

Xu, Ankai; Kouwoaye, Amèvi Rocard

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## How do natural disasters affect services trade?

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**World Trade Organization**

Economic Research and Statistics Division

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**How do natural disasters affect services trade?**

Ankai Xu <sup>\*</sup>

Amèvi Rocard Kouwoaye <sup>†</sup>

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<sup>\*</sup> World Trade Organization. Email: [ankai.xu@wto.org](mailto:ankai.xu@wto.org). The authors would like to thank Robert Teh, Roberta Piermartini, Michael Roberts, Antonia Carzaniga and Marc Bacchetta for their comments and suggestions on earlier drafts of the paper, and Antonella Liberatore and Barbara D'Andrea for explaining the WTO-OECD Trade in Services database. Thanks also go to Grégoire Mansio for his assistance in the early stage of the research.

<sup>†</sup> PhD candidate in Agricultural and International Economics at Laval University. Email: [amevirocard.kouwoaye.1@ulaval.ca](mailto:amevirocard.kouwoaye.1@ulaval.ca)

# How do natural disasters affect services trade?

Ankai Xu\*, Amèvi Rocard Kouwoaye<sup>†</sup>

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## Abstract

This paper is the first in the literature to examine the impact of natural disasters on trade in services. We measure the magnitude of natural disasters using two distinct sets of variables and quantify the effect of natural disasters on trade in services using a structural gravity model. We find that, overall, natural disasters lead to a decline of services exports of the affected country but have ambiguous effects on its services imports. On average, a large natural disaster can reduce services exports by 2% to 3%. Capital-intensive service sectors such as transport and communications are most affected by a large natural disaster, with the negative impact on communications exports lasting for up to five years after a disaster. We also find consistently across all estimations that the negative impact of natural disasters on services trade is larger than that on merchandise trade.

**Keywords:** international trade, gravity model, services, natural disasters, climate change

**JEL classification numbers:** F14, P48, L80, C23, Q54, H84

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\*World Trade Organization. Email: ankai.xu@wto.org. The authors would like to thank Robert Teh, Roberta Piermartini, Michael Roberts, Antonia Carzaniga and Marc Bacchetta for their comments and suggestions on earlier drafts of the paper, and Antonella Liberatore and Barbara D'Andrea for explaining the WTO-OECD Trade in Services database. Thanks also go to Grégoire Mansio for his assistance in the early stage of the research.

<sup>†</sup>PhD candidate in Agricultural and International Economics at Laval University. Email: amevi-rocard.kouwoaye.1@ulaval.ca

# 1 Introduction

The increasing frequency and intensity of natural disasters as a result of climate change pose significant risks for the global economy (IPCC, 2012; World Bank, 2009) and call for in-depth research on their economic and trade impacts. Large sudden natural disasters such as earthquakes, tsunamis, hurricanes and floods generate economic destruction. A disaster’s initial impact causes death, disease, and loss of physical infrastructure, followed by consequent impacts on the economy. A spate of economic studies has attempted to understand the determinants of the initial direct costs of disasters as well as the long-term effects.

While there are many studies examining the impact of natural disasters on merchandise trade (e.g., Gassebner et al., 2010; Oh and Reuveny, 2010; Andrade da Silva et al., 2012), the literature is scant on the effects of natural disasters on services trade. Filling this research gap becomes increasingly important as services have grown to be a major component of the modern economy. Globally, trade in services through all modes of supply amounts to USD 13.3 trillion. In particular, services exports now constitute a third or more of the total exports of goods and services of the United Kingdom and United States, and close to 40% of total exports in some developing countries such as India and the Philippines (WTO, 2018). International trade in services is also expected to increase in the next decades (WTO, 2019b). This paper is, to our knowledge, the first study in the literature to systematically investigate the impact of natural disasters on trade in services.

Major natural disasters can affect services trade in a number of important ways. Typically, disasters disrupt normal economic activity due to loss of production, human and physical capital and/or infrastructure, leading to an immediate contraction in output. Geophysical disasters (earthquakes, volcanic eruptions, etc.) and meteorological disasters (floods, hurricanes, etc.) destroy or limit the use of roads, bridges, air space, telecommunications and harbors, which increases the logistical and transportation costs associated with trade. On the other hand, a country hit by a large natural disaster may need services for immediate disaster relief and long-term reconstruction, which could lead to an increase in services imports. Some researchers also suggest that disasters may speed up the Schumpeterian “creative destruction” process - a process of industrial mutation that revolutionizes the economic structure, destroying the old one and creating a new one - thus allowing exports to grow stronger after natural disasters (e.g., Crespo Cuaresma et al., 2008; Skidmore and Taya, 2002). With these opposing forces at play, the net effect of natural disasters and services trade is an empirical question.

The primary contribution of this paper is to quantify the effects of natural disasters on services exports and imports using a structural gravity model. We employ two datasets that measure disasters by (1) their human casualty and economic loss, and (2) their geophysical and meteorological magnitudes. Furthermore, we examine the heterogeneous impacts of natural disasters on different service sub-sectors. Our hypothesis is that natural disasters may have large and more immediate

effects on services exports, particularly in sectors prone to infrastructure damage such as transport and telecommunications services. On the import side, natural disasters may simultaneously increase demand for services imports to meet domestic consumption needs and reduce services trade due to higher trade costs resulting from damages to trade-related infrastructure.

Our results reveal that a large natural disaster can lead to a decrease in services exports by 2% to 3% while its impact on services imports are ambiguous. Among the service sub-sectors, transport services, communications services and royalty license fees are most affected by a natural disaster. While the negative impact of a large natural disaster on most service sectors last for a year, such negative impact can persist for up to five years for the exports of communications services. We also find that the openness of a country's services trade policy influences the impact of natural disasters: countries with higher services trade restrictions tend to import more services after a large natural disaster.

The second contribution of our study is to shed light on the distinct feature of services trade as compared to goods trade. The literature reveals that major disasters reduce merchandise exports and imports. For example, [Gassebner et al. \(2010\)](#) find, as a conservative estimate, that a major disaster reduces imports on average by 0.2%, conditional on a country's level of democracy, and exports by 0.1%. [Oh and Reuveny \(2010\)](#) distinguish climatic disasters from geophysical disasters, and find that an additional climatic disaster reduces imports by 2.68% and exports by 0.59%. [Andrade da Silva et al. \(2012\)](#) find that natural disasters affect most negatively the exports of small developing countries: exports of affected small developing countries decline by 22% following a natural disaster, whereas exports of larger developing countries are not significantly affected, and that such effects tend to last for about 3 years. By comparing our results with the literature examining natural disasters' impact on merchandise trade, we are able to assess how disasters affect services trade differently. Whenever possible, in our empirical results we report mirror estimates on trade in goods to facilitate this comparison.

Although this paper focuses on a quantitative analysis of natural disasters' impact on services trade, we recognize that natural disasters can affect services trade in ways not easily captured by data. For example, weather forecast services and disaster surveillance help to provide early warnings ahead of a natural disaster. Online information sources such as ReliefWeb provide reliable and timely information on global crises and disasters, enabling humanitarian workers to make informed decisions and to plan effective responses. Efforts to mitigate and tackle climate-related risks and enhance disaster resilience also increase demand for eco-friendly design and renewable energy. Natural disasters tend to create a tremendous amount of debris, which surpasses the ability of the national refuse or environmental services to manage, requiring imports of environmental services. Although of crucial importance to prevent and mitigate natural disasters' negative impact, the amount of trade in these services are often too quantitatively trivial to be captured in national trade statistics.

One of the shortcomings of this paper stems from the shortage of high-quality data on services trade. We confine our study to countries that report services trade data at aggregate or sub-sectoral level. This limitation constrains our analysis to mostly high-income or middle-income countries.<sup>1</sup> Much is unknown about the impact of natural disasters on low-income countries, which calls for more efforts in data collection.

The reminder of the paper is organized as follows: Section 2 describes the empirical model and the data. Section 3 discusses the estimation results and presents alternative estimations. It also assesses the role of policy in affecting countries' ability to respond to and recover from natural disasters. Finally, Section 4 concludes.

## 2 Empirical model and data

### 2.1 Empirical model

We investigate the effects of natural disasters on bilateral trade using a structural gravity model. The structural gravity model has its theoretical underpinning in a broad range of trade models (Anderson and Van Wincoop, 2003; Arkolakis et al., 2012) and has been widely used to study the flow of merchandise trade. More recently, the gravity model has also been applied to quantify the determinants of services trade (e.g., Walsh, 2006; Kimura and Lee, 2006; Eaton and Kortum, 2018). A basic version of the gravity model can be summarised as follows:

$$\ln(T_{odt}) = \alpha D_{o,dt} + \beta_1 \ln(GDP_{o,dt}) + \beta_2 \ln(GDP_{pc,o,dt}) + \beta_3 T_{od} + \nu_o + \nu_d + \varepsilon_{odt} \quad (1)$$

where  $T_{odt}$  represents the value of trade from the origin country (exporting country)  $o$  to the destination country (importing country)  $d$  in year  $t$ .  $D_{o,dt}$  are count variables indicating the occurrence of large disasters in the exporting or the importing country in year  $t$ . Disasters are counted, for any given year or country, if they meet the definition of large disasters specified in Gassebner et al. (2010).<sup>2</sup> All countries are assigned a zero for years in which no observation meets this criterion. The advantage of a count variable as opposed to an indicator variable is that it allows us to obtain a more precise estimate of the impact of disasters on international services trade, as countries experiencing multiple large natural disasters are likely to see a sharper impact on their services trade. The coefficient  $\alpha$  measures the effect of one additional large natural disaster on services exports and imports.  $GDP_{o,dt}$  indicates the GDP of both the origin country and the destination country and  $GDP_{pc,o,dt}$  represents the per capita income of the origin country and the destination country.  $T_{od}$  is a set of bilateral variables representing bilateral trade costs,

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<sup>1</sup>Appendix A.2 identifies the countries and economies included in our sample.

<sup>2</sup>A disaster is a large one if it meets any of the following criteria: 1) total deaths is no less than 1000, or 2) total injured is no less than 1000, or 3) total number of people affected is no less than 100 000, or 4) the total damage is no less than 1 billion USD (in constant 2000 dollars).

comprising the log of physical distance between the trading pair, and dummies for common border, common language, colonial links and free trade agreements.<sup>3</sup>

We include fixed effects to control for variations pertaining to the exporting and importing countries and time. The exporter- and importer-specific fixed effects  $\nu_o$  and  $\nu_d$  account for unobserved, time-invariant country characteristics, including latitude and longitude of countries, which may correlate with the incidence of disasters and with institutional quality or natural resources. The importer- and exporter- fixed effects also control for “multilateral resistance” - a measure of how the trade costs of the countries compare with the rest of the world.<sup>4</sup> In some specifications, country-pair fixed effects are included to control for time-invariant bilateral trade costs, which addresses the issue of endogeneity of trade policy variables (Baier and Bergstrand, 2007). The downside of including country-pair fixed effects is that the effects of any time-invariant bilateral determinants, such as distance, can no longer be identified. Finally,  $\varepsilon_{odt}$  is the error term.

In addition to the Ordinary Least Square (OLS) model specified above, we further include Poisson Pseudo Maximum Likelihood (PPML) estimator. As advocated by Silva and Tenreyro (2006), this method addresses two empirical issues – zero trade flows and heteroscedasticity. The issue of zero flows is especially severe for sectoral services trade data due to the highly localized consumption and specialized production of services and the limitation to countries that record and report services trade data. In the OLS estimator, zero flows are simply dropped out of the sample when the value of trade is transformed into a logarithmic form. The PPML estimator treats trade flows in levels as opposed to a log transformation, thus taking into account trade flows of all country pairs even when the proportion of zero flows is large. It also avoids altering the model’s error terms in the presence of heteroscedasticity, which could severely bias the estimated coefficients in the OLS estimator.

The PPML estimator entails that equation (1) be rewritten as follows:

$$T_{odt} = \exp[\alpha D_{o,dt} + \beta_1 \ln(GDP_{o,dt}) + \beta_2 \ln(GDP_{pc_{o,dt}}) + \beta_3 T_{od} + \nu_o + \nu_d] \times \varepsilon_{odt} \quad (2)$$

Two additional advantages of the PPML estimator pertain to its flexibility and interpretation of the results. First, the estimator remains consistent in the presence of fixed effects (Arvis and Shepherd, 2013; Fally, 2015), thus allowing us to incorporate country- and pair-fixed effects to control for unobserved factors that may affect services trade flows, notably the multilateral resistance. Second, the interpretive methods for PPML estimators remain the same as that of OLS

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<sup>3</sup>More specifically, the set of bilateral dummy variables comprises the following: a dummy variable *fta\_wto* indicating if the country pair is parties to a free trade agreement according to the WTO database, a dummy *contig* indicating whether the trading partners have a common border, dummy variables *comlang\_off* and *comlang\_ethno* take a value of one if the two countries share the same official language or the same ethnic language, a dummy *comcol* indicating if the country pair share a common colonizer after 1945, a dummy *col45* indicating colonial relationships after 1945

<sup>4</sup>Omission to account for multilateral resistance has been pointed out by Baldwin and Taglioni (2006) as the “gold medal of gravity mistakes”.

despite its multiplicative property. As such, the coefficients of the variables can be interpreted as elasticity in the case of a continuous variable or as percentage change associated with a change in an indicator variable ([Head and Mayer, 2014](#); [Yotov et al., 2016](#)).

## 2.2 Data

The data in the empirical analysis mainly consist of bilateral services trade and measures of natural disasters. We briefly discuss these data below. Table A.1 in the Appendix summarizes the data sources.

### 2.2.1 Services trade data

The services trade data are from the OECD-WTO Balanced Trade in Services Dataset (BaTis). The data cover the period 1995-2012 for 191 reporters and 193 partners and 11 main EBOPS 2002 categories in addition to total services. The data include services trade through three modes of supply: cross-border supply (mode 1 of the General Agreement on Trade in Services – GATS) such as via the internet, consumption abroad (mode 2) such as the case of tourism, where a country receiving tourists are considered exporting tourism services, and the presence of individuals in the territory of another country (mode 4) such as consultants providing service in a foreign country. Commercial presence in another country (mode 3) is excluded.<sup>5</sup>

The BaTis dataset combines all available official data including the OECD Trade in Services by Partner Country statistics, Eurostat International Trade in Services statistics, UN Services Trade, IMF, and additional data from a number of complementary national sources. We use the final value reported in the dataset, which has been estimated and adjusted based on the value of trade reported by the relevant statistical authorities to ensure consistency. Data gaps were filled by estimations using derivations, backcasting, and interpolation. In cases where no information on bilateral services trade is available, the estimates are derived from an econometric gravity model. Detailed methodologies can be found in [Fortanier et al. \(2017\)](#).

We note that it is problematic to use data predicted by a gravity model, since these data do not reflect actual observations, and may lead to biases when we estimate the effects of natural disasters using a gravity model. Hence, we limit our analysis to officially reported services exports.<sup>6</sup> This choice has important implications in our country coverage. Table 1 provides the summary statistics of bilateral services trade data by income groups.<sup>7</sup> No low-income economies reported

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<sup>5</sup>Appendix A.4 provides a detailed explanation of the types of services trade covered in each service sub-sectors.

<sup>6</sup>We keep the services trade flow data entries if they are estimated using simple derivation or calculated using national or regional growth rates, or estimated based on mirror data. These data entries are marked as E1-E9 in the methodology description. We discard data entries that were predicted using gravity-type model estimates. These data entries are marked as M1-M5 in the methodology description.

<sup>7</sup>We use the World Bank income classification in year 2010. High-income economies have GNI per capita higher than 12,275 USD, middle-income economies have GNI per capita between 1,006 and 12,275 USD and low-income



services exports and imports, and the observations are very limited for middle-income economies. The issue of data limitation is even more severe for services trade at sub-sectoral levels.<sup>8</sup>

Table 1: Summary statistics of bilateral services trade values

<i>Exporter</i> <i>Income level</i>	<i>Importer</i> <i>Income level</i>	Reported service exports (in million USD)			Reported service imports (in million USD)		
		<i>Obs</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Obs</i>	<i>Mean</i>	<i>Std. Dev.</i>
High	High	13,738	1397.942	3951.062	13,700	1293.373	3627.646
High	Middle	20,261	155.320	888.532	2,659	398.214	2063.215
High	Low	5,316	10.893	40.162	0		
Middle	High	2,667	329.303	1926.925	20,335	129.4013	626.3895
Middle	Middle	4,192	46.194	256.619	4,095	49.914	304.342
Middle	Low	1,145	7.354	58.048	0		
Low	High	0			5,355	10.567	33.311
Low	Middle	0			1,099	3.648	23.587
Low	Low	0			0		

In the robustness check, we use an alternative dataset - the World Input-Output Database (WIOD) (Timmer et al., 2015). The WIOD data cover 40 countries and 35 sectors - including 17 services sector - for the period 1995-2011, allowing us to observe the international flow of services trade as well as domestic trade. As demonstrated in Heid et al. (2017), combining domestic and international trade data enables us to control for multilateral resistance using fixed effects while still capturing the effect of country-specific events such as natural disasters.

### 2.2.2 Disaster data

The data on natural disasters come from two main sources. The first data source is the "Emergency events database" (EM-DAT, 2018) maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at Université Catholique de Louvain. It contains data on the occurrence and effects of over 10 000 disasters in the world dating from 1900 and reports the number of people killed or affected (i.e., injured or rendered homeless) or the estimated monetary damage. Following Gassebner et al. (2010), we define major disasters based on the criteria set out in Munich Re's category of great natural catastrophe. A disaster is a large one if it meets any of the following criteria: 1) total deaths is no less than 1000, or 2) total injured is no less than 1000, or 3) total number of people affected is no less than 100 000, or 4) the total damage is no less than 1 billion USD (in constant 2000 dollars).

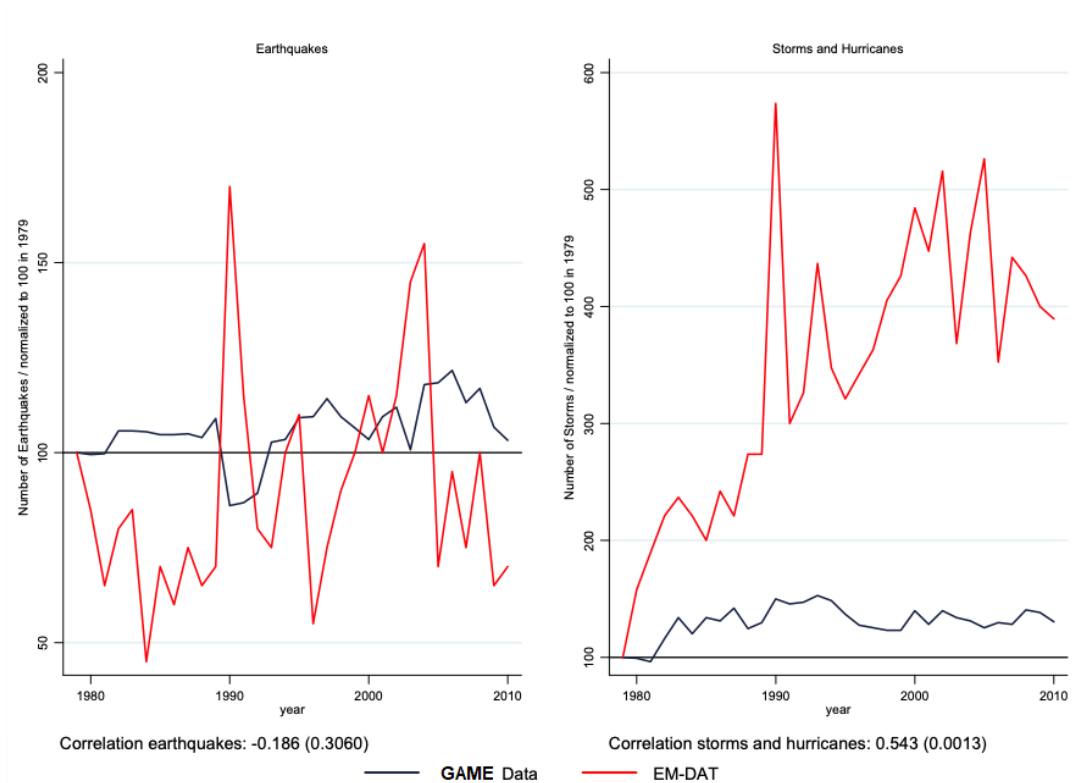
Additionally, we use the ifo Geological and Meteorological Events (GAME) database compiled by Felbermayr and Gröschl (2014) in the robustness check. The GAME database reports physical

economies have GNI per capita lower than 1,005 USD.

<sup>8</sup>See Appendix A.2 for the list of countries and economies in the sample that report service trade at aggregate and sub-sectoral levels.

intensity measures for the universe of geophysical and meteorological events for all countries worldwide from 1979 to 2010. It has been argued that insurance-based or news-driven data of natural disasters may be subject to selection bias, since the measures of disaster intensity are likely correlate with economic factors (Felbermayr and Gröschl, 2014). For example, disasters taking place in higher-income economies may incur higher economic losses, and thus, a large natural disaster defined by measure of economic loss may be correlated with the economic outcome variables.

Figure 1: The number of natural disasters over time



Source: Felbermayr and Gröschl (2014)

Notes: The red line shows the occurrence of large earthquakes and storms/hurricanes measured by the total human and economic loss in the EM-DAT database. The black line shows an equivalent number from the ifo Geological and Meteorological Events (GAME) data. The initial level in year 1979 is normalised to 100.

Figure 1 shows the occurrence of two most common types of natural disasters over time. The left-hand plot shows the yearly number of large earthquake events from EM-DAT against an equivalent number from the GAME data, and the right-hand plot reports storms and hurricanes. Although the number of earthquakes reported in both datasets do not exhibit any time trend, the EM-DAT data are much more volatile. As for storms and hurricanes, both the GAME data and the EM-DAT data exhibit upward trends, presumably due to climate change, but the EM-DAT data are more volatile than the GAME data.

### 2.2.3 Other data sources

The other data in our analysis are obtained from standard sources, notably the Centre d’Etudes Prospectives et d’Informations Internationales (CEPII) for gravity related data, and the World Bank’s World Development Indicators for data related to economic size.

In the analysis on the role of policy, we include variables that indicate the openness of services trade and political systems of countries. The Service Trade Restrictions Index (STRI) is compiled by the World Bank and measures the barriers to services trade. The index covers 103 countries and indicates the level of services restrictions for the overall services industry ranging from 0 to 100 (Borchert et al., 2012). Countries that have more restrictive services trade policies have a higher STRI score.

The data on bilateral trade in goods are from World Trade Flows (WTF) Bilateral Data, compiled by the Center for International Data, University of California, Davis (Feenstra et al., 2005). The data we use cover the period 1995 to 2010, which overlaps with the year coverage of the services trade and disaster data.

## 3 Results

In this section, we report the results of the empirical analysis and discuss their interpretations. We start by discussing the results of our baseline model, and examine the heterogeneous impacts of natural disasters on service sub-sectors. We then present results using alternative measures of disasters and services trade to verify the robustness of our baseline estimates.

### 3.1 Baseline results

The results of the baseline gravity model are reported in Table 2. Columns (1) and (2) of Table 2 present the results with an OLS model including exporter-/importer- fixed effects and country-pair fixed effects respectively. Columns (3) and (4) give the results of PPML estimates with the dependent variable being the reported value of trade. Values of bilateral trade that are predicted using gravity-type model in the BaTis dataset are treated as missing in the PPML models and are thus given the value of zero.

We broadly interpret the results as the impact of natural disasters on services trade, although due to the possible risk of endogeneity, the coefficients should strictly speaking be interpreted as correlation rather than causation. In Section 3.3 we will discuss the exogeneity assumption and perform robustness check using an alternative measure of natural disasters.

Across all specifications, the variable  $Disaster_o$  displays a negative and significant coefficient,

Table 2: Impact of large disasters on services trade - baseline results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	PPML	PPML	OLS	OLS	PPML	PPML
	Trade in Services				Trade in Goods			
<i>Disaster<sub>o</sub></i>	-0.029*** (0.007)	-0.022*** (0.005)	-0.024*** (0.009)	-0.020*** (0.006)	-0.017*** (0.006)	-0.002 (0.005)	0.002 (0.007)	0.004 (0.003)
<i>Disaster<sub>d</sub></i>	0.022*** (0.007)	0.019*** (0.006)	-0.018** (0.009)	-0.015** (0.006)	-0.001 (0.006)	0.003 (0.005)	0.002 (0.007)	0.002 (0.003)
<i>lnGDP<sub>o</sub></i>	3.089*** (0.385)	2.796*** (0.306)	1.208*** (0.364)	1.456*** (0.266)	-2.115*** (0.335)	-2.338*** (0.298)	-1.311*** (0.290)	-1.022*** (0.154)
<i>lnGDP<sub>d</sub></i>	0.438*** (0.166)	1.136*** (0.122)	1.955*** (0.207)	2.187*** (0.145)	0.575*** (0.114)	0.879*** (0.088)	-0.150 (0.134)	0.199** (0.082)
<i>lnGDPpc<sub>o</sub></i>	-2.569*** (0.387)	-2.132*** (0.306)	0.021 (0.369)	-0.254 (0.274)	2.470*** (0.342)	2.866*** (0.309)	1.838*** (0.304)	1.532*** (0.157)
<i>lnGDPpc<sub>d</sub></i>	0.527*** (0.178)	-0.274** (0.130)	-1.249*** (0.216)	-1.545*** (0.148)	0.313** (0.123)	-0.109 (0.092)	0.959*** (0.139)	0.575*** (0.086)
<i>lnDist</i>	-1.208*** (0.051)		-0.692*** (0.022)		-1.307*** (0.048)		-0.742*** (0.018)	
<i>fta_wto</i>	0.096 (0.060)	0.070** (0.034)	0.180*** (0.045)	0.122*** (0.047)	0.060 (0.049)	0.119*** (0.031)	0.410*** (0.031)	0.039* (0.020)
<i>contig</i>	0.577*** (0.140)		0.163*** (0.035)		0.365*** (0.105)		0.439*** (0.027)	
<i>comlang_off</i>	0.078 (0.095)		0.301*** (0.051)		0.355*** (0.090)		0.104** (0.044)	
<i>comlang_ethno</i>	0.527*** (0.101)		0.098* (0.055)		0.172* (0.096)		0.055 (0.044)	
<i>comcol</i>	1.236*** (0.144)		0.180* (0.101)		1.542*** (0.124)		-0.029 (0.072)	
<i>col45</i>	1.662*** (0.161)		0.465*** (0.071)		1.385*** (0.144)		0.075 (0.070)	
<i>comcur</i>	-0.266*** (0.086)	0.100** (0.046)	0.319*** (0.037)	0.543*** (0.072)	-0.304*** (0.067)	0.070** (0.032)	0.049* (0.027)	0.127*** (0.018)
Observations	34,722	34,722	114,210	72,508	45,372	45,372	123,215	86,170
R <sup>2</sup>	0.839	0.370	0.905	0.952	0.883	0.2054	0.913	0.954
Exporter FE	Yes		Yes		Yes		Yes	
Importer FE	Yes		Yes		Yes		Yes	
Pair FE		Yes		Yes		Yes		Yes

Notes: The first four columns report results with the bilateral trade in services as dependent variable.

The last four columns report the same estimators with bilateral trade in goods as the dependent variable.

Robust standard errors are clustered by country pair, reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

suggesting large natural disasters have a negative impact on the exports of services. On average, a country could see a decline of total services exports by 2.0% to 2.9% after the occurrence of an additional large natural disaster.<sup>9</sup> The impact of large natural disasters on services imports, represented by the coefficient of the variable *Disaster<sub>d</sub>*, is more ambiguous: it appears to be positive in the OLS estimates and negative in the PPML estimates.

To understand how large natural disasters affect trade in services differently than merchandise trade, columns (5) to (8) report the results of the mirror estimates for trade in goods. We limit the sample to the same countries and time period as the services trade data, and report the results with the same specifications. The OLS estimates indicate that large natural disasters

<sup>9</sup>This percentage change is calculated by taking the estimated coefficients -0.020 and -0.029, and transform by  $[\exp(-0.020) - 1] \times 100 = -2.0$  and  $[\exp(-0.029) - 1] \times 100 = -2.9$ .

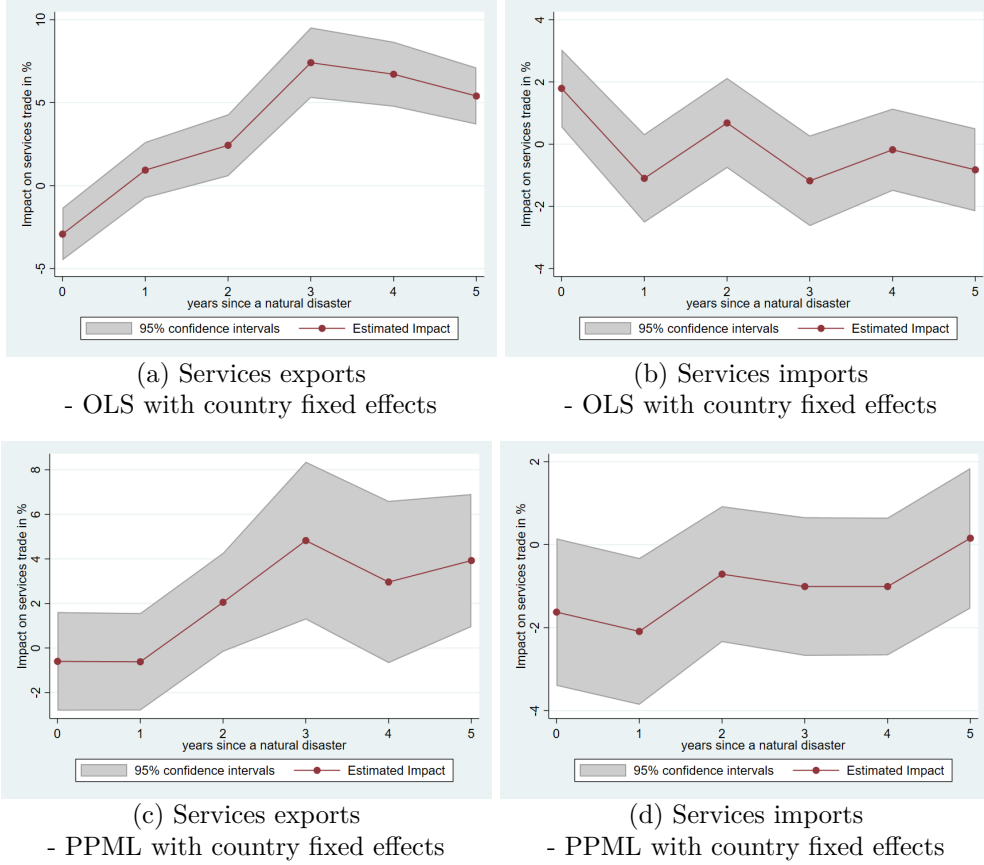
have negative and significant impact on merchandise exports, although the magnitude is smaller compared to the impact on services trade. The results are consistent with the literature on the impact of natural disasters on merchandise trade ([Felbermayr and Gröschl, 2014](#); [Gassebner et al., 2010](#)). On average, an additional large natural disaster can lead to a decline of merchandise exports by 1.7% by one estimate, and the coefficient appears to be insignificant according to the PPML estimator. Overall, we find that large natural disasters have larger impact on services trade than on merchandise trade.

The coefficients on the rest of the variables are in line with the standard gravity model literature. For example, similar as the results on merchandise trade reported in [Silva and Tenreyro \(2006\)](#), the distance elasticity of services trade is smaller than one in the PPML estimator and larger than one in the OLS estimator. The distance elasticity also appears to be slightly smaller for trade in services than trade in goods. Regional trade agreements, common borders, official language and colonial ties have positive correlation with bilateral services trade. According to the PPML estimator, trade in services appears less sensitive to the trading partners' sharing a common border, but more sensitive to trading partners sharing a common language or a common colonizer. A common currency also appears to have positive correlation with services trade in most of the model specifications.

A large natural disaster can have long lasting impact on services trade beyond the year a disaster occurs. In Figure 2, we report in a visual manner the lasting impact of large natural disasters for up to five years after the occurrence of a disaster. The horizontal axis shows the number of years following a natural disaster, and the vertical axis indicates the impact of a large disaster. The results are obtained by including up to five lags of the variables  $Disaster_o$  and  $Disaster_d$  in the baseline model, and the coefficients of these lagged count variables indicate the impact of one additional large disaster on services exports and imports in the years following a disaster.

We observe that an additional large natural disaster leads to a reduction of services exports in the year the disaster occurs and the negative impact gradually diminishes in the years after. In the second or the third year after a natural disaster, services exports appear to increase above what the level was before the disaster struck. This seems to support the "creative destruction" hypothesis that output and exports can grow stronger after large natural disasters. On the import side, the long-term effects of a large natural disaster are generally small and the direction of its impact varies depending on the estimation method, suggesting that the impacts of natural disasters on services imports are rather ambiguous.

Figure 2: Lagged impact of large natural disasters on services trade



Notes: The horizontal axis shows the number of years following a natural disaster, with the value zero indicating the year a disaster occurs; the vertical axis indicates the impact of a large disaster. The red dots represent the estimated impact of an additional large disaster in up to five years after it occurs; the shaded areas represent 95% confidence intervals.

### 3.2 Effects of natural disasters on service sub-sectors

Services comprise a diverse array of sub-sectors, ranging from transport, travel, communications to financial and business services. Large natural disasters can have major negative impacts on exports in some service sub-sectors, particularly these that rely on physical capital and infrastructure. At the same time, natural disasters can also trigger an increase in demand for certain services imports. Appendix A.4 provides a detailed explanation on the types of services trade covered in each service sub-sectors.

To investigate the heterogeneous effects of natural disasters on service sub-sectors, we quantifying the impact of natural disasters by apply the gravity model on each service sub-sector. Tables 3 and 4 report the OLS and PPML estimates. As previously explained, we limit our sample to countries that report their services trade data at sub-sectoral level.

We observe that communications services and transport services are most affected by a large natural disaster. On average, the occurrence of one additional large disaster can reduce exports

of communications services by 5%-9% and transportation services by 2%-4%. The range of percentage change reflects the different coefficients reported by the OLS and PPML estimators. Transport services consist of the cross-boarder carriage of passengers and movement of goods, and communications services cover telecommunications as well as postal and courier services. The negative impact may be explained by the fact that both service sub-sectors rely on physical infrastructure: the supply of communications services is reliant on a functioning telecommunications network and postal routes, and trade in transport services depends on roads, ports and cross-border logistics. When large natural disasters damage or destroy physical infrastructure, the exports in these services sectors are negatively impacted.

The exports of travel are also negatively correlated with natural disasters, with one large natural disaster leading to a decline of travel exports by 3% according to one estimate. This decline may be explained by a decrease in tourist arrivals due to disruptions to transportation or cancellations of trips for fear of risks in the aftermath of a natural disaster. Some anecdotal evidence suggests that significant differences exist within different segments of cross-border tourism: cruise trips are largely unaffected after a natural disaster as tourists often have somewhere to stay (i.e. the cruise ship) despite damages caused in land-based infrastructure, whilst the overnight stay is often badly knocked back after a large natural disaster (WTO, 2019a).

A negative impact can also be observed in relation to royalty license fees, with an additional large natural disaster leading to a decline of 2.2% - 2.6% of royalty license fee income. In addition, the exports of computer and information services, other business services as well as personal, cultural and recreational services can also experience a decline after a large natural disaster, although the effect on these sub-sectors are statistically insignificant in some cases.

Overall, we find that large natural disasters can have particularly severe negative impacts in services sectors that rely on physical infrastructure and exhibit higher capital- and knowledge-intensity.

On the other hand, the exports of insurance services and financial services are positively correlated with the occurrence of a large natural disaster. According to the applicable definition of services trade, insurance services exports are recorded as total premiums minus the estimated service charge and claims payable. A country hit by a large natural disaster can see a sharp rise in insurance claim payments, likely recorded as insurance exports.<sup>10</sup> Similarly, the rise in financial service exports may be due to an increasing amount of foreign aid and remittances into the affected country.

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<sup>10</sup>In the new edition of Balance of Payments and International Investment Position Manual (BPM6), the methodology to estimate insurance services trade has been adjusted to smoothen claims volatility.

Table 3: Impact of large disasters on services trade by sub-sectors - OLS with country fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Total services	Transport services	Travel	Communi- cations	Constru- ction	Insurance	Financial services	Computer and info	Royalties license fees	Other biz services	Recreation services	Government services
Disaster <sub>o</sub>	-0.029*** (0.007)	-0.039*** (0.008)	-0.010 (0.007)	-0.051*** (0.014)	-0.026 (0.024)	0.038*** (0.013)	0.011 (0.014)	-0.047*** (0.013)	-0.026** (0.011)	-0.054*** (0.015)	-0.049*** (0.018)	0.063*** (0.014)
Disaster <sub>d</sub>	0.018*** (0.007)	-0.004 (0.010)	0.003 (0.009)	-0.016 (0.012)	-0.026 (0.021)	-0.013 (0.013)	-0.018 (0.012)	0.004 (0.013)	0.004 (0.014)	0.015 (0.012)	-0.008 (0.016)	0.013 (0.012)
lnGDP <sub>o</sub>	3.142*** (0.378)	0.897 (0.588)	-0.031 (0.487)	1.252* (0.712)	-3.542** (1.746)	1.508 (0.989)	3.381*** (0.816)	6.529*** (0.792)	5.093*** (0.843)	7.660*** (0.630)	5.200*** (0.781)	-5.454*** (0.867)
lnGDP <sub>d</sub>	0.279* (0.162)	-0.877** (0.390)	-0.225 (0.350)	-1.238*** (0.438)	-0.124 (0.730)	0.091 (0.545)	-2.215*** (0.533)	1.651*** (0.472)	1.644*** (0.420)	1.203*** (0.415)	-0.210 (0.485)	1.933*** (0.457)
lnGDPpc <sub>o</sub>	-2.531*** (0.379)	-0.323 (0.584)	0.399 (0.490)	-0.584 (0.716)	4.032** (1.735)	-1.002 (0.978)	-2.739*** (0.814)	-5.748*** (0.805)	-4.554*** (0.867)	-7.378*** (0.641)	-4.977*** (0.811)	6.069*** (0.896)
lnGDPpc <sub>d</sub>	0.618*** (0.173)	1.844*** (0.396)	1.343*** (0.365)	2.091*** (0.434)	0.780 (0.734)	0.865 (0.566)	2.782*** (0.554)	-0.620 (0.481)	-0.712 (0.447)	-0.070 (0.422)	0.793 (0.494)	-1.603*** (0.470)
lnDist	-1.208*** (0.043)	-1.249*** (0.062)	-1.325*** (0.053)	-1.334*** (0.064)	-1.154*** (0.117)	-0.923*** (0.072)	-0.995*** (0.077)	-1.144*** (0.064)	-0.879*** (0.075)	-1.313*** (0.062)	-0.912*** (0.075)	-0.586*** (0.065)
fta_wto	0.131** (0.053)	0.016 (0.087)	0.353*** (0.085)	0.111 (0.109)	-0.247 (0.159)	-0.068 (0.122)	-0.073 (0.134)	-0.047 (0.112)	-0.096 (0.124)	0.069 (0.095)	0.117 (0.126)	0.087 (0.103)
contig	0.629*** (0.133)	0.612*** (0.145)	0.805*** (0.127)	0.564*** (0.130)	0.659*** (0.194)	0.733*** (0.148)	0.503*** (0.162)	0.247** (0.128)	0.430*** (0.144)	0.228 (0.141)	0.479*** (0.155)	0.159 (0.131)
comlang_off	0.017 (0.091)	-0.140 (0.153)	0.128 (0.144)	-0.188 (0.191)	-0.077 (0.357)	-0.010 (0.202)	-0.161 (0.192)	0.034 (0.180)	0.050 (0.209)	0.035 (0.151)	0.304 (0.193)	-0.025 (0.205)
comlang_ethno	0.465*** (0.095)	0.327** (0.142)	0.347*** (0.134)	0.370** (0.160)	-0.193 (0.329)	0.275 (0.184)	0.409** (0.187)	0.358** (0.166)	0.164 (0.202)	0.447*** (0.144)	0.150 (0.175)	0.113 (0.191)
comcol	0.878*** (0.117)	1.133*** (0.213)	0.753*** (0.257)	1.032*** (0.281)	0.201 (0.353)	0.337 (0.344)	0.577* (0.301)	0.659*** (0.242)	0.820** (0.354)	0.327 (0.282)	1.100*** (0.308)	0.562** (0.241)
col45	1.502*** (0.149)	1.405*** (0.239)	1.639*** (0.232)	1.587*** (0.234)	0.519 (0.385)	1.001*** (0.299)	1.116*** (0.337)	1.515*** (0.232)	1.228*** (0.339)	1.283*** (0.336)	1.399*** (0.246)	1.577*** (0.276)
comcur	-0.233*** (0.077)	-0.493*** (0.096)	0.120 (0.085)	-0.424*** (0.104)	-0.255* (0.151)	0.157 (0.116)	-0.094 (0.122)	-0.267** (0.118)	-0.457*** (0.122)	-0.539*** (0.098)	-0.162 (0.125)	-0.162 (0.130)
Constant	-8.300*** (0.801)	-2.632** (1.255)	-2.699** (1.087)	-4.450*** (1.413)	12.392** (6.133)	-15.034*** (3.379)	-16.268*** (2.844)	-34.801*** (2.669)	-31.312*** (2.764)	-31.488*** (2.123)	-12.952*** (1.457)	4.149** (1.705)
Observations	39,859	19,231	20,794	12,800	9,091	10,322	12,154	12,539	10,705	18,138	9,256	9,890
R <sup>2</sup>	0.830	0.769	0.826	0.757	0.599	0.764	0.783	0.775	0.805	0.805	0.718	0.735
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors clustered by country pair, reported in parentheses. \*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1



Table 4: Impact of large disasters on services trade by sub-sectors - PPML with country fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Total services	Transport services	Travel	Commu- nications	Constru- ction	Insurance	Financial services	Computer and info	Royalties license fees	Other biz services	Recreation services	Government services
Disaster <sub>o</sub>	-0.026** (0.010)	-0.024* (0.012)	-0.032*** (0.011)	-0.088** (0.036)	-0.002 (0.034)	0.009 (0.029)	0.038* (0.021)	0.011 (0.032)	-0.022* (0.013)	-0.030 (0.027)	-0.074 (0.061)	-0.009 (0.023)
Disaster <sub>d</sub>	-0.015* (0.009)	-0.017 (0.010)	-0.023 (0.015)	-0.053*** (0.019)	-0.047* (0.024)	-0.102*** (0.034)	-0.053* (0.030)	-0.060** (0.027)	-0.012 (0.013)	-0.058*** (0.017)	-0.068** (0.032)	-0.004 (0.020)
lnGDP <sub>o</sub>	1.481*** (0.373)	0.764 (0.672)	-1.064* (0.587)	2.565** (1.063)	-2.934** (1.168)	9.339*** (1.311)	9.208*** (0.983)	9.135*** (1.027)	-1.329 (0.870)	8.148*** (0.745)	3.352*** (1.277)	2.062 (1.838)
lnGDP <sub>d</sub>	1.965*** (0.206)	1.245*** (0.309)	-0.798* (0.451)	1.182** (0.588)	1.340*** (0.438)	0.647 (1.532)	3.283*** (1.172)	1.170 (0.898)	5.328*** (0.971)	1.121** (0.517)	0.427 (1.105)	0.036 (1.104)
lnGDPpc <sub>o</sub>	-0.191 (0.383)	0.446 (0.677)	2.229*** (0.610)	-1.148 (1.044)	4.023*** (1.135)	-8.996*** (1.469)	-9.966*** (1.091)	-7.727*** (1.067)	2.749*** (1.001)	-7.103*** (0.740)	-2.382* (1.278)	-1.528 (1.839)
lnGDPpc <sub>d</sub>	-1.283*** (0.213)	-0.357 (0.311)	1.634*** (0.465)	0.055 (0.601)	-0.732 (0.454)	0.457 (1.590)	-0.935 (1.291)	0.376 (0.968)	-4.365*** (1.043)	0.096 (0.546)	0.886 (1.138)	0.737 (1.095)
lnDist	-0.668*** (0.020)	-0.666*** (0.027)	-1.022*** (0.032)	-0.956*** (0.043)	-0.885*** (0.077)	-0.678*** (0.061)	-0.565*** (0.052)	-0.702*** (0.054)	-0.782*** (0.049)	-0.388*** (0.036)	-0.934*** (0.075)	-0.406*** (0.060)
fta_wto	0.272*** (0.052)	0.185*** (0.071)	0.228*** (0.082)	0.369*** (0.092)	0.251** (0.119)	-0.113 (0.115)	0.242*** (0.094)	0.748*** (0.097)	-0.301*** (0.098)	0.747*** (0.079)	0.217 (0.157)	0.696*** (0.104)
contig	0.223*** (0.039)	0.216*** (0.054)	0.449*** (0.054)	0.274*** (0.065)	0.101 (0.090)	0.014 (0.099)	-0.023 (0.110)	0.039 (0.091)	-0.414*** (0.095)	0.149** (0.063)	-0.091 (0.102)	-0.797*** (0.158)
comlang_off	0.287*** (0.048)	0.389*** (0.063)	0.136** (0.066)	0.173 (0.128)	0.946*** (0.190)	0.643*** (0.164)	0.824*** (0.116)	0.216 (0.157)	0.202* (0.122)	0.402*** (0.111)	1.189*** (0.166)	-0.913*** (0.154)
comlang_ethno	0.138*** (0.052)	-0.005 (0.062)	0.433*** (0.075)	0.083 (0.118)	-0.054 (0.175)	0.147 (0.148)	-0.313*** (0.119)	-0.412*** (0.123)	0.133 (0.093)	0.043 (0.086)	0.086 (0.150)	1.014*** (0.144)
comcol	0.013 (0.073)	-0.246** (0.115)	0.000 (0.134)	0.400** (0.165)	-0.102 (0.347)	0.178 (0.377)	0.784*** (0.195)	0.936*** (0.247)	0.179 (0.266)	-0.284 (0.177)	1.090*** (0.359)	-0.458 (0.348)
col45	0.466*** (0.056)	0.041 (0.083)	0.945*** (0.074)	1.216*** (0.093)	-0.027 (0.210)	-0.041 (0.166)	0.391*** (0.147)	0.714*** (0.164)	-0.863*** (0.164)	0.438*** (0.113)	0.462** (0.203)	1.209*** (0.174)
comcur	0.250*** (0.038)	0.236*** (0.049)	0.385*** (0.060)	0.257*** (0.073)	0.112 (0.097)	1.600*** (0.145)	0.661*** (0.122)	0.581*** (0.103)	-0.028 (0.145)	0.341*** (0.076)	0.361*** (0.121)	-0.027 (0.149)
constant	-20.313*** (1.229)	-17.622*** (2.056)	1.504 (1.815)	-29.557*** (3.541)	0.775 (4.747)	-42.789*** (6.187)	-44.111*** (3.444)	-52.227*** (3.391)	-25.225*** (4.078)	-46.109*** (2.994)	-26.194*** (5.043)	-14.060*** (6.362)
Observations	142,201	124,973	130,046	106,190	90,183	98,990	108,108	105,432	94,829	126,730	89,170	89,300
pseudo R <sup>2</sup>	0.904	0.868	0.890	0.844	0.765	0.842	0.878	0.880	0.930	0.868	0.801	0.845
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors clustered by country pair, reported in parentheses. \*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Appendix B presents the lagged effects of large natural disasters by sub-sector. We observe the following patterns: (i) The exports of transport services, other business services and the receipt of royalty license fees are negatively affected in the year a large disaster occurs, but such negative impacts diminish in the years following the disaster. (ii) The negative impact on the exports of communications services persists over time, lasting for as long as five years. Natural disasters causing damages to communications infrastructure could severely deter the supply in these services sectors, possibly altering their growth trajectory in the long-term. (iii) The exports of travel see a decline in the year a disaster occurs and the negative effect lasts for three years after the disaster. (iv) The exports of insurance services see a rise in the year a disaster occurs, and the effect can last for two to three years post-disaster. A similar pattern can be seen for the exports of financial services, although the effect is statistically insignificant in some cases. (v) The exports of construction services increase two to three years after a large disaster occurs. This may be related to the reconstruction and rebuilding that occur in the aftermath of a disaster, as construction materials and services sourced locally by foreign construction firms are often recorded as services exports.

### 3.3 Robustness

In what follows, we perform analysis with alternative data on services trade and alternative measure of natural disasters to verify the robustness of our results.

#### 3.3.1 Alternative measure of disasters

First, we use an alternative measure of natural disasters. It has been pointed out that the data on natural disasters collected in the EM-DAT database are mostly based on insurance claims or news stories, rather than primary geophysical or meteorological data, and it is quite plausible that news or insurance coverage correlates with income. Moreover, defining large natural disasters by measure of human or economic loss may lead to estimation bias. As [Felbermayr and Gröschl \(2014\)](#) point out, since the monetary damage of a given disaster is higher in a richer economy, disaster intensity measures from EM-DAT are likely to correlate with GDP per capita and the value of trade, leading to endogeneity issues. Several studies have raised the possibility that the nature of the insurance- or news-based disaster data is responsible for some of the empirical puzzles ([Noy, 2009](#); [Cavallo et al., 2013](#); [Felbermayr and Gröschl, 2014](#)).

To address the potential endogeneity issue, it would be preferable to use physical disaster intensity measures to capture the causal effect of natural disasters. We use the natural disasters data provided in the ifo Geological and Meteorological Events (GAME) database, which measures the magnitude of a natural disaster by its geophysical or meteorological intensity. The intensity of an earthquake, for example, is measured by its strength in Richter scale and the intensity of a

storm or a hurricane is defined as the maximum wind speed in knots. To meaningfully compare different types of natural disasters, we measure the intensity of natural disasters in relation to all observed disasters of the same type: we create a dummy variable that takes the value of one if the intensity of a natural disaster exceeds 75 percentile or 95 percentile of all disasters of the same type recorded in the dataset.<sup>11</sup> Since natural disasters represent unforeseen contingencies and can be thought of as exogenous, the coefficients can be interpreted as causal impact of natural disasters on services trade.

Table 5: Natural disasters defined by type and intensity  
(Year 1995-2010)

	(1) Observations	(2) Mean	(3) Standard Deviation	(4) Minimum	(5) Maximum
<u>Emergency events database (EM-DAT)</u>					
Large disasters	2,780	0.377	1.202	0	18
All disasters	2,780	1.904	3.585	0	40
Large disaster dummy	2,780	0.203	0.402	0	1
All disaster dummy	2,780	0.586	0.493	0	1
<u>ifo Geological and Meteorological Events (GAME): 75 percentile</u>					
Earthquake	2,780	0.458	0.498	0	1
Storm	2,780	0.274	0.446	0	1
Volcano	2,780	0.919	0.273	0	1
Flood	2,780	0.293	0.455	0	1
Drought	2,780	0.096	0.295	0	1
Heatwave	2,780	0.328	0.470	0	1
Cold wave	2,780	0.982	0.132	0	1
Disaster Index 1	2,780	0.225	0.418	0	1
Disaster Index 2	2,780	0.249	0.432	0	1
<u>ifo Geological and Meteorological Events (GAME): 95 percentile</u>					
Earthquake	2,780	0.351	0.477	0	1
Storm	2,780	0.0917	0.289	0	1
Volcano	2,780	0.919	0.273	0	1
Flood	2,780	0.106	0.308	0	1
Drought	2,780	0.029	0.167	0	1
Heatwave	2,780	0.328	0.470	0	1
Cold wave	2,780	0.982	0.132	0	1
Disaster Index 1	2,780	0.049	0.215	0	1
Disaster Index 2	2,780	0.052	0.222	0	1

Additionally, we define a Disaster Index by taking the unweighted sum of physical intensity measures of each type of natural disaster - earthquake, volcano, storm, flood, drought, extreme heatwave or extreme cold weather - that took place in a country in a specific year, divided by the log area of the affected country, to account for the fact that given disasters have very different effects in countries of different geographical extension. Following [Felbermayr and Gröschl \(2014\)](#), we also propose an alternative Disaster Index, reported as Disaster Index 2, in which the physical intensity measures of different disaster types are weighted with their inverse sample standard deviation. We then convert both indices into indicator variables if the values exceed the 75 or 95 percentile of the disaster index measure. Table 5 provides the summary statistics of the disaster

<sup>11</sup>A 75 percentile of intensity for an earthquake roughly translates into 6 degree in Richter scale, and a wind speed of 66.8 knots in a storm (124 km/h). A 95 percentile intensity translates into a 7.1 degree earthquake or a wind speed of 95.2 knots in a storm (176 km/h). See Appendix A.1 for a description of the data and their sources.

variables by their type and intensity.

Table 6: Effects of natural disasters by disaster type and intensity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	PPML	OLS	PPML	OLS	PPML	OLS	PPML
	Trade in services				Trade in goods			
	75 percentile		95 percentile		75 percentile		95 percentile	
Disaster Index1 <sub>o</sub>	-0.055*** (0.015)	-0.017 (0.019)	-0.056** (0.022)	-0.048** (0.020)	0.034** (0.014)	-0.010 (0.021)	-0.012 (0.022)	-0.023 (0.024)
Disaster Index1 <sub>d</sub>	0.029 (0.020)	0.001 (0.017)	-0.029 (0.025)	-0.027 (0.024)	0.025 (0.016)	-0.003 (0.021)	-0.013 (0.021)	-0.010 (0.036)
Disaster Index2 <sub>o</sub>	-0.030* (0.016)	-0.018 (0.019)	-0.035 (0.022)	-0.044** (0.020)	0.024* (0.014)	0.004 (0.021)	0.040* (0.022)	-0.012 (0.028)
Disaster Index2 <sub>d</sub>	0.038* (0.020)	0.002 (0.017)	-0.018 (0.024)	-0.016 (0.024)	0.016 (0.015)	-0.001 (0.020)	-0.002 (0.024)	-0.006 (0.047)
Earthquake <sub>o</sub>	-0.020 (0.018)	-0.006 (0.016)	0.092*** (0.021)	0.017 (0.018)	-0.020 (0.014)	-0.027 (0.018)	0.015 (0.018)	0.002 (0.028)
Earthquake <sub>d</sub>	0.028* (0.017)	-0.009 (0.016)	-0.007 (0.019)	-0.011 (0.021)	-0.001 (0.014)	-0.029 (0.019)	0.014 (0.016)	-0.021 (0.030)
Storm <sub>o</sub>	0.064*** (0.019)	-0.025 (0.022)	-0.034* (0.020)	-0.023 (0.021)	0.081*** (0.016)	0.006 (0.023)	0.016 (0.015)	0.033 (0.025)
Storm <sub>d</sub>	0.003 (0.020)	0.019 (0.021)	-0.051** (0.024)	-0.017 (0.019)	-0.026 (0.017)	-0.006 (0.024)	0.006 (0.025)	0.031 (0.022)
Volcano <sub>o</sub>	-0.074** (0.037)	0.010 (0.026)	-0.074** (0.037)	0.010 (0.026)	-0.189*** (0.027)	0.028 (0.026)	-0.189*** (0.027)	0.028 (0.026)
Volcano <sub>d</sub>	0.003 (0.029)	0.005 (0.028)	0.003 (0.029)	0.005 (0.028)	-0.022 (0.024)	0.026 (0.041)	-0.022 (0.024)	0.026 (0.041)
Flood <sub>o</sub>	0.060*** (0.020)	-0.006 (0.027)	-0.030 (0.020)	0.014 (0.021)	0.056*** (0.017)	0.011 (0.020)	-0.029* (0.018)	0.006 (0.032)
Flood <sub>d</sub>	0.008 (0.033)	0.015 (0.024)	0.031 (0.024)	0.020 (0.025)	0.004 (0.036)	0.011 (0.027)	0.001 (0.026)	0.011 (0.025)
Drought <sub>o</sub>	-0.120** (0.049)	-0.051 (0.033)			0.051 (0.039)	0.038 (0.107)	0.015 (0.013)	0.019 (0.016)
Drought <sub>d</sub>	0.111*** (0.037)	-0.000 (0.033)			-0.006 (0.033)	0.130*** (0.041)	0.005 (0.021)	-0.008 (0.024)
Heatwave <sub>o</sub>	-0.016 (0.014)	0.007 (0.017)	-0.016 (0.014)	0.007 (0.017)	0.015 (0.013)	0.019 (0.016)	-0.368 (0.245)	-0.022 (0.353)
Heatwave <sub>d</sub>	0.007 (0.022)	0.010 (0.017)	0.007 (0.022)	0.010 (0.017)	0.005 (0.021)	-0.008 (0.024)	0.008 (0.056)	0.041 (0.111)
Cold wave <sub>o</sub>	-0.098 (0.094)	0.043 (0.106)	-0.098 (0.094)	0.043 (0.106)	-0.368 (0.245)	-0.022 (0.353)	-0.357 (0.235)	-0.001 (0.118)
Cold wave <sub>d</sub>	0.023 (0.064)	0.009 (0.074)	0.023 (0.064)	0.009 (0.074)	0.008 (0.056)	0.041 (0.111)	-0.025 (0.054)	0.015 (0.052)

Notes: the table reports the coefficients of disaster variables in a gravity model using either OLS or PPML estimator. The first four columns report results with the bilateral trade in services as dependent variable. Natural disasters are defined as 75 or 95 percentile in intensity. The last four columns report the same estimators with the value of bilateral trade in goods as the dependent variable. Robust standard errors are clustered by country pair, reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. The coefficients of the other variables in the gravity model are not reported.

Measuring a large natural disaster by its physical intensity provides plausibly exogenous variations to economic or societal outcomes, and also allows us to measure the heterogeneous effects of natural disasters on service trade by the type of disasters. Table 6 reports the results of the gravity model where the coefficients of disasters are reported by their type and intensity. Columns (1) and (2) report the OLS and PPML results with larger disasters defined as the 75 percentiles of the physical intensity and columns (3) and (4) report the results with disasters measured at

95 percentiles of their intensity.

The first measure of Disaster Index, defined at 75 percentile of intensity, displays a negative but sometimes insignificant effect on services exports. The Disaster Index measured at the 95 percentile displays a significantly negative effect on services exports. Quantitatively, a country with a 95 percentile Disaster Index in a particular year can expect an average of 4.8% decline in services exports. The second measure of Disaster Index also shows a similar pattern, with a Disaster Index at 95 percentile leading to a decline of services exports by 4.4%. The effects of the natural disaster indices on services imports vary depending on the estimation methods and are generally insignificant.

The remaining rows of Table 6 report the coefficients of each type of natural disasters, which generally show negative but insignificant effects on services trade. For instance, large earthquakes at 95 percentile intensity appears to be positively correlated with services exports in the OLS estimation, but the PPML estimator gives insignificant coefficients. Overall, the results using the alternative measure of natural disasters broadly confirm our baseline estimates - large natural disasters have negative impacts on services exports and ambiguous impacts on services imports.

Columns (5) to (8) of Table 6 shows the results of the same estimates with the dependent variable being the value of bilateral merchandise trade. We draw two observations from this comparison. First, the disaster indices at 95 percentile are negatively correlated with goods exports but the effects are statistically insignificant. At 75 percentile, the disaster indices even display a positive correlation with services exports. This suggests that, counting all natural disasters altogether, merchandise exports are less affected by large disasters than services exports. Second, looking at each natural disaster by type, earthquakes, storms, volcanic eruptions, floods, droughts and extreme temperatures do not have strong negative impact on goods exports. In the case of storms and floods, the disasters may even be positively correlated with merchandise exports. This finding confirms that services trade is more likely to be negatively impacted by natural disasters compared to goods trade.

### **3.3.2 Alternative services data**

Although the BaTis data is by far the most comprehensive dataset covering bilateral services trade, our choice to limit the sample to countries that report bilateral services trade may entail a degree of selection bias. As a robustness check, we use an alternative source of services trade data - the World Input-Output Database (WIOD) - to verify our results. The World Input-Output Tables are constructed from data covering 40 countries and 17 services sectors for the period of 1995 to 2011.

One key advantage of using the data is the possibility to reconstruct domestic production or

*intra-national* trade, thus allowing us to estimate the effects of country-specific variables while controlling for country-time and pair fixed effects (Heid et al., 2017; Beverelli et al., 2018; Larch et al., 2019). For the reasons discussed in Section 3.3.1, the disaster variable from the EM-DAT database may be correlated with the dependent variable value of services trade, resulting in concerns of endogeneity. Estimating the structural gravity model with *international* and *intra-national* trade flows allows us to capitalize on the fact that country-specific variables apply to international trade but not to *intra-national* trade.

The estimation equations are expressed as follows:

$$\ln(T_{odt}) = \alpha D_{o,dt} * INTL + \beta_1 \ln(GDP_{o,dt}) + \beta_2 \ln(GDP_{pc_{o,dt}}) + \beta_3 (T_{od}) + \pi_{it} + \chi_{jt} + \mu_{ij} + \varepsilon_{odt} \quad (3)$$

For the PPML estimator:

$$T_{odt} = \exp\left[\alpha D_{o,dt} * INTL + \beta_1 \ln(GDP_{o,dt}) + \beta_2 \ln(GDP_{pc_{o,dt}}) + \beta_3 T_{od} + \pi_{it} + \chi_{jt} + \mu_{ij}\right] \times \varepsilon_{odt} \quad (4)$$

As a result of including *intra-national* trade, it is possible to identify the effects of country-specific variables on international trade while controlling for exporter-time fixed effects ( $\pi_{it}$ ), importer-time fixed effects ( $\chi_{jt}$ ), and pair fixed effects ( $\mu_{ij}$ ). This estimation is less likely to be subject to endogeneity concerns for two reasons. First, it is unlikely that a country-specific variable such as a natural disaster will be influenced by any bilateral trade flows. Second, the directional fixed effects in the structural gravity model will absorb much of the unobserved correlation between the country-specific covariates and the gravity error term.

To capture the impact of natural disasters on services trade flows, we interact the disaster variable with the variable *INTL* that equals one in cases of international trade between countries and equals zero in cases of *intra-national* trade within one country. In this way, the coefficient  $\alpha$  captures the impact of an additional large natural disaster on *international* trade relative to *intra-national* trade.

Table 7 reports the gravity model estimates derived from the WIOD data. Columns (1) and (2) report the results using OLS and PPML estimators respectively. The set of exporter-time, importer-time and pair fixed effects we include in the model absorbs the effect of all other covariates. The variable  $Dis \times INTL$  captures the effect of a large natural disaster in the exporting country on its services exports relative to its domestic services. The coefficients of -1.87 and -3.11 imply that an additional large disaster would reduce the exports of services by 85% to 96% relative to *intra-national* supply of services.<sup>12</sup> Although this result is not directly comparable to the baseline results, it confirms that a large natural disaster can indeed lead to a significant decline in services trade. We do not report the effect on the importing countries, since the bilateral variable

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<sup>12</sup>The percentage change is calculated as follows:  $[\exp(-1.87) - 1] \times 100 = -84.5$  and  $[\exp(-3.11) - 1] \times 100 = -95.5$ .

Table 7: Effect of natural disasters on services trade - WIOD data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	PPML	OLS	PPML	OLS	PPML	OLS	PPML
	Trade in services				Trade in goods			
Dis×INTL	-1.872*** (0.391)	-3.113*** (0.347)	-0.527*** (0.195)	-0.851*** (0.125)	-1.330*** (0.274)	-1.195*** (0.147)	-0.400*** (0.119)	-0.324*** (0.049)
Dis×INTL1			-0.304*** (0.116)	-0.591*** (0.125)			-0.256*** (0.085)	-0.269*** (0.043)
Dis×INTL2			-0.314*** (0.118)	-0.825*** (0.141)			-0.240*** (0.071)	-0.118*** (0.035)
Dis×INTL3			-0.337*** (0.101)	-0.722*** (0.120)			-0.461*** (0.119)	-0.427*** (0.062)
Dis×INTL4			-0.352*** (0.111)	-0.996*** (0.147)			-0.240*** (0.069)	-0.205*** (0.053)
Dis×INTL5			-0.478*** (0.173)	-1.051*** (0.188)			-0.305*** (0.095)	-0.237*** (0.050)
Observations	24,155	24,336	16,599	16,731	24,330	24,336	16,731	16,731
R <sup>2</sup>	0.904	0.947	0.918	0.987	0.954	0.933	0.962	0.962
Importer time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The first four columns report results with the bilateral trade in services as dependent variable. The last four columns report the same estimators with the value of bilateral trade in goods as the dependent variable. Robust standard errors are clustered by country pair, reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

is symmetrical and the coefficient would be the same.

In columns (3) and (4), we report the OLS and PPML results including up to five lags of the large disaster variable. The effects of large natural disasters on *international* services trade relative to *intra-national* trade are negative and significant even five years after the occurrence of a large disaster. In the year after a large disaster, *international* services trade can on average decline by 26% to 44% relative to *intra-national* trade, and the negative impact can persist in a similar magnitude in the years following the disaster.

Columns (5) to (8) of Table 7 report the estimates with the dependent variable being trade in goods, also derived from the WIOD data. A large natural disaster leads to a decline of merchandise trade by 70% to 74% relative to *intra-national* trade in the year it occurs. The negative effect is similar as trade in services, but smaller in magnitude. The impact of natural disasters can also exert a lasting impact on goods trade for up to five years and the magnitude of the long-term impact on goods trade is much smaller than that on services trade. For example, in the fifth year after the occurrence of a large natural disaster, services exports are expected to decline by 38% to 65% relative to domestic sales, whereas goods exports decline by 21% to 26%.

Our results using different datasets and estimation methods reveal consistently that the negative impact of natural disasters on services trade is larger than the impact on merchandise trade. This may be explained by the fact that, compared with goods trade, services trade faces higher costs and relies more on physical infrastructure for cross-border delivery. Services delivered through

cross-border supply (GATS mode 1) often rely on connectivity through telecommunication networks, consumption abroad (mode 2) requires consumers to be located closer to the suppliers of the services, which requires cross-border transportation, and the presence of individuals abroad (mode 4) similarly requires the services suppliers to be temporarily located to another country. These modes of services delivery often demand well-functioning infrastructure and business environment, more so than goods trade. Therefore natural disasters damaging infrastructure and disrupting economic activities affect service trade more severely.

### 3.4 The role of services trade policy

Policy differences affect countries' ability to respond to and recover from natural disasters. We examine the role of service trade policies that influence the impact of natural disaster on services trade.

Services trade barriers are captured by the World Bank Service Trade Restrictions Index (STRI). Covering 103 countries, the STRI indicates the level of services restrictions for the overall services industry. Countries that have more restrictive services trade policy receive a higher STRI score. Although the original STRI ranges from 0 to 100, we transform the index by dividing it by 100 so that it runs from 0 to 1.

Unfortunately, the STRI only covers one year (2009) and thus is time-invariant. To capture the impact of STRI on services trade value, we exclude exporter- and importer- fixed effects in some of the model specifications. Taking this approach allows us to capture the effect of services trade restrictions and the interaction between services trade restrictions and natural disasters, but it also means that we can no longer control for country-specific characteristics. As a compromise, we follow [Baier and Bergstrand \(2009\)](#) and approximate international trade-cost effects, or “multilateral resistance”, using a Taylor-series expansion.

Table 8 reports the results. The first column reports the results of the OLS model including exporter- and importer- fixed effects, which absorb the variation of the STRI variables. The second column reports the OLS estimate including pair fixed effects. The third column reports the results of the OLS model without fixed effects, and the variable MRT represents the approximated multilateral resistance term. Columns (4) to (6) report the same model specifications with the PPML estimator.

We first note that the coefficients of the STRI variable for the services importer are negative and significant, and the coefficient of the exporters' STRI is also negative in the PPML estimate. This suggests that countries with higher services trade restrictions import less trade in services, and they are also less likely to export services. Consistent with similar findings in the literature (e.g., [Nordås and Rouzet, 2015](#)), higher services trade restrictions indeed impede a country's capacity to participate in services trade.



How does openness in services trade affect the impact of natural disasters? We measure the role of services trade restrictions by interacting the natural disaster variable with STRI, labeled as  $disaster \times STRI_o$  and  $disaster \times STRI_d$ . A positive coefficient of the interaction term would indicate that the services trade of a country with higher services trade restrictions is more likely to be impacted by a natural disaster. We observe a statistically insignificant coefficient for the exporting country, indicating that services trade restrictions do not affect the impact of natural disasters on service exports. In other words, natural disasters have a negative impact on service exports, regardless of the country's services trade regime. On the other hand, we observe a positive and significant coefficient of the interaction term for the importing country in most of the specifications. This suggests that countries with a relatively higher levels of service restrictions tend to import more services after a natural disaster. This may be due to the fact that countries with higher services trade restrictions are less prepared for a large natural disaster, and thus require more services imports to tackle in the aftermath of a disaster.

Table 8: The role of services trade restrictions

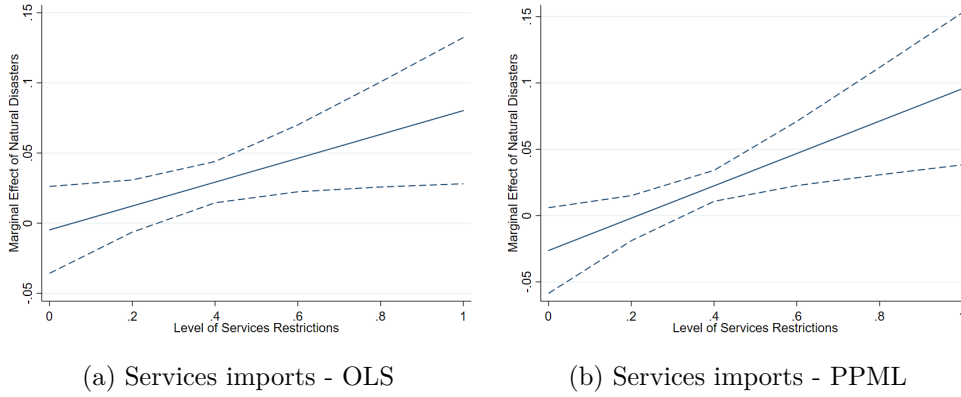
	(1) OLS	(2) OLS	(3) OLS	(4) PPML	(5) PPML	(6) PPML
Disaster <sub>o</sub>	0.010 (0.029)	0.011 (0.026)	0.006 (0.060)	-0.058 (0.041)	-0.042 (0.038)	-0.017 (0.024)
Disaster <sub>d</sub>	-0.005 (0.016)	0.000 (0.013)	0.011 (0.030)	-0.058*** (0.019)	-0.053*** (0.013)	-0.026 (0.016)
Disaster $\times$ STRI <sub>o</sub>	-0.169 (0.149)	-0.162 (0.135)	-0.195 (0.279)	0.192 (0.215)	0.127 (0.206)	0.091 (0.116)
Disaster $\times$ STRI <sub>d</sub>	0.085** (0.040)	0.059* (0.033)	0.062 (0.075)	0.172*** (0.052)	0.160*** (0.035)	0.122*** (0.044)
STRI <sub>o</sub>			0.284 (0.454)			-4.205*** (0.203)
STRI <sub>d</sub>			-0.342 (0.223)			-1.612*** (0.162)
MRT			0.547*** (0.105)			0.095** (0.040)
Observations	20,352	20,352	20,352	55,464	39,328	158,424
R <sup>2</sup>	0.852	0.386	0.783	0.904	0.951	0.904
Exporter FE	Yes			Yes		
Importer FE	Yes			Yes		
Pair FE		Yes		Yes		Yes

Notes: The first three columns report of the results of the OLS estimates. Column (1) includes exporter- and importer- fixed effects, column (2) includes pair fixed effects, column (3) does not include any fixed effects. Columns (4) to (6) report the same model specifications with the PPML estimates. Robust standard errors clustered by country pair, reported in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Figure 3 depicts the marginal effect of disasters conditional on the level of services trade restrictions. The solid line indicates the marginal effect of natural disasters and the dashed lines represent 95% confidence level. Countries with higher services trade restrictions are more likely to increase services imports following a natural disaster. For a country with an overall STRI of around 40, a large disaster increases services imports by roughly 3%, and a country with an overall

STRI of around 60 would see services imports increase by roughly 5% after a large disaster.

Figure 3: Marginal effect of disasters conditional on level of services restrictions



Notes: The graphs depict the marginal effect of disasters in an importing country conditional on the level of services trade restriction (solid line) and the 95% confidence interval (dashed line). The left graph shows the result using OLS regression with fixed effects, the right graph shows the result using PPML regression.

## 4 Conclusions

Services - especially modern services such as transport, communications, financial intermediation and business services - have been identified as a catalyst for growth in developing countries (Ghani and O’Connell, 2014; IMF, 2018). Unexpected large external shocks such as natural disasters that disrupt economic activities and hinder international trade in services may pose severe challenges for countries aiming to catch up in the development process. This paper documents the impact of natural disasters on services trade by using a structural gravity model, which allows us to single out the effect of natural disasters while taking into account other factors affecting trade in services. We measure the magnitude of natural disasters using two distinct sets of variables that define large disasters by (1) their human casualty and economic loss, and (2) their geophysical and meteorological magnitudes.

First, we define large natural disasters by reference to the casualties and economic loss incurred, based on EM-DAT data. Our results reveal that natural disasters indeed cause a negative impact on services exports. A large natural disaster, *ceteris paribus*, reduces services exports by about 2% to 3% in the year it occurs. The impact of natural disasters on services imports are ambiguous: on one hand, affected countries may need more services imports to meet its consumption needs; on the other hand, large disasters can destroy trade-infrastructure and disrupt services imports.

We also investigate the effect of disasters in different service sub-sectors and find that exports in capital- and knowledge-intensive sectors such as transport services, communications services and royalty license fees are most affected by natural disasters. On average, one additional large

natural disaster can reduce the exports of communications services by 5%-9%, transportation services by 2%-4%, and royalty license fees by roughly 2%. While the negative effects on transport services and royalty license fees recover in the year following a large natural disaster, the negative impact on communications service exports persists for as long as five years. As transport and communications services tend to provide the necessary infrastructure for other sectors of the economy (Fink et al., 2002; El Khoury and Savvides, 2006), natural disasters disrupting the supply and exports in these sectors may bring negative spillovers to the entire economy and alter growth trajectories. A decline is also seen in the exports of business services and travel following a natural disaster. The exports of insurance services see a rise in the year it occurs, and the exports of construction services rise two to three years after a large natural disaster.

Our results stand broadly when we use alternative variables on natural disasters, defined by reference to the associated geophysical and meteorological measures in the Geological and Meteorological Events (GAME) database. Measuring large disasters by their physical intensity provides plausibly exogenous variations to economic outcomes, allowing us to rid the potential endogeneity issue associated with insurance- or news-based disaster measures. We find that natural disasters at an intensity of 95 percentile lead to a decline of services exports by 4%.

We also test the results using an alternative dataset covering both *international* and *intra-national* trade. Leveraging the rich set of fixed effects, the gravity model absorbs much of the unobserved correlation between the country-specific covariates and the gravity error term, allowing us to identify the causal impact of natural disasters on services trade. We find that an additional natural disaster would reduce the exports of services by 85% to 96% relative to *intra-national* supply of services. The result confirms that a large natural disaster can indeed lead to a significant decline in services trade.

Our results using different datasets and estimation methods reveal consistently that the negative impact of natural disasters on services trade is larger than the impact on merchandise trade. This finding may be explained by the fact that trade in services faces higher costs and more heavily relies on physical infrastructure for cross-border delivery. Natural disasters causing damages to infrastructure and disrupting economic activities therefore affect service trade more severely.

Additionally, we investigate whether the openness in services trade would mitigate or aggravate the impact of natural disasters. While countries with higher services trade restrictions in general import and export less services, we find that these countries tend to import relatively more services in the aftermath of a large natural disaster. It may be due to the fact that countries with higher levels of trade restrictions are less prepared for disasters, and thus require more service imports to respond to and recover from a large natural disaster.

Due to the shortage of high-quality data on services trade, we confine our study to the countries

that report services trade data included in an OECD-WTO trade in services database. However, most of the countries that report services trade at aggregate or sub-sectoral levels are high-income countries. This limitation constrains our analysis. Much is still unknown about the impact of natural disasters on low-income countries, which is likely to be even larger in magnitude. As climate change is likely to give rise to larger and more frequent natural disasters ([IPCC, 2012](#); [World Bank, 2009](#)), more research on the economic impact of natural disasters, especially those of small low-income countries, would be of strong policy relevance.

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# Appendix

## A Data sources and summary statistics

### A.1 Variables - Description and Sources

Variable	Description	Source
Value ( <i>services</i> )	Adjusted value of services exports in million USD (1995 to 2010).	OECD-WTO services trade database
Value ( <i>goods</i> )	Adjusted value of bilateral goods trade in million USD (1995 to 2010).	World Trade Flows (WTF) Bilateral data
Disaster	Number of major disasters, magnitude defined by total death, casualty or economic loss (1979 to 2010).	EM-DAT (2017)
Earthquake	Magnitude defined by Richter scale strength (1995 to 2010).	Felbermayr and Gröschl (2014)
Storm	Magnitude defined as maximum wind speed in knots (1995 to 2010).	Felbermayr and Gröschl (2014)
Volcano	Magnitude defined by the Volcanic Explosivity Index (VEI) (1995 to 2010).	Felbermayr and Gröschl (2014)
Flood	Magnitude defined by the positive difference in total monthly precipitation from long-run average (1995 to 2010).	Felbermayr and Gröschl (2014)
Drought	Dummy = 1 if at least three consecutive months or at least five months within a year have rainfall below 50% of long-run average (1995 to 2010).	Felbermayr and Gröschl (2014)
Heatwave	Magnitude defined by the positive deviation of the maximum temperatures from long-run monthly mean (1995 to 2010).	Felbermayr and Gröschl (2014)
Codewave	Magnitude defined by the negative deviation of the maximum temperatures from long-run monthly mean (1995 to 2010).	Felbermayr and Gröschl (2014)
$\ln$ GDP	Log of GDP (in million USD)	CEPII (2015) and World Bank (2018)
$\ln$ GDPpc	Log of GDP per capita (in USD)	CEPII (2015) and World Bank (2018)
$\ln$ Dist	Natural log of weighted distance	CEPII (2015)
fta_wto	Dummy for parties to a free trade agreement (Source: WTO, 2015)	CEPII (2015)
contig	Dummy for common border	CEPII (2015)
comlang off	Dummy for common official language	CEPII (2015)
comlang ethno	Dummy for common ethnic language	CEPII (2015)
comcol	Dummy for common colonizer post 1945	CEPII (2015)
col45	Dummy for country pairs in colonial relationship post-1945	CEPII (2015)
comcur	Dummy for common currency	CEPII (2015)
STRI	Services Trade Restrictions Index, ranging from 0 to 100	Borchert et al. (2012)

## A.2 Coverage of countries and economies: all services

Table 1: Countries and economies reporting total services exports

Exporter	Frequency	Percent	Exporter	Frequency	Percent
Australia	1,129	2.32	Latvia	1,679	3.45
Austria	2,012	4.13	Lithuania	1,300	2.67
Azerbaijan	127	0.26	Luxembourg	1,641	3.37
Belarus	273	0.56	Malta	657	1.35
Belgium	1,834	3.77	Mexico	21	0.04
Brazil	293	0.6	Moldova, Republic of	55	0.11
Bulgaria	1,222	2.51	Netherlands	1,604	3.29
Canada	944	1.94	New Zealand	90	0.18
Chile	42	0.09	Norway	9	0.02
China	23	0.05	Pakistan	854	1.75
Cyprus	1,524	3.13	Poland	1,221	2.51
Czech Republic	1,673	3.44	Portugal	711	1.46
Croatia	1,023	2.1	Romania	1,047	2.15
Denmark	1,397	2.87	Russian Federation	1,151	2.36
Estonia	1,166	2.39	Singapore	257	0.53
Finland	1,313	2.7	Slovakia	1,225	2.52
France	1,625	3.34	Slovenia	1,849	3.8
Germany	2,776	5.7	Spain	562	1.15
Greece	1,195	2.45	Swaziland	10	0.02
Hong Kong, China	514	1.06	Sweden	2,147	4.41
Hungary	1,219	2.5	Tunisia	431	0.89
Iceland	350	0.72	Turkey	65	0.13
Ireland	1,221	2.51	Ukraine	519	1.07
Italy	1,838	3.77	United Kingdom	1,682	3.45
Japan	458	0.94	United States	457	0.94
Korea, Republic of	261	0.54			



### A.3 Coverage of countries and economies: service sub-sectors

Table 2: Countries and economies reporting services exports by sub-sector

Exporter	Frequency	Percent	Exporter	Frequency	Percent
Afghanistan	176	0.02	Kiribati	2,806	0.33
Algeria	175	0.02	Korea, Republic of	2,377	0.28
Angola	9,998	1.18	Kuwait	2,806	0.33
Argentina	3,403	0.4	Laos	8,418	1
Australia	10,589	1.25	Latvia	27,356	3.24
Austria	20,392	2.41	Lesotho	7,542	0.89
Azerbaijan	2,582	0.31	Liberia	11,224	1.33
Bangladesh	701	0.08	Libyan	2,806	0.33
Barbados	351	0.04	Lithuania	18,261	2.16
Belarus	1,407	0.17	Luxembourg	6,638	0.79
Belgium	19,677	2.33	Malawi	14,014	1.66
Bermuda	175	0.02	Maldives	8,418	1
Bhutan	5,612	0.66	Mali	525	0.06
Brazil	4,602	0.54	Malta	18,613	2.2
Brunei Darussalam	8,418	1	Mauritius	526	0.06
Bulgaria	16,332	1.93	Mexico	47	0.01
Burkina Faso	4,381	0.52	Moldova, Republic of	1,078	0.13
Cameroon	526	0.06	Namibia	6,314	0.75
Canada	2,841	0.34	Nepal	5,612	0.66
Cape Verde	1,053	0.12	Netherlands	8,700	1.03
Central African Republic	16,836	1.99	New Zealand	718	0.08
Chad	11,224	1.33	Nicaragua	15,956	1.89
Chile	3,030	0.36	Niger	4,383	0.52
China	41	0	Norway	106	0.01
Colombia	11,214	1.33	Oman	9,807	1.16
Comoros	17,186	2.03	Pakistan	14,746	1.75
Congo	5,612	0.66	Papua New Guinea	2,982	0.35
Costa Rica	702	0.08	Philippines	176	0.02
Cote d'Ivoire	2,633	0.31	Poland	18,156	2.15
Cyprus	12,755	1.51	Portugal	2,650	0.31
Czech Republic	14,305	1.69	Romania	16,048	1.9
Croatia	18,790	2.22	Russian Federation	10,588	1.25
Denmark	8,199	0.97	Rwanda	175	0.02
Djibouti	8,418	1	Saint Lucia	11,224	1.33
Ecuador	2,806	0.33	Saint Vincent and Grenadines	2,806	0.33
El Salvador	176	0.02	Samoa	2,806	0.33
Equatorial Guinea	19,642	2.33	Sao Tome And Principe	5,456	0.65
Estonia	14,354	1.7	Senegal	876	0.1
Ethiopia	1,577	0.19	Sierra Leone	6,659	0.79
Fiji	175	0.02	Singapore	397	0.05
Finland	21,664	2.56	Slovakia	21,536	2.55
France	11,488	1.36	Slovenia	21,660	2.56
Gambia	9,818	1.16	Solomon Islands	878	0.1
Georgia	2,625	0.31	Spain	1,122	0.13
Germany	14,970	1.77	Sudan	875	0.1
Greece	13,495	1.6	Swaziland	1,331	0.16
Grenada	8,418	1	Sweden	15,538	1.84
Guatemala	2,105	0.25	Tajikistan	2,806	0.33
Guinea-Bissau	3,332	0.39	Tanzania	879	0.1
Guyana	2,806	0.33	Tonga	5,788	0.69
Haiti	2,806	0.33	Tunisia	1,484	0.18
Hong Kong, China	3,214	0.38	Turkey	6,733	0.8
Hungary	13,718	1.62	Uganda	175	0.02
Iceland	13,333	1.58	Ukraine	534	0.06
Ireland	20,180	2.39	United Kingdom	6,551	0.78
Israel	1,463	0.17	United States	3,294	0.39
Italy	16,006	1.89	Vanuatu	1,228	0.15
Japan	5,602	0.66	Zambia	13,326	1.58
Kazakhstan	2,456	0.29	Zimbabwe	5,612	0.66

## A.4 Definition of trade in commercial services by sub-sector

Exports (credits) and imports (debits) of commercial services are derived from statistics on international service transactions included in the balance of payments statistics, in conformity with the concepts, definitions and classification of the fourth (1977) or fifth (1993) edition of the IMF Balance of Payments Manual.

In the fifth edition of the Balance of Payments Manual, the current account is subdivided into goods, services (including government services, n.i.e.), income (investment income and compensation of employees), and current transfers. The commercial services category is defined as services minus government services, n.i.e. Commercial services is further sub-divided into transport, travel, and other commercial services. The definitions of each service sub-sectors are summarised in the following table.

Service sector	Coverage
Transport services	Transportation services (sea, air and other - including land, internal waterway, space and pipeline) that are performed by residents of one economy for those of another, and that involve the carriage of passengers, the movement of goods (freight), rentals (charters) of carriers with crew, and related supporting and auxiliary services.
Travel	Goods and services acquired by personal travellers, for health, education or other purposes, and by business travellers. Unlike other services, travel is not a specific type of service, but an assortment of goods and services consumed by travellers. The most common goods and services covered are lodging, food and beverages, entertainment and transportation (within the economy visited), gifts and souvenirs.
Communications services	Two primary categories of transactions (i) telecommunications: the transmission of information by telephone, telex, telegram, cable, broadcasting, satellite, electronic mail, facsimile services, etc. and include business network services, teleconferencing, and support services; and (ii) postal and courier services: the pickup, transport, and delivery of letters, parcels, and packages by national postal administrations and other operators.
Construction	Work performed on construction projects and installations by employees of an enterprise in locations outside the economic territory of the enterprise. Goods imported by the enterprise for use in the projects are included in the value of these services.
Insurance services	The provision of various types of insurance, such as freight insurance, life and health insurance, and reinsurance, to nonresidents by resident insurance enterprises, and vice versa. Total premiums minus the estimated service charge and claims payable are recorded.
Financial services	Financial intermediary and auxiliary services (except those of insurance enterprises and pension funds) conducted between residents and nonresidents. Included are intermediary service fees, commissions and other fees related to transactions in securities, services related to asset management, financial market operational and regulatory services.
Computer and information services	Computer data and news-related service transactions between residents and nonresidents. Included are data bases, hardware consultancy; software implementation; maintenance and repair of computers and peripheral equipment; and news-related services.
Royalties and licence fees	Payments and receipts for the use of intangible non-financial assets and proprietary rights, such as patents, copyrights, trademarks, industrial processes, and franchises.
Other business services	Professional and technical services such as legal, accounting, management consulting, public relations services, advertising, market research and public opinion polling, research and development services, architectural, engineering, and other technical services.
Personal, cultural and recreational services	(i) audiovisual and related services, and (ii) other cultural and recreational services.
Government services n.i.e.	A residual category covering government service transactions (including those of international organizations) not contained in previous classifications. Included are all transactions by embassies, consulates, military units, and defense agencies with residents of economies in which the embassies, etc. are located and all transactions with other economies.

Source: WTO, Technical notes on the definitions, methods and sources of the statistics used in International Trade Statistics; IMF, Balance of payment manual, fifth edition (BPM 5).

## B Lagged impact of large disasters by services sub-sector

Figure 1: All services

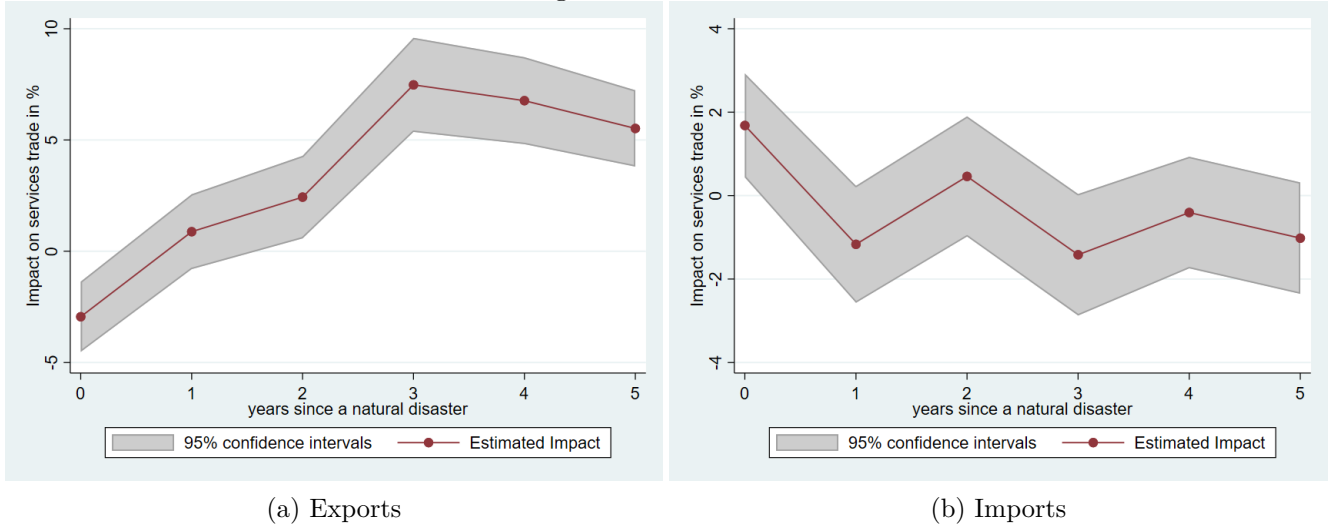


Figure 2: Transportation

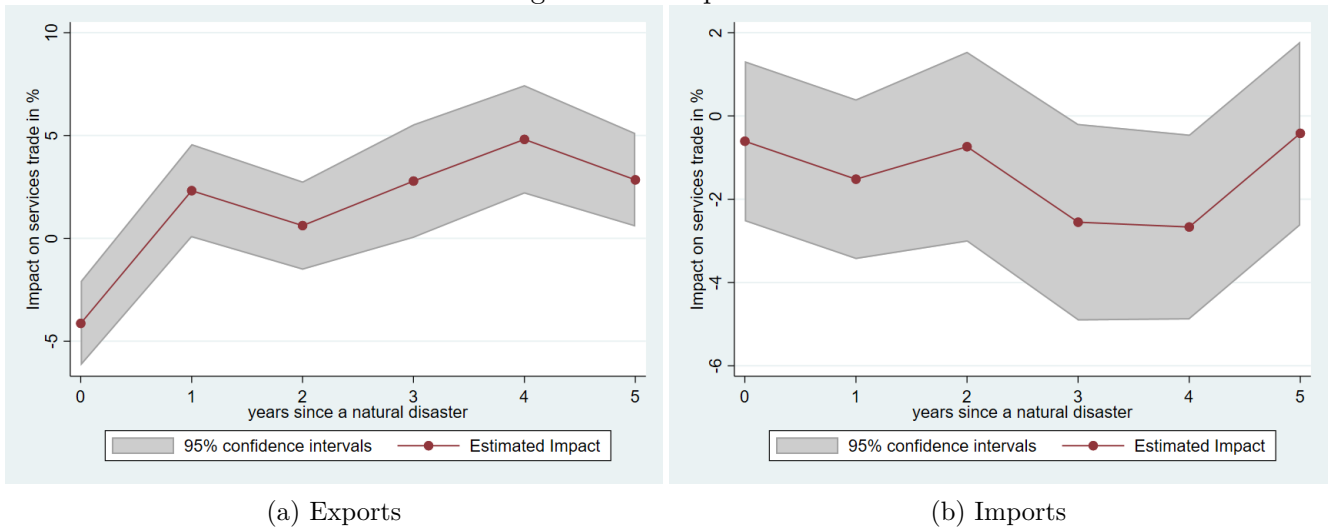


Figure 3: Travel

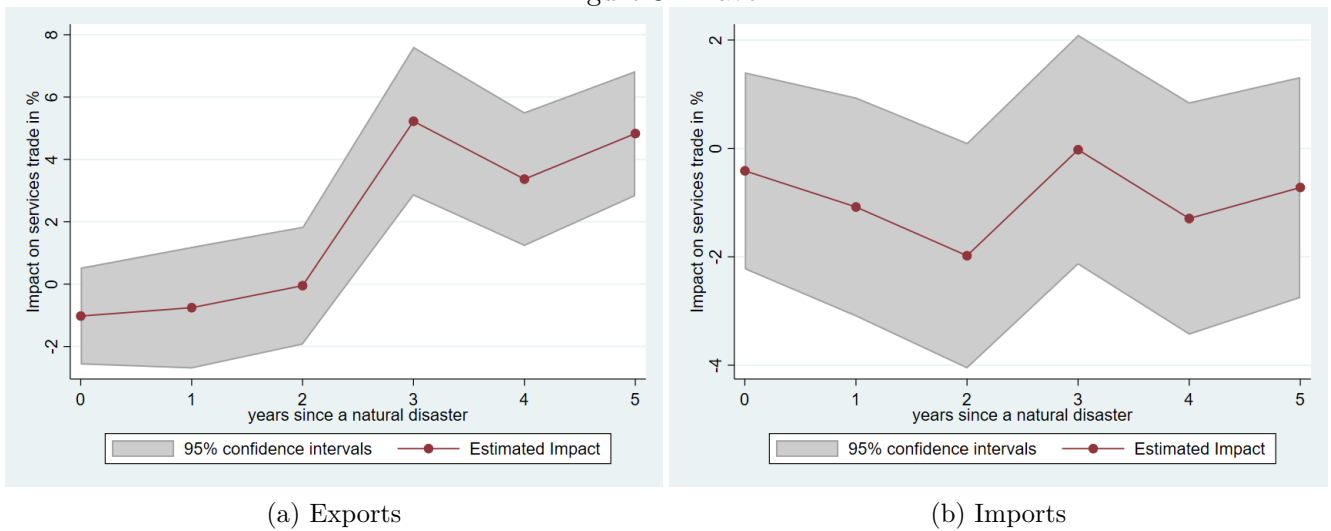


Figure 4: Communications services

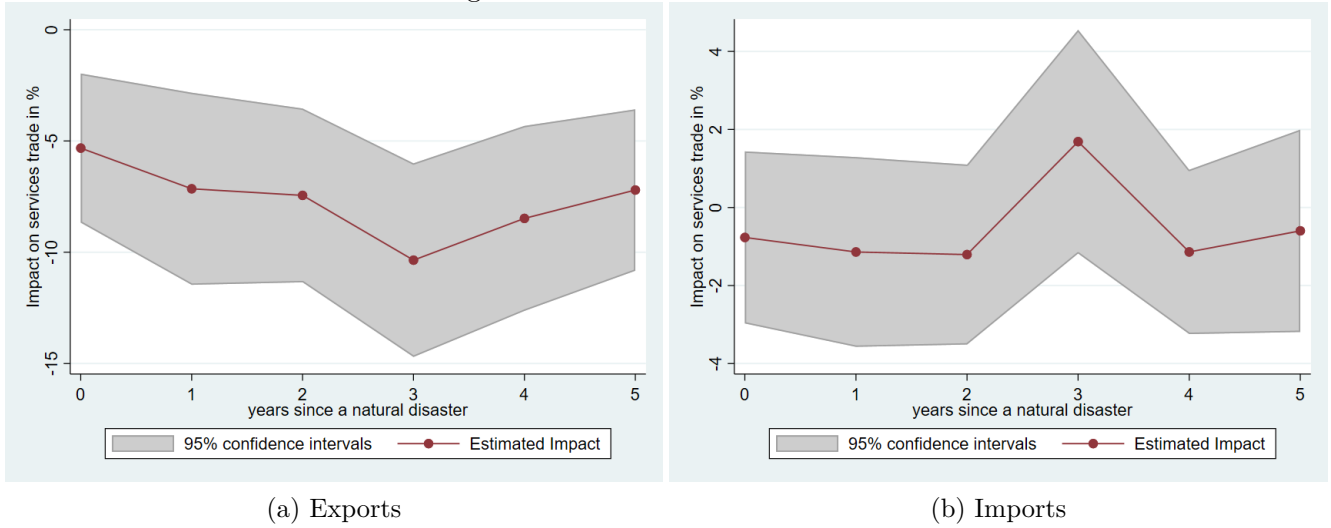


Figure 5: Construction

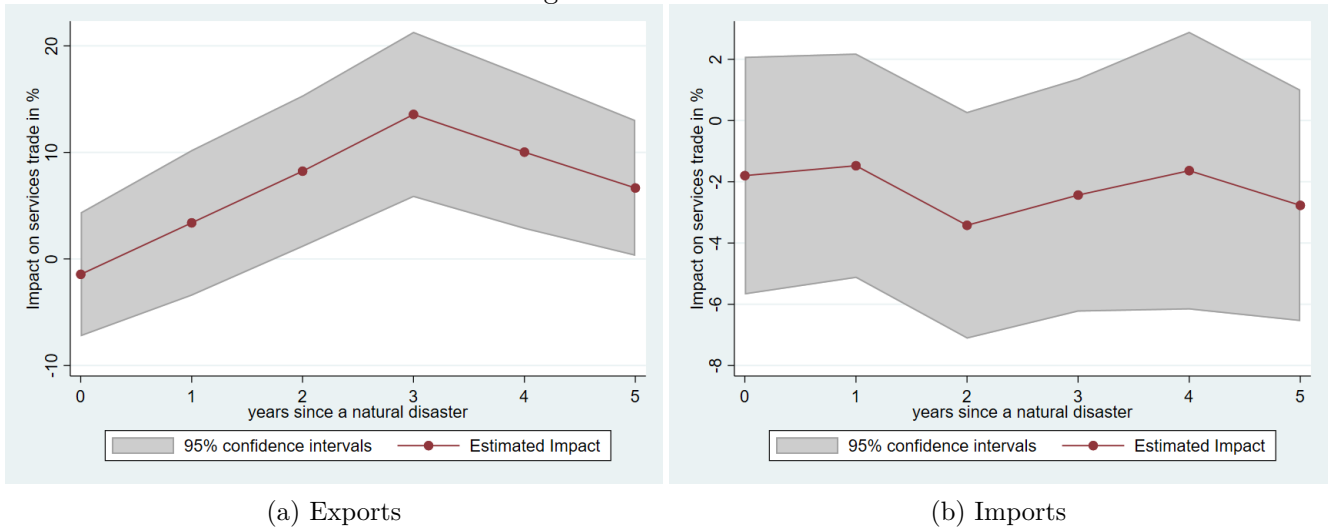


Figure 6: Insurance services

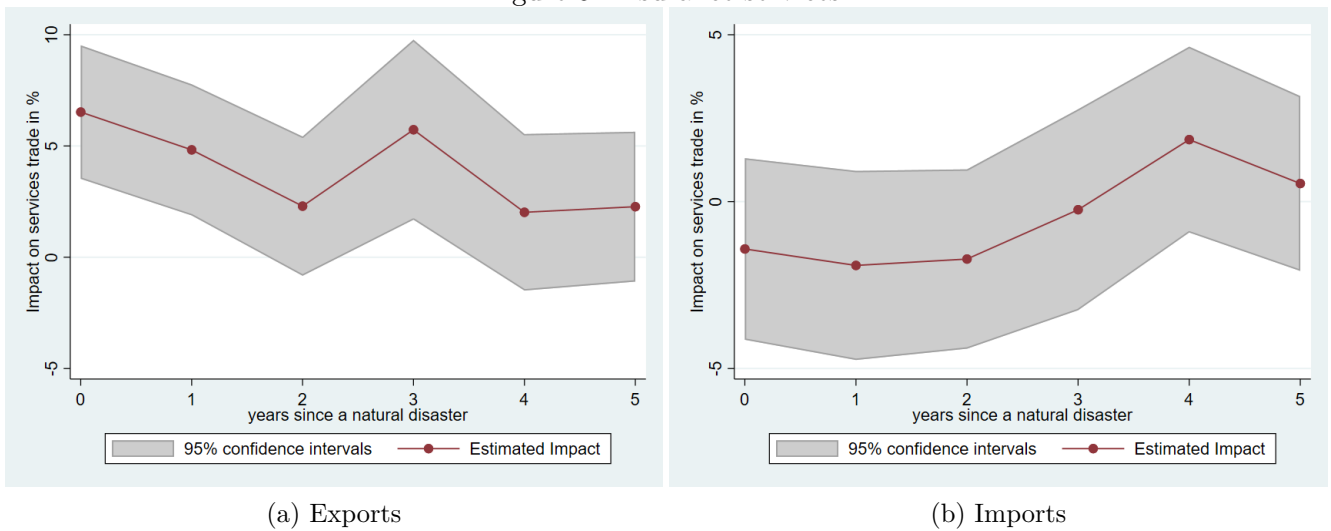


Figure 7: Financial services

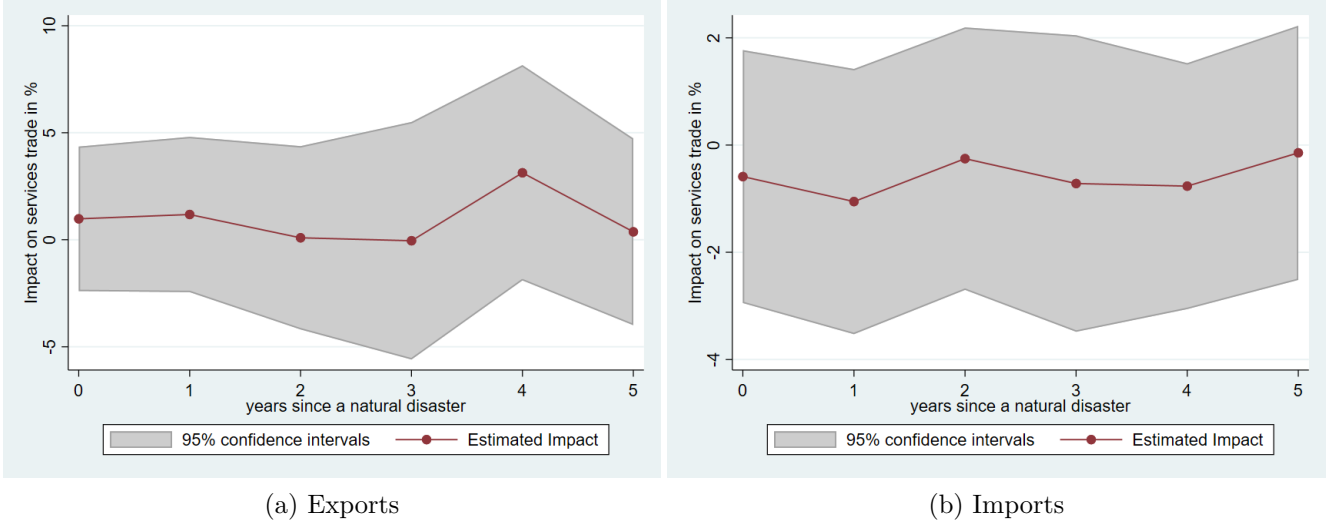


Figure 8: Computer and information services

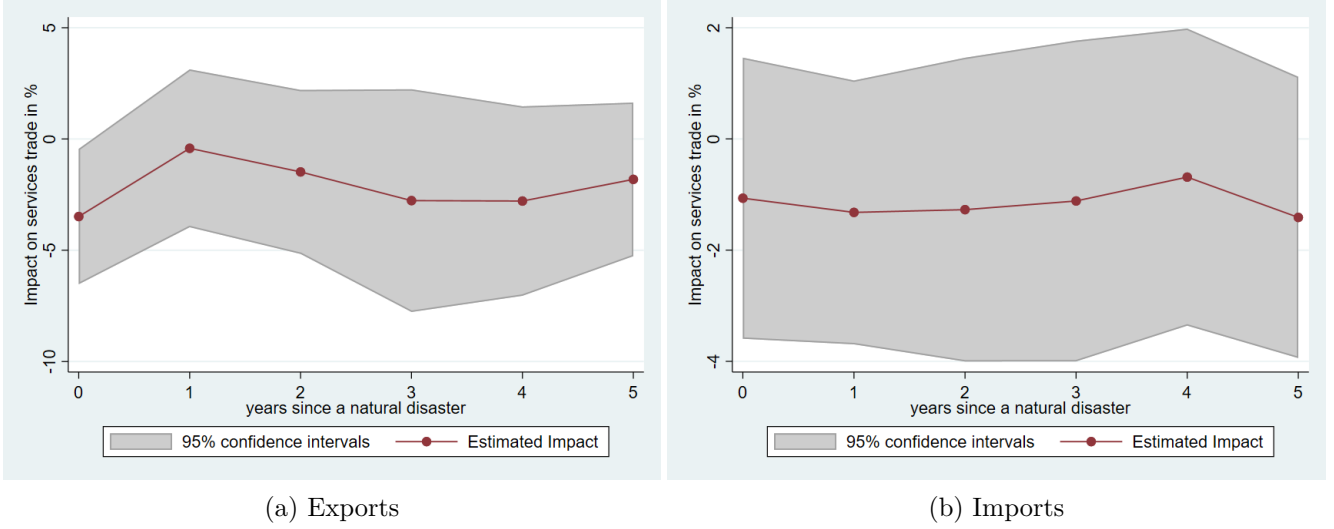


Figure 9: Royalties and license fees

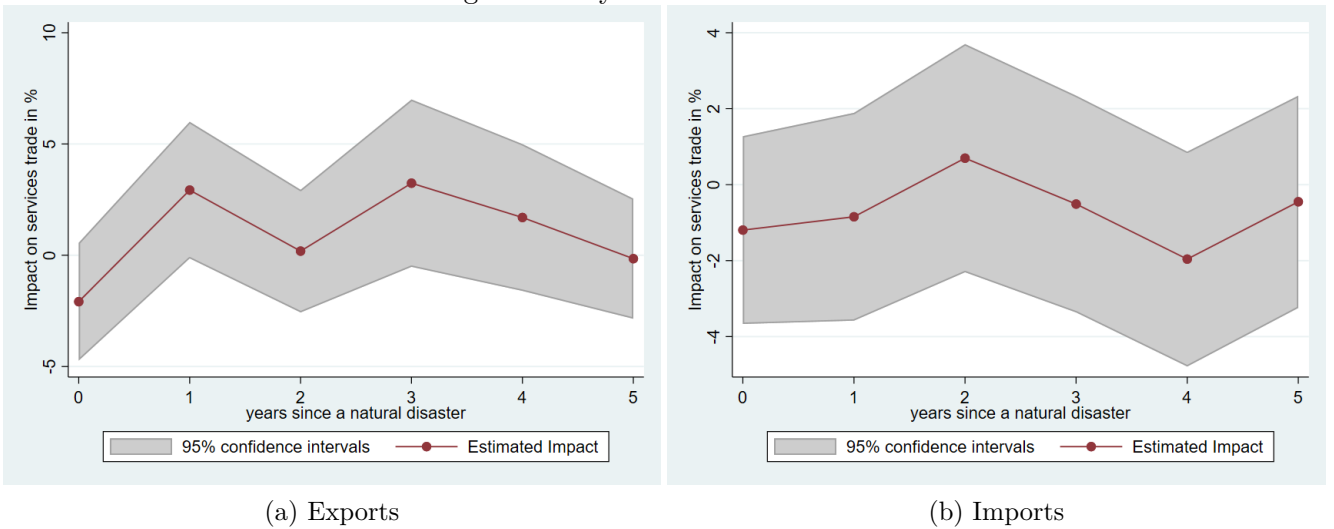


Figure 10: Other business services

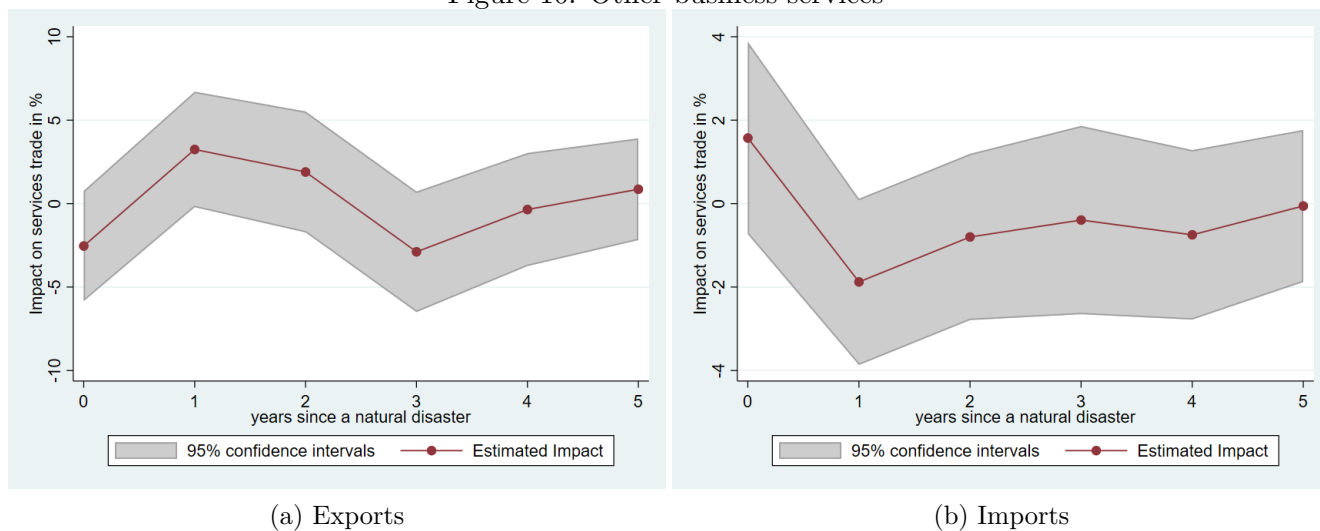


Figure 11: Personal, cultural and recreational services

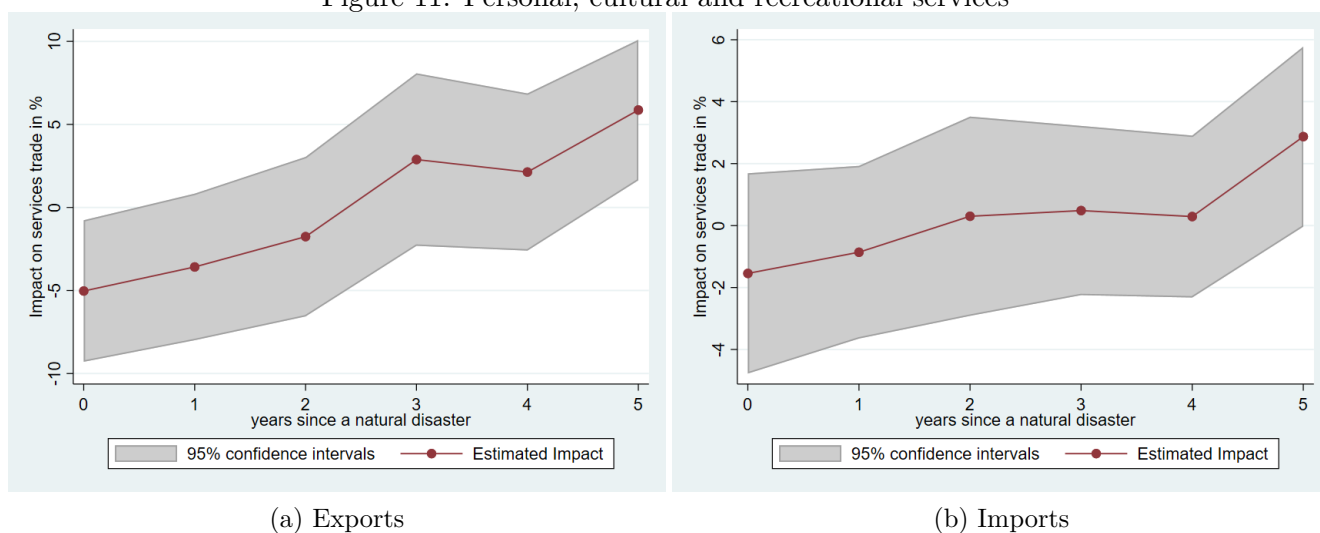


Figure 12: Government services, n.i.e.

