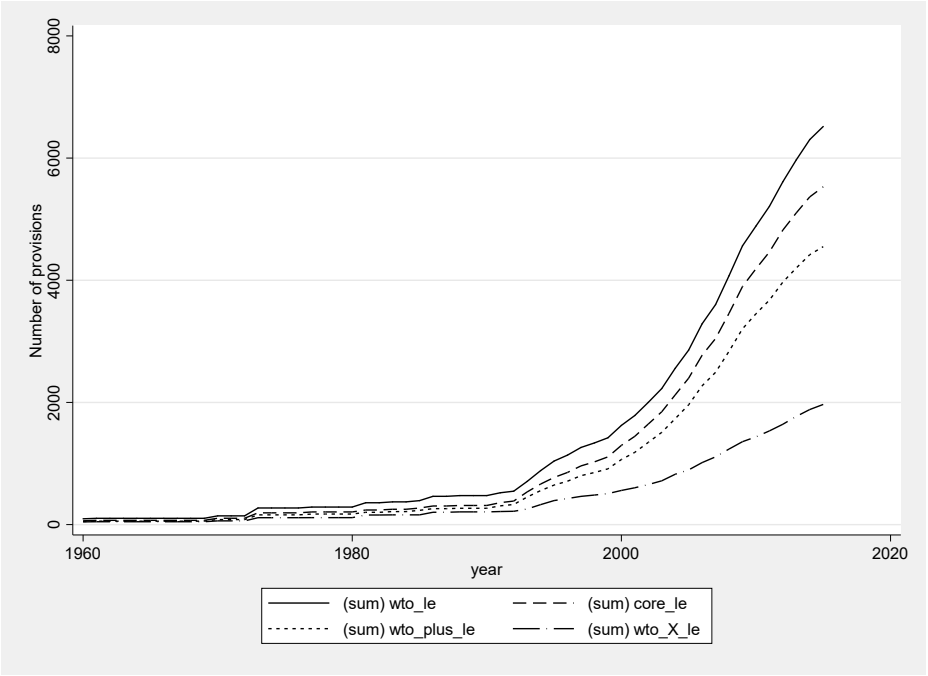
Notes: Biological and technological disasters are excluded. Major disasters refer to disasters that meet at least one of the following criteria adopted by Gassebner et al. (2010): (i) the number of killed is no fewer than 1000; (ii) the number of injured is no fewer than 1000; (iii) the number of affected is no fewer than 100,000; or (iv) the amount of damages is no less than $1 billion.
Source: Data from the EM-DAT database

Figure 2. Average total damage ($ billions), 2000-2014



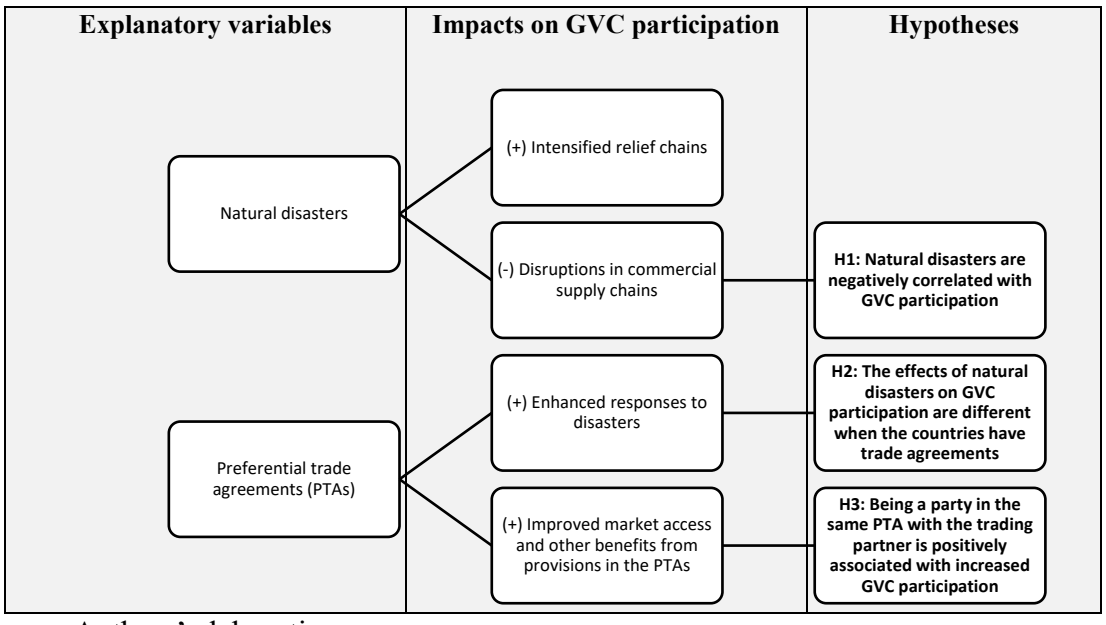
Notes: the dollar values are converted into constant 2000 dollars using the US GDP deflator
Source: Data from the EM-DAT database

Figure 3. Depth of trade agreements, 1960-2015



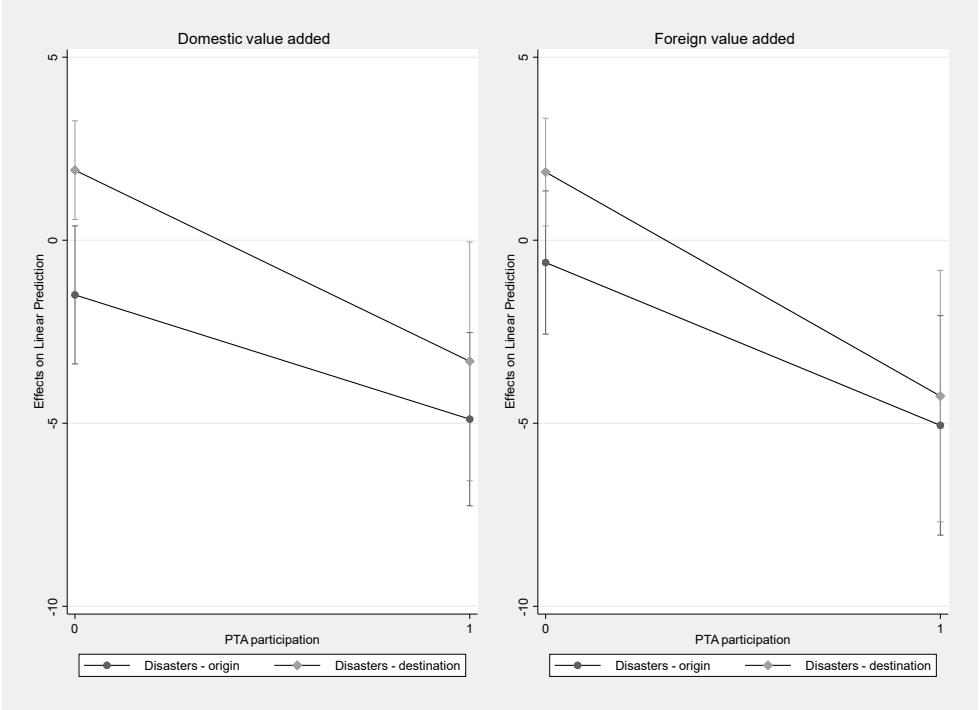
Source: Data from the Content of Deep Trade Agreements Database at the World Bank (Hofmann et al. 2017).

Figure 4. Testable hypotheses on the associations between natural disasters, PTAs and GVC participation



Source: Authors' elaboration

Figure 5. Marginal effects of natural disasters on GVC by PTA participation



Notes: The average marginal effects of the rescaled disaster variable $DISASTERAREA$ (e.g. the ratio of the number of major disasters to the area of the disaster-affected country) at two levels of PTA derived from estimates in Columns (4) and (8) of Table 3.

Figure 6. Disaster management, supply chain aspects, and relevant FTA provisions

Disaster management stage	Supply chain aspects	Relevant FTA provisions
Impact Response	- Possible disruptions to existing supply chains - Relief consignment including food, medical supplies, special vehicles and equipment - In-country distribution of relief goods - Cross-border movement of rescuers and humanitarian workers -	- Customs procedures and trade facilitation - Movement of rescuers and humanitarian workers - SPS measures
Recovery Development	- Flows of goods, services and investment required to redevelop the disaster-hit areas - Movement of natural persons such as contractual service suppliers, business visitors, etc. - Resume of production network operations with the domestic industry's competitiveness possibly below the pre-disaster level - Capacity building programs including to assist SMEs	- Trade in goods - Rules of origins - Customs procedures and trade facilitation - Trade in Services - Movement of Natural Persons - Investment - Government Procurement - Cooperation - SME
Mitigation Preparedness	- Investment in disaster risk reduction programs including the use of advanced technologies, cross-border data transfers, insurance, etc. - Capacity building programs - Enhancing transparency of laws, regulations and procedures related to disaster risk reduction - Cooperation, coordination and, as deemed appropriate, harmonisation of regulations and procedures particularly on relief consignment through bilateral, regional and multilateral platforms on disaster risk reduction	- Investment - Intellectual property - E-Commerce - Cooperation - Transparency - Government Procurement - Customs procedures and trade facilitation

Notes: TIG stands for Trade in Goods; CPTF Customs Procedures and Trade Facilitation; SPS Sanitary and Phytosanitary Measures; STRACAP Standards, Technical Regulations and Conformity Assessment Procedures; TIS Trade in Services; MNP Movement of Natural Persons; IP Intellectual Property; ECOTECH Economic and Technical Cooperation; SME Small and Medium Enterprises.
Source: Authors' compilation

Table 1. Variables – Descriptions and sources

Variable	Description	Expected sign	Source
DVA_{eit}	Nominal domestic value added (DVA) in millions of dollars deflated by US GDP deflator	(dependent variable)	WIOD (Timmer et al. 2015, Timmer et al. 2016)
FVA_{eit}	Nominal foreign value added (DVA) in millions of dollars deflated by US GDP deflator	(dependent variable)	WIOD (Timmer et al. 2015, Timmer et al. 2016)
$DISASTER_{et}$	Number of large disasters occurred in the exporting country	−	EM-DAT
$DISASTER_{it}$	Number of large disasters occurred in the importing country	−	EM-DAT
PTA_{eit}	Dummy for pairs having preferential trade agreements in effect	+	World Bank (Hofmann et al. 2017)
$PTAyr_{eit}$	Number of years since the first PTA between two trading partners came into effect	+	Calculated using data from World Bank (Hofmann et al. 2017)
$PTAlegal_{eit}$	Number of legally enforceable provisions included in an agreement between the exporting and importing countries	+	Calculated using data from World Bank (Hofmann et al. 2017)
$PTAcore_{eit}$	Number of core provisions in an agreement between the exporting and importing countries	+	Calculated using data from World Bank (Hofmann et al. 2017)
$PTAWTOplus_{eit}$	Number of WTO^{+} provisions in an agreement between the exporting and importing countries	+	Calculated using data from World Bank (Hofmann et al. 2017)
$PTAWTOextra_{eit}$	Number of WTO^{X} provisions in an agreement between the exporting and importing countries	+	Calculated using data from World Bank (Hofmann et al. 2017)
GDP_{et}	Real GDP of the exporting country	+	World Development Indicator (The World Bank)
GDP_{it}	Real GDP of the importing country	+	World Development Indicator (The World Bank)
POP_{et}	Population of the exporting country	−	World Development Indicator (The World Bank)
POP_{it}	Population of the importing country	−	World Development Indicator (The World Bank)
$DISTANCE_{ei}$	Distance between the exporting and importing country (in km)	−	CEPII GeoDist (Mayer and Zignago 2011)
$COLONIAL_{ei}$	Dummy for pairs ever in colonial relationship	+	CEPII GeoDist (Mayer and Zignago 2011)
$LANGUAGE_{ei}$	Dummy for pairs sharing an official language	+	CEPII GeoDist (Mayer and Zignago 2011)
$LANDLOCKED_{ei}$	Dummy for at least one trading partner being landlocked	−	CEPII GeoDist (Mayer and Zignago 2011)

Table 2. Descriptive statistics

Year	DVA	FVA	$DISASTER$	$DISASTERAREA$	PTA	$CORE$	WTO^X	WTO^+	GDP	POP	$DISTANCE$	$COLONIAL$	$LANGUAGE$	$LANDLOCKED$
	$millions	$millions	Number of major disasters per year	Major disasters per year per sq km	Dummy	No. provisions	No. provisions	No. provisions	$trillion	millions	km	dummy	dummy	dummy
2000	2,015	564	0.26	0.0053	0.20	21.87	25.96	18.64	0.71	95.41	5,067	0.04	0.05	0.27
2001	1,978	546	0.24	0.0013	0.20	21.92	25.97	18.68	0.71	96.35	5,067	0.04	0.05	0.27
2002	2,090	570	0.55	0.0001	0.22	22.37	26.14	19.03	0.74	97.27	5,067	0.04	0.05	0.27
2003	2,437	681	0.33	0.0020	0.22	22.37	26.14	19.03	0.83	98.17	5,067	0.04	0.05	0.27
2004	2,892	865	0.43	0.0002	0.50	71.90	88.49	61.07	0.94	99.05	5,067	0.04	0.05	0.27
2005	3,176	993	0.31	0.0023	0.51	71.98	88.52	61.14	1.00	99.93	5,067	0.04	0.05	0.27
2006	3,522	1,166	0.45	0.0016	0.51	72.06	88.54	61.20	1.08	100.79	5,067	0.04	0.05	0.27
2007	4,051	1,378	0.36	0.0000	0.54	91.45	112.00	76.71	1.20	101.64	5,067	0.04	0.05	0.27
2008	4,475	1,586	0.26	0.0014	0.54	91.46	112.01	76.72	1.30	102.49	5,067	0.04	0.05	0.27
2009	3,642	1,143	0.29	0.0013	0.55	91.55	112.03	76.79	1.24	103.32	5,067	0.04	0.05	0.27
2010	4,188	1,456	0.07	0.0010	0.55	91.66	112.06	76.89	1.34	104.15	5,067	0.04	0.05	0.27
2011	4,815	1,794	0.14	0.0009	0.58	92.60	112.41	77.61	1.48	104.98	5,067	0.04	0.05	0.27
2012	4,686	1,720	0.10	0.0001	0.59	92.63	112.43	77.64	1.49	105.75	5,067	0.04	0.05	0.27
2013	4,799	1,749	0.21	0.0015	0.59	112.81	137.65	94.42	1.53	106.57	5,067	0.04	0.05	0.27
2014	4,903	1,773	0.14	0.0009	0.59	112.87	137.67	94.47	1.59	108.27	5,067	0.04	0.05	0.27

Table 3. Fixed effect results – Dependent variables: $ln(DVA)$ and $ln(FVA)$

Variables	$\ln(DVA)$				$\ln(FVA)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PTA_{ei}	0.234***	0.246***	0.234***	0.244***	0.224***	0.239***	0.225***	0.238***
	(0.053)	(0.055)	(0.054)	(0.055)	(0.057)	(0.058)	(0.058)	(0.058)
$DISASTER_e$	0.009	0.012			0.014	0.018		
	(0.009)	(0.011)			(0.015)	(0.017)		
$DISASTER_i$	0.003	0.005			0.003	0.005		
	(0.006)	(0.006)			(0.006)	(0.007)		
$DISASTER_e \times PTA_{ei}$		-0.062**				-0.075**		
		(0.021)				(0.025)		
$DISASTER_i \times PTA_{ei}$		-0.026				-0.037*		
		(0.019)				(0.021)		
$DISASTERAREA_e$			-1.988***	-1.493			-1.257**	-0.609
			(0.512)	(0.962)			(0.492)	(0.998)
$DISASTERAREA_i$			1.157***	1.913**			0.975***	1.862**
			(0.296)	(0.688)			(0.292)	(0.750)
$DISASTERAREA_e \times PTA_{ei}$				-3.394**				-4.449**
				(1.490)				(1.675)
$DISASTERAREA_i \times PTA_{ei}$				-5.220**				-6.120***
				(1.841)				(1.926)
$\ln(GDP_e)$	0.819***	0.822***	0.805***	0.804***	0.550***	0.554***	0.529***	0.529***
	(0.067)	(0.066)	(0.063)	(0.062)	(0.086)	(0.085)	(0.076)	(0.075)
$\ln(GDP_i)$	0.852***	0.854***	0.848***	0.847***	0.883***	0.886***	0.880***	0.879***
	(0.032)	(0.032)	(0.027)	(0.027)	(0.039)	(0.040)	(0.033)	(0.033)
$\ln(POP_e)$	-2.645***	-2.624***	-2.688***	-2.664***	-3.027***	-3.001***	-3.050***	-3.018***
	(0.181)	(0.184)	(0.203)	(0.209)	(0.250)	(0.252)	(0.264)	(0.270)
$\ln(POP_i)$	-0.168	-0.157	-0.142	-0.104	-0.290**	-0.274**	-0.267**	-0.222*
	(0.127)	(0.130)	(0.116)	(0.126)	(0.118)	(0.122)	(0.111)	(0.121)
$\ln(DISTANCE_{ei})$	-1.334***	-1.335***	-1.334***	-1.335***	-1.369***	-1.370***	-1.369***	-1.370***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)	(0.019)	(0.019)	(0.019)
$COLONIAL_{ei}$	0.500***	0.499***	0.500***	0.499***	0.511***	0.510***	0.511***	0.510***

	(0.012)	(0.012)	(0.012)	(0.013)	(0.014)	(0.015)	(0.015)	(0.015)
$LANGUAGE_{ei}$	0.004	0.005	0.004	0.006	-0.022*	-0.021	-0.022*	-0.019
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
$LANDLOCKED_{ei}$	-0.087***	-0.086***	-0.087***	-0.086***	-0.010	-0.008	-0.010	-0.009
	(0.013)	(0.012)	(0.013)	(0.012)	(0.015)	(0.015)	(0.015)	(0.015)
Observations	25,830	25,830	25,830	25,830	25,830	25,830	25,830	25,830
Adjusted R-squared	0.890	0.890	0.890	0.890	0.879	0.879	0.879	0.879
Expoter FE	YES	YES	YES	YES	YES	YES	YES	YES
Importer FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4. Marginal effects at means

Dependent variable	Explanatory variables	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
$\ln(DVA_{ei})$	$DISASTERAREA_e$	- 2.656	0.958	- 2.770	0.006	- 4.533	- 0.779
	$DISASTERAREA_i$	- 0.953	0.892	- 1.070	0.285	- 2.701	0.795
	PTA_{ei}	0.224	0.057	3.910	0.000	0.112	0.337
$\ln(FVA_{ei})$	$DISASTERAREA_e$	- 3.055	0.786	- 3.890	0.000	- 4.596	- 1.514
	$DISASTERAREA_i$	- 0.488	0.829	- 0.590	0.556	- 2.113	1.137
	PTA_{ei}	0.233	0.054	4.340	0.000	0.128	0.338

Notes: The marginal effects at means derived from estimates in Columns (4) and (8) of Table 3.

Table 5. Fixed effect results – Heterogeneity of PTAs

	Core provisions		WTO^X		WTO^+	
	$\ln(DVA_{ei})$	$\ln(FVA_{ei})$	$\ln(DVA_{ei})$	$\ln(FVA_{ei})$	$\ln(DVA_{ei})$	$\ln(FVA_{ei})$
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
$DISASTERAREA_e$	-1.224	-0.507	-1.260	-0.554	-1.231	-0.513
	(1.021)	(0.977)	(1.018)	(0.969)	(1.020)	(0.976)
$DISASTERAREA_i$	2.053***	1.879**	2.001***	1.818**	2.051***	1.877**
	(0.674)	(0.674)	(0.656)	(0.653)	(0.677)	(0.676)
$CORE_{ei}$	0.002***	0.001***				
	(0.000)	(0.000)				
$DISASTERAREA_e \times CORE_{ei}$	-0.026**	-0.028**				
	(0.009)	(0.011)				
$DISASTERAREA_i \times CORE_{ei}$	-0.032**	-0.034**				
	(0.012)	(0.012)				
WTO_{ei}^X			0.001***	0.001***		
			(0.000)	(0.000)		
$DISASTERAREA_e \times WTO_{ei}^X$			-0.021**	-0.022**		
			(0.008)	(0.009)		
$DISASTERAREA_i \times WTO_{ei}^X$			-0.025**	-0.027**		
			(0.009)	(0.009)		
WTO_{ei}^+					0.002***	0.002***
					(0.000)	(0.000)
$DISASTERAREA_e \times WTO_{ei}^+$					-0.031**	-0.033**
					(0.011)	(0.014)
$DISASTERAREA_i \times WTO_{ei}^+$					-0.038**	-0.041**
					(0.014)	(0.014)
Observations	25,830	25,830	25,830	25,830	25,830	25,830
Adjusted R-squared	0.891	0.879	0.891	0.879	0.891	0.879
Exporter FE	YES	YES	YES	YES	YES	YES
Importer FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6. Fixed effect results – Agriculture focus

VARIABLES	$\ln(DVA_{ei})$				$\ln(FVA_{ei})$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$DISASTERAREA_e$	2.859**	3.517***	3.446***	3.505***	2.809**	3.517***	3.447***	3.505***
	(1.119)	(0.991)	(0.974)	(0.991)	(1.279)	(1.134)	(1.115)	(1.136)
$DISASTERAREA_i$	4.358***	5.050***	4.988***	5.045***	4.414***	5.168***	5.101***	5.161***
	(1.022)	(1.032)	(1.012)	(1.034)	(1.025)	(1.034)	(1.013)	(1.037)
PTA_{ei}	0.476***				0.510***			
	(0.062)				(0.062)			
$DISASTERAREA_e \times PTA_{ei}$	-11.203***				-10.296***			
	(2.176)				(2.153)			
$DISASTERAREA_i \times PTA_{ei}$	-10.454***				-10.628***			
	(3.367)				(3.307)			
$CORE_{ei}$		0.004***				0.005***		
		(0.000)				(0.000)		
$DISASTERAREA_e \times CORE_{ei}$		-0.067***				-0.061***		
		(0.010)				(0.012)		
$DISASTERAREA_i \times CORE_{ei}$		-0.063***				-0.065***		
		(0.017)				(0.017)		
WTO_{ei}^{X}			0.003***				0.004***	
			(0.000)				(0.000)	
$DISASTERAREA_e \times WTO_{ei}^{X}$			-0.053***				-0.049***	
			(0.008)				(0.010)	
$DISASTERAREA_i \times WTO_{ei}^{X}$			-0.051***				-0.052***	
			(0.014)				(0.013)	
WTO_{ei}^{+}				0.005***				0.006***
				(0.001)				(0.000)
$DISASTERAREA_e \times WTO_{ei}^{+}$				-0.079***				-0.073***
				(0.012)				(0.014)
$DISASTERAREA_i \times WTO_{ei}^{+}$				-0.075***				-0.077***
				(0.020)				(0.020)
Observations	25,719	25,719	25,719	25,719	25,719	25,719	25,719	25,719
Adjusted R-squared	0.785	0.788	0.788	0.788	0.766	0.770	0.770	0.770
Exporter FE	YES	YES	YES	YES	YES	YES	YES	YES
Importer FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: The following sectors are included: 1) Crop and animal production, hunting and related service activities; (2) Forestry and logging; and (3) Fishing and aquaculture. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 1. List of countries in the sample

Australia	Japan
Austria	Latvia
Belgium	Lithuania
Bulgaria	Luxembourg
Canada	Malta
China	Mexico
Croatia	Netherlands
Cyprus	Norway
Czech Republic	Poland
Denmark	Portugal
Estonia	Slovak Republic
Finland	Slovenia
France	South Korea
Germany	Spain
Greece	Sweden
Hungary	Switzerland
India	Turkey
Indonesia	United Kingdom
Ireland	United States
Italy	