The Effect of Tohoku Earthquake on Japan's Bilateral Trade Distribution: Case Study of African Markets

Onur BIYIK (✉ biyik-onur@fuji.waseda.jp)

Research

Keywords: Japanese international trade, panel data, gravity model, Tohoku earthquake, African markets

Posted Date: March 8th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1388597/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

The Effect of Tohoku Earthquake on Japan's Bilateral Trade Distribution: *Case Study of African Markets*¹.

Onur Biyik²

¹ Author is grateful for feedback and suggestions from Dr. Nabeshima, N and Dr. Saito, K and from participations at the 38th EBES Conference and the African Productivity Conference.

² PhD Program, Graduate School of Asia-Pacific Studies, Waseda University, 1-21-1 Nishiwaseda, Shinjuku, Tokyo, Japan, 165-0051 (biyik-onur@fuji.waseda.jp)

Abstract

This paper examines the Japanese International Bilateral Trade Flow (JIBTF) in relation to the economic crisis, such as the Tohoku earthquake, and focuses on changes in the Distribution Networks of JIBTF (DNoJ) concerning African countries and Japanese Major Trade Partners (JMTP). The Harmonized System 6-digit level (“total” and product level) panel data from 2001 to 2019 are analyzed by employing the (structural) gravity method. The results of the study find that the Tohoku earthquake affects the DNoJ among Japanese trade partners. Specifically, Japanese trade intention with African markets decreases relatively. In other words, exporting to African countries has a negative interaction effect after 2015. On the contrary, this interaction effect on JMTP comparatively increases; thus, Japan relocates its export to other markets such as JMTP. The Tohoku earthquake shaped the JIBTF to be more integrated with the Asia-Pacific and the EU regions, instead of African markets.

Keywords: Japanese international trade, panel data, gravity model, Tohoku earthquake, African markets

JEL Classification Codes: F10, F14, C23, C20

1. Introduction

Japan has actively participated in bilateral and multilateral economic partnership agreements (EPAs) since 2002, increasing its participation to around 80% in terms of free trade agreements (FTAs) in total foreign trade (Biyik, 2021) and strengthening the links between the Japanese economy and the world economy. FTAs/EPAs boost the volume of bilateral and multilateral international trade flow and thereafter enhance sectoral interconnection between a member of trading partners (Baier & Bergstrand, 2007). This also applies to the spread of negative influence between countries through sectoral linkage. As examples, the Global Financial Crisis (GFC) (Acemoglu et al., 2015), the Tohoku Earthquake (TE) (Carvalho et al., 2021), and other natural disasters (Barrot & Sauvagnat, 2016; Raddatz, 2009) cause major adverse effects on macroeconomic variables worldwide. In other words, idiosyncratic shocks in multi-connected sectors, such as finance and energy, propagate negative macroeconomic impact among countries, transmitting negative shocks from the origin to all over the world (Acemoglu et al., 2017; Barrot & Sauvagnat, 2016).

This reflects the fact that the geographical distribution of activities by Japanese firms/affiliates transfer any shock to (or from) other countries, thus, the Japanese economy faced various problems and bottlenecks due to the Lehman shock and the TE shock (Ando & Kimura, 2012; Carvalho et al., 2021; Yonemoto, 2016). Specifically, TE shock had different (negative) impacts on the industrial productions in the Japanese domestic market and then the Japanese International Bilateral Trade Flow (JIBTF) (Cavallo et al., 2014; Kajitani et al., 2013). This leads to changes in the Distribution Networks of JIBTF (DNoJ) among Japanese trading partners. In this context, this study aims to estimate the impact of TE shock on changes in Japanese trade distribution among its trading partners. The objective of this study is to estimate the impact of the earthquake on changes in the DNoJ regarding the African countries and Japanese Major Trade Partners (JMTP as a control group), in particular.

Quantitative analyses of the international trade studies rely on the (structural) gravity method (Head & Mayer, 2014; Yotov et al., 2016), a common and most convenient tool for trade-related estimation (Fally, 2015; Larch et al., 2019). Past literature focuses on the impact of TE shock on the Japanese market (Carvalho et al., 2021) and JIBTF (Ando & Kimura, 2012). Since Japanese trade policy with JMTP, such as China and the EU, has improved by participating in EPAs (Biyik, 2021), I investigate what/how Japanese trade intentions (relationships in the production networks) with African countries has been. This is because no scholar has researched Japan's relationship in production networks with African countries regarding TE shock. To elucidate this purpose, this paper answers the following questions: To what extent does the earthquake affect DNoJ among Japanese trade partners? Is there a relocation of Japan's exports?

This study finds that the Tohoku earthquake affects the DNoJ among Japanese trade partners. As an answer to those questions, while Japanese trade intention with the African countries decreases, this interaction effect on JMTP comparatively increases. Specifically, Japanese export to African countries has a negative interaction effect after the beginning of recovery from the earthquake; thus, Japan shifts its exports from African markets to other markets.

The reason is, is that being involved in the regional production networks among JMTP is more likely to sustain trade and achieve recovery from the TE shocks. Among African countries, those that have weak trade relationships in the production networks are not likely to recover from the

TE shock. In short, the TE shock shaped the JIBTF to be more integrated with the Asia-Pacific and the EU regions, leading to deeper links within regional blocs.

The rest of this paper is organized as follows: The second section explains the background and literature to elucidate the working logic. The third section presents this paper's datasets and portrays the data-related methodology and the empirical models. The fourth section discusses the empirical results of the two datasets. The fifth section critiques results and policies. The last section concludes this study.

2. Background and Literature

Figure 1 shows Japanese export to its partners (lines as seen in different colors) as well as total export and import (bars as seen in red and blue). The largest Japanese exporting partners are China (22%) and the USA (19%), followed by ASEAN (15%) and EU (12%) members in the list of JMTP (see Table A1). Japanese trade with aggregated African countries as a group (hereafter Africa) accounts for approximately 4% of total Japanese trade over a 20-year period.

Among African countries, Japan's primary export partner is South Africa (60%), followed by Nigeria (8%), Egypt (2%), and Morocco (1.5%). Japan exports mainly manufacturing (55%) related to sectors 87 and 89 in the Harmonized System (HS) 2-digit level classification to Africa. Japan's major import partner is South Africa (30%), followed by Liberia (20%), Egypt (10%), and Kenya (7%). African countries export mainly energy and mining-related products (60%) regarding sectors 71 and 27 in HS 2-digit level classification to Japan. The Japanese trade with JMTP exhibits structure/flow change similar to its total export and import change during the period (see Figure 1). Here I investigate how Japanese trade with African countries displays trade flow changes during the period and focus on the impact of the earthquake on Japan's relationship in productions networks with African countries in particular.

Figure 1: Japanese Bilateral Export Flows, Total Import, and Total Export

Note: Total import and export are based on the right axis. Japanese bilateral export flows are based on the left axis.

Source: Autor's preparation, the data available from the website of International Trade Center.

The figure presents the V-shape recovery of 2008-2009 GFC in terms of total export and import, seeing an initial peak in 2008 and a bottom in 2009. However, the TE shock displays a different

pattern for export and import. For example, after the TE happened in 2011, while export (red bar, the right axis) immediately decreased till 2015, imports (blue bars, the right axis) increased till 2012 and thereafter decreased till 2016 as seen by the U-shape line. After one year, the U-shaped³ recovery of the trade from the TE shock saw in 2016 for export and in 2017 for import.

In general, After the TE (followed by a tsunami and the failure of the Fukushima Dai-ichi Nuclear Power Plant) happened, people from Tohoku prefectures have emigrated and manufacturing industries in the disaster-stricken areas suffered (Higuchi et al., 2012). Not only the collapse of many buildings and infrastructures but many dead people resulted in massive damage to the Japanese economy/society, costing around ¥ 16.9 trillion (Carvalho et al., 2021). Japanese export decreased consequences of a sharp decline of production⁴ in the manufacturing and mining sectors (Ando & Kimura, 2012). This is because adverse supply shocks from small and medium enterprises in disaster areas affect exports through production chains (Carvalho et al., 2021).

In the literature, the impact of the natural disaster shock on the macro-economy is empirically investigated (Cavallo et al., 2014; Raddatz, 2009). Acemoglu et al., (2012), Acemoglu et al., (2017), and Baqaee and Farhi (2019) contribute propagation of microeconomic shock over firms-linkages within a country as well as across countries. Any natural disaster or financial shocks to the economy cause severe impacts on macroeconomic variables across the world (Acemoglu et al., 2015; Boehm et al., 2019). Empirical evidence for these shocks with input-output linkages shows that macroeconomic volatility coming from sectoral idiosyncratic shocks is significantly large and diffuses/spreads (negative) cross-country transmission through multinational firms (Acemoglu et al., 2016; Barrot & Sauvagnat, 2016).

This study is similar to the approach of Noy (2009), Raddatz (2009), and Strobl (2012), which comparatively estimate various disaster effects for developed and developing countries. For example, the Tohoku earthquake not only harmed industrial productions in the Japanese domestic market and (Carvalho et al., 2021) but also indirectly exposed the negative impact on the US market through Japanese affiliates (Boehm et al., 2019; Cavallo et al., 2014). This study analysis is closely related to the paper of Ando and Kimura (2012) which examines Japanese machinery export volume changes across final and intermediate goods under GFC and TE shocks. They remark that the GFC shock was relatively the most devastating impact on Japan's trade. The limitation of their paper is due to the monthly (seasonal and short-term) dataset. In this regard, this study estimates the earthquake effects on changes in the Japanese trade distribution network regarding African countries by using annual trade flow datasets from 2001 to 2019 and fills the gap in Japanese trade studies in which there is no research on TE that take African countries into account, which is crucial for policymakers.

3. Methodology and Data

3.1.Data Source

3.1.1. The Outcome of Japanese Bilateral Trade Flow

This paper's dependent variable as an outcome of Japanese bilateral trade data at the 6-digits level of the Harmonized System (HS) is extracted from International Trade Center-TradeMap. The HS 6-digit level (hereafter panel B dataset) data comprises approximately 5,300 articles

³ As seen an initial peak in 2011/2012 and a bottom in 2015/2016 in relation to export/import (see Figure 1)

⁴ The four prefectures provide 4.5 % of the Japanese output (Carvalho et al., 2021).

descriptions and is aggregated to build as total-level (hereafter panel A dataset) data. Accordingly, the total data represents a two-dimensional bilateral trade dataset (countries, aggregated sector, years) and HS 6-digit product-level data accounts for a three-dimensional bilateral trade dataset (countries, sectors, years). The (annual) panel A and B datasets contain, respectively, 3,686 observations from 194 Japanese trading partners and 8,197,094 observations from 70 Japanese trading partners between 2001 and 2019 (see Table A1; A2). In short, panel A and B datasets account for roughly 99% of and 81% of the Japanese trade flows, respectively.

3.1.2. Country Characteristics

This study uses several broad country characteristic variables in the analysis that help us to explain cross-country variation. Independent variables include output, expenditure, distance, recovery year dummies for import/export, African/JMTP dummy. The primary use of these independent variables (i) satisfies theory-consistent empirical work and (ii) estimates the impact of the TE shock on changes in the distribution of Japanese trade flows among its trading partners.

One would expect that big nations in economic size (a country with high output and expenditure) have bigger foreign trade between each other. However, the trade amount between any two countries is diminished when the distance (trade cost) increases (Head & Mayer, 2014). To estimate this integration, output and expenditure data⁵ are calculated based on export and import value over the years 2001–2019, respectively. I also obtained distance variables from CEPII GeoDist (Mayer & Zignago, 2011) to quantify Japanese trade partners' geographic characteristics.

To comparatively explain the impact of the TE shock on African countries, I created African and the control group (as presented by JMTP) dummies as regional preferences. Specifically, I constructed (i) African dummy ($dmAfrica \cong \text{country belongs to African countries "1", otherwise "0"}$) and (i) control group dummy ($dmJMTP \cong \text{country belongs to Japanese major trade partners "1", otherwise "0"}$). To provide sufficient evidence for the interaction between recovery year and selected group countries, I first created (i) 2016 recovery dummy that explains a Japanese export recovery ($dmy_ex2016 \cong 2016 \geq 1$, otherwise “0”) and (ii) 2017 recovery dummy that presents a Japanese import recovery ($dmy_im2017 \cong 2017 \geq 1$, otherwise “0”) (see Figure1).

Technically, interpreting interaction dummy explains 1 when African/JMTP dummy and recovery dummy equal to 1 (e.g., the interaction of Africa equal 1 if $dmy_ex2016 = 1$ & $dmAfrica = 1$, otherwise “0”). This model examines two groups with recovery years and then provides comparative robust evidence for the question of regional preferences.

3.2. Methodology

A gravity model is often regarded as the most popular and successful framework in international economics, highlighting many of the great future of theory-consistent empirical and political studies (Head & Mayer, 2014; Yotov et al., 2016). Scholars such as Anderson and van Wincoop (2003) propose the theory of gravity equation to assess the main determinants of international trade. I introduce the gravity model, as presented in equation (1⁶)

$$X_{od} = [\tau_{od}/(\Pi_o P_d)]^{1-\sigma} Y_o E_d / Y \quad (1)$$

⁵ I used stata coding (bysort country: egen Y/E = sum(EX/IM)) to obtain two variables, see Yotov et al., (2016) for more information.

⁶ $Y_i \equiv \omega_i L_i = E_i$, $Y \equiv \sum_i Y_i$, see Head and Mayer (2014), Fally (2015), and Yotov et al., (2016) for more information

$$\Pi_o = \left[\sum_d (\tau_{od}/P_d)^{1-\sigma} E_d/Y \right]^{1/(1-\sigma)}$$

$$P_d = \left[\sum_o (\tau_{od}/\Pi_o)^{1-\sigma} Y_o/Y \right]^{1/(1-\sigma)}$$

Where X_{od} presents export from countries o (origin) to d (destination). Y_o , E_d , and Y (size term) are o 's total income, d 's total expenditure, and world total income respectively. $[\tau_{od}/(\Pi_o P_d)]^{1-\sigma}$ is the total trade cost term regarding $(\sigma > 1)$ by controlling fixed effect; thus, Π_o and P_d are, respectively, o 's outward multilateral resistance (weighted average of o 's export trade costs) and d 's inward multilateral resistance (weighted average of d 's import trade costs).

A structure of the gravity model in panel data is written as a logarithmic form in equation (2):

$$X_{od,t} = Y_{o,t} + E_{d,t} - Y_t + (1 - \sigma)\tau_{od,t} - (1 - \sigma)P_{d,t} - (1 - \sigma)\Pi_{o,t} + \varepsilon_{od,t} \quad (2)$$

Where: $X_{od,t}$ is (log) trade flow between partners regarding time period ($t = 1, 2, \dots, T$), Y_o , E_d , and Y are (log) explanatory variables, $\tau_{od,t}$ is (log) trade costs (e.g., distance and tariff level of a destination country), $(1 - \sigma)$ is structural parameters (constant elasticity substitution), and ε is random component/error term.

The theoretically-consistent estimation of the structural gravity model shows in equation (3):

$$X_{od,t} = \exp[Y_{o,t} + E_{d,t} - Y_t + (1 - \sigma)\tau_{od,t} - (1 - \sigma)P_{d,t} - (1 - \sigma)\Pi_{o,t}] + \varepsilon_{od,t} \quad (3)$$

The export-time and import-time with pair fixed effects (Π_o, P_d) ensure the theoretical restrictions implied by structural gravity are satisfied (Larch et al., 2019).

3.2.1. The Regression Speciation

The general (panel) gravity model in this study accounts for output and expenditure, the measure of bilateral distance, and sets of dummy variables for addressing TE shocks, as explained above. To answer this papers' questions, empirical models followed by Yotov et al., (2016) and Head and Mayer (2014) are determined.

Equation of Trade Distributional Change:

$$\begin{aligned} Trade_{jpnP,t} = & \beta_0 + \beta_1 Y_{jpn,t} + \beta_2 E_{P,t} + \beta_3 D_{jpn,P} + \beta_4 RecoveryDummy_t \\ & + \beta_5 RationDummy_P + \beta_6 RecoveryDummy_t \# RationDummy_P + \delta_c + \eta_y \\ & + \varepsilon_{jpnP,t} \#(4) \end{aligned}$$

$$\begin{aligned} Trade_{jpnP,t} = & \exp[\beta_0 + \beta_1 Y_{jpn,t} + \beta_2 E_{P,t} + \beta_3 D_{jpn,P} + \beta_4 RecoveryDummy_t \\ & + \beta_5 RationDummy_P + \beta_6 RecoveryDummy_t \# RationDummy_P + \delta_c + \eta_y] \\ & + \varepsilon_{jpnP,t} \#(5) \end{aligned}$$

Where: $Trade_{jpnP,t}$ represents bilateral trade flow of export and import. $Y_{jpn,t}$ and $E_{P,t}$ are output and expenditure of trade partners, respectively. $D_{jpn,P}$ is the distance between Japanese capital to its trade partner capital. $RecoveryDummy_t$ is the beginning of the trade recovery from the Tohoku earthquake (2016/2017 for export/import). $RationDummy_{P,t}$ is the region dummy of

Africa/JMTP. $RecoveryDummy_t \# RigionDummy_{p,t}$ is the interaction variable between the recovery year and region. δ_c captures country-fixed effect and η_y captures year-fixed effect.

3.2.2. Estimation Techniques

Every estimator has pros and cons in relation to a distributional characteristic of variables in a dataset. This paper's results are presented through Between (long-run), Within (short-run), Poisson, PPML, and OLS simulations because one method is not advisable (Gómez-Herrera, 2013). These (naïve) estimation methods require dependent variables into size-adjusted (Santos & Tenreyro, 2006). Therefore, all equations, dependent and independent variables, are divided by 100000 concerning trade values between 100 and 1000 as a maximum so that the log-likelihood function has values (Santos & Tenreyro, 2010; 2011).

This study uses the Housman test to identify whether the panel data estimation regarding two datasets implies the Random Effect (RE) or Fixed Effect (FE). While product-level estimation in panel B cannot reject the RE, the total-level estimation in panel A cannot prove if the RE is appropriate (see Table 1; 2). Since this study uses differential weights data regarding the country level that cause/induce unequal variation (heteroscedasticity), the cluster/robust is implied to adjust standard error for the fact that each of the units is individually weighted appropriately (Cameron et al., 2011; Egger & Tarlea, 2015).

The aggregated gravity model with product-level data is another challenge for the estimation in this study. This is because bilateral trade contains more “0” (trade) values in the panel B dataset. To address zero trade flow in disaggregated trade data as documented by Santos and Tenreyro (2006; 2010; 2011), the Poisson Pseudo-Maximum Likelihood (PPML⁷)/Poisson method is implemented with fixed effect and nested pair groups (Correia et al., 2019; Fally, 2015) for the theory-consistent empirical work as presented in equations (5).

4. Empirical Result

This section is to investigate the impact of the TE shock on changes in the DNoJ and presents the results of the two selected regions. To improve this result and present the best fit estimation, panel and pooled analysis in panel A and B datasets are examined through RE, FE, Poisson, OLS, and PPML and provide similar results for Japanese trade distribution change between two selected regions (see Table 1 and 2; A3 and A4).

The economic cycle concerning economic shock causes different impacts such as changes in trade distribution. Table 1 shows compares the interaction between two regions in the panel A dataset. It can be seen that export and import recovery year dummies (2016 and 2017) from TE shock have statistically (positive) significant correlations (see rows 1 and 2 in Table 1). Whereas importing from JMTP increases (as seen in row 8, the blue color), importing from Africa decreases (as seen in row 6 in Table 1; A3, the red color) after the beginning of recovery from the TE shock. Likewise, Japanese exports to African countries see a decrease trend with a statistically significant result. However, this study does not provide statistically significant results for Japanese exports to JMTP (see Table 1; A3). Thus, the impact of TE shock on Japanese export with Africa and JMTP display -0.307 (0.0819*+0.389*) and 0 (insignificant result), respectively.

⁷ Coding of the “ppmlhdf” is a Stata package that implements the PPML with multi-way fixed effects and codes time variant variables.

This study further examines product-level trade flow in the panel B dataset. Table 2 presents a comparison of the interaction between regions relying on two different estimators. Explanatory variable of Japanese exporting (or importing) to (or from) African/JMTP countries (red/blue color in row 3/4) provides reverse results between RE and Poisson due to taking into account zero trade value in each variable among countries-product pairs, displaying coefficients with opposite signs (see Table 2; A4). It also appears that zero trade values become more dominant in the import recovery year of 2017 (dmy_im2017) for JTMP through Poisson⁸ and then dmy_im2017 displays negative result with statistically significant; in contrast, just value changes among years through FE⁹ proves the positive result with statistically significant at 5% (see column 6 and 9 in Table 2).

Table 1: Result of the Interaction Between Regions, Panel Estimates of Between and Within Effect in Panel A

VARIABLES	Export		Import		Export		Import	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
dmy_ex2016	0.380*	1.461**			0.0350	1.116***		
	(0.228)	(0.621)			(0.0414)	(0.411)		
dmy_im2017			0.634**	1.971***			-0.0461	1.292***
			(0.310)	(0.704)			(0.0726)	(0.426)
dmAfrica	0.0819*	-	0.106**	-				
	(0.0481)		(0.0491)					
dmJMTP					-0.237	-	-0.371**	-
					(0.159)		(0.156)	
dmy_ex2016#dmAfrica	-0.389*	-0.389*						
	(0.229)	(0.229)						
dmy_im2017#dmAfrica			-0.671**	-0.671**				
			(0.311)	(0.312)				
dmy_ex2016#dmJMTP					1.128	1.128		
					(0.757)	(0.759)		
dmy_im2017#dmJMTP							2.351**	2.351**
							(0.987)	(0.988)
<i>Estimator</i>	RE	FE	RE	FE	RE	FE	RE	FE
<i>Region</i>	(Africa)	(Africa)	(Africa)	(Africa)	(JMTP)	(JMTP)	(JMTP)	(JMTP)
<i>Equation</i>	Eq.4	Eq.4	Eq.4	Eq.4	Eq.4	Eq.4	Eq.4	Eq.4
<i>Sample</i>	Panel A	Panel A	Panel A	Panel A	Panel A	Panel A	Panel A	Panel A
<i>Period</i>	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19
<i>Y, E, and D</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Country FE</i>		✓		✓		✓		✓
<i>Year FE</i>		✓		✓		✓		✓
<i>Cluster/Robust</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Observations</i>	3,686	3,686	3,686	3,686	3,686	3,686	3,686	3,686
<i># Countries</i>	194	194	194	194	194	194	194	194
<i>R-squared</i>		0.032		0.048		0.035		0.056

Note: (1) ***, **, * represent significance at 1%, 5% and 10% level respectively; (2) standard errors in parentheses. Y, E, and D are, respectively, output, expenditure, and distance of trade partners.

Source: Author's calculation

Interaction variables display the significantly positive result for Japanese exports (or imports) with JMTP (as seen in row 7/8 in Table 2); however, the interaction variables for Japanese exports (or imports) with Africa see a decreasing trend (seen row 5/6) after the beginning of recovery from the TE shock (see Table 2; A4). For example, the impact of TE shock on Japanese imports with Africa and JMTP display -0.0097 (0.0018***+ -0.011***) and 0.0095 (-0.00178***+ 0.0113***) by employing RE (estimator), respectively (see column 3 and 8 in Table 2). Therefore, the overall

⁸ dmy_ex2016/dmy_im2017 (see column 6/8 in Table A4) in PPML with controlled year presents statistically (positive) insignificant results.

⁹ Note that FE (or estimators with FE) discards all heterogeneous information and then calculates the estimate based on value differences/changes among years; thus, these changes might apply to few sectors (countries) as one of the limitations of this method documented by Mundlack (1978), see Beck and Katz (1995) and Bell et al. (2019) for more empirical evidences.

impact of the TE shock on Japanese trade in production networks with African countries receives result in more damages, compared to its trade with JMTP (see Table 1 and 2).

Table 2: Result of the Interaction Between Regions, Panel Estimation of Between, Within Effect, and Poisson/PPML in Panel B

VARIABLES	Export		Import		Export			Import		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<i>dmy_ex2016</i>	0.00568* (0.00309)	0.0990** (0.0438)			-4.19e-05 (3.10e-05)	0.00496** (0.00215)	-0.157* (0.0840)			
<i>dmy_im2017</i>			0.0111*** (0.00420)	0.212*** (0.0334)				-0.000110** (5.52e-05)	0.00452** (0.00199)	-0.364** (0.183)
<i>dmAfrica</i>	0.00120* (0.00065)	-3.353*** (0.150)	0.0018*** (0.00066)	-3.866 (3.442)						
<i>dmJMTP</i>					-0.00120* (0.00065)	-	3.353*** (0.150)	-0.00178*** (0.000663)	-	3.866 (3.442)
<i>dmy_ex2016#dmAfrica</i>	-0.00572* (0.00309)	-0.256*** (0.0947)								
<i>dmy_im2017#dmAfrica</i>			-0.011*** (0.00420)	-0.576*** (0.186)						
<i>dmy_ex2016#dmJMTP</i>					0.00572* (0.00309)	0.00572* (0.00309)	0.256*** (0.0947)			
<i>dmy_im2017#dmJMTP</i>								0.0113*** (0.00420)	0.0113*** (0.00420)	0.576*** (0.186)
<i>Estimator</i>	RE	Poisson	RE	Poisson	RE	FE	Poisson	RE	FE	Poisson
<i>Region</i>	(Africa)	(Africa)	(Africa)	(Africa)	(JMTP)	(JMTP)	(JMTP)	(JMTP)	(JMTP)	(JMTP)
<i>Equation</i>	Eq. 4	Eq.5	Eq. 4	Eq.5	Eq. 4	Eq. 4	Eq.5	Eq. 4	Eq. 4	Eq.5
<i>Sample</i>	Panel B	Panel B	Panel B	Panel B	Panel B	Panel B	Panel B	Panel B	Panel B	Panel B
<i>Period</i>	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19
<i>Y, E, and D</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Country FE</i>						✓			✓	
<i>Year Dummy</i>						✓			✓	
<i>Cluster/Robust</i>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Observations</i>	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094
<i># Countries</i>	70	70	70	70	70	70	70	70	70	70
<i>R-squared</i>						0.000			0.000	

Note:(1)***, **, * represent significance at 1%,5% and 10% level respectively; (2) standard errors in parentheses. Y, E, and D are, respectively, output, expenditure, and distance of trade partners. The 28 EU countries are aggregated as a single market in JMTP (see Table A1).

Source: Autor's calculation

In summary, exporting to African countries saw a decrease (interaction) effect whereas exporting to JMTP comparatively increased after 2015; thus, Japan has repositioned its exports/imports from African markets to JMTP in terms of the panel B dataset (see rows 5/6 and 7/8 in see Table 2; A4).

5. Discussion of the Empirical Results

The 2011 TE shock not only harmed the JIBTF but also changed DNoJ among Japanese trade partners. The empirical analysis in this study finds that Japanese exports/imports with JMTP result in an increased interaction effect (see Table 1; 2). This is because being involved in the regional production networks among JMTP, such as China, the US, and the EU, is likely to sustain and recover trade from the TE shock.

Likewise, among African countries, such as South Africa and Liberia, those that have strong trade relationships in the production networks are likely to maintain and achieve trade recovery from the TE shock. In contrast, countries, such as Kenya, Tanzania, and Morocco, that have weakened relationships in the production networks are not likely to recover trade from the TE shock. Therefore, Japan lost its trade intention with African countries due to the weak(ened) relationships in the production networks in general.

Japan finds alternative supply sources and relocates routes of the supply chains based on the dependency of each country's relationships in the production networks, unlike the JMTP where it is involved in network productions, leading to deeper links within regional blocs. The empirical results convince us that Japan switched its export from African countries to other markets such as JMTP after the earthquake.

Did the earthquake drive Japan into more regional or even local (national) production? Given the earthquake's structural negative consequence on the Japanese economy, this shaped Japanese trade and policy, thus, Japanese participation in the global chain of production is decentralized/regionalized. This high dependency (in the regions) is another challenge for the Japanese economy if any negative shock comes from JMTP or its local market. Since Japan tries to reach new sources of growth outside of traditional regions through its FTAs/EPAs, Japan should consider investing in relationships in other markets such as Africa and managing its market focus from a global perspective, instead of regional preferences. This also contributes to the diversity of goods as well as markets, which not only boosts Japanese welfare/GDP but also improves recovery dynamism from any negative shocks.

6. Conclusion

As a consequence of negative/positive shocks propagating from the origin to all over the world, the Japanese economy faced various problems and bottlenecks due to the 2011 TE shock. This paper examines the impact of the TE shock on changes in the DNoJ among Japanese trading partners. The panel (A and B) datasets from 2001 to 2019 are examined by employing the (structural) gravity method through different estimators.

The nature and characteristics of the TE shock harmed JIBTF and then caused the change in DNoJ among Japanese trading partners. Regarding the impact of TE shock on trading partners, while Japanese trade intention with JMTP has increased, this interaction effect on the African countries has decreased comparatively. Japanese export to African countries had a negative interaction effect after the recovery from the earthquake. This is because countries such as Kenya, Tanzania, and Morocco that have weakened relationships in the production networks are not likely to recover trade after the TE shock. In short, Japan has repositioned its exports from African markets to other markets after 2015.

The TE shock shaped the JIBTF to be more integrated with the Asia-Pacific and the EU regions, leading to deeper links within regional blocs. Nevertheless, expanding the global production chain with African countries as a new source of growth would not only boost Japanese welfare/GDP but also improve recovery dynamism from any negative shocks.

Appendix A

Table A1: Japanese Bilateral Trade Partners

Japanese Major Trade Partners (Control Group)	African Countries	South Africa, Nigeria, Egypt, Morocco, Algeria, Mauritania, Ghana, Madagascar, Ethiopia, Tunisia, Seychelles, Tanzania, Kenya, Libya, State of Mozambique, Burkina Faso, Zimbabwe, Sierra Leone, Gabon, Congo, the Democratic Republic of, Senegal, Zambia, Somalia, Botswana, Uganda, Namibia, Malawi, Côte d'Ivoire, Sudan, Cameroon, Mauritius, Togo, Mali, Saint Helena, Rwanda, Angola, Eswatini, Western Sahara, Guinea, Congo, Burundi, Djibouti, Niger, Central African Republic, Lesotho, Comoros, Gambia, Liberia, Chad, Sao Tome and Principe, Eritrea, Equatorial Guinea, Benin, Guinea-Bissau, Cabo, Verde.
	The European Union (EU)	Austria (AUT), Belgium (BEL), Cyprus (CYP), Czech Republic (CZE), Denmark (DNK), Estonia (EST), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Hungary (HUN), Ireland (IRL), Italy (ITA), Latvia (LVA), Lithuania (LTU), Luxembourg (LUX), Malta (MLT), Netherlands (NLD), Poland (POL), Portugal (PRT), Slovakia (SVK), Slovenia (SVN), Spain (ESP), Sweden (SWE), Bulgaria (BGR), Croatia (HRV), Romania (ROU).
	ASEAN	Malaysia (MYS), Singapore (SGP), Brunei Darussalam (BRN), Vietnam (VNM), Cambodia (KHM), Indonesia (IDN), Lao PDR (LAO), Philippines (PHL), Thailand (THA), Myanmar.
	China (CHN)	China (CHN)
	United States (USA)	United States of America (USA)
	Korea (KOR)	Republic of Korea (KOR)
	Taiwan (TWN)	Taipei, Chinese (TWN)
	Australia (AUS)	Australia (AUS)
Rest of the World		Hong Kong, India, Mexico, Canada, Russian Federation, United Arab Emirates, Panama, Saudi Arabia, Brazil, Turkey, New Zealand, Israel, Bangladesh, Kuwait, Oman, Marshall Islands, Pakistan, Qatar, Chile, Colombia, Bahrain, Jordan, Argentina, Peru, Sri Lanka, Iraq, Kazakhstan, Mongolia, Macao, Ecuador, Costa Rica, Bahamas, Yemen, Jamaica, Dominican Republic, Papua New Guinea, Cyprus, Uzbekistan, United States Minor Outlying Islands, Trinidad and Tobago, Georgia, Turkmenistan, Barbados, Lebanon, El Salvador, Iran, Islamic Republic of, Tunisia, Paraguay, Honduras, Guyana, Azerbaijan, Suriname, Nicaragua, Iceland, Nepal, New Caledonia, Fiji, Uruguay, Afghanistan, Macedonia, North, Tuvalu, Belize, Serbia, French Polynesia, Maldives, Venezuela, Bolivarian Republic of, Northern Mariana Islands, Micronesia, Federated States of, Haiti, Kyrgyzstan, Samoa, Solomon Islands, Curaçao, Palau, Cuba, Cayman Islands, Vanuatu, Syrian Arab Republic, Bermuda, Antigua and Barbuda, Armenia, Saint Lucia, Kiribati, Saint Kitts and Nevis, Timor-Leste, Grenada, British Virgin Islands, Saint Vincent and the Grenadines, Somalia, Moldova, Republic of, Tajikistan, Bhutan, Palestine, State of, Dominica, Montenegro, Nauru, Cook Islands, Bosnia and Herzegovina, Turks and Caicos Islands, Albania, Anguilla, Comoros, Montserrat, Andorra, Saint Helena, Greenland, Falkland Islands (Malvinas), British Antarctic Territory, British Indian Ocean Territory, Faroe Islands, French Southern and Antarctic Territories, Gibraltar, Democratic People's Republic of Korea, Oceania Nes, Niue, Africa not elsewhere specified, Pitcairn, America not elsewhere specified, St. Pierre and Miquelon, Tokelau, Serbia and Montenegro, Area Nes.

Source: Author's aggregation based on data availability from International Trade Center-TradeMAP.

Table A2: Summary Statistics of Variables

Variable	Obs	Mean	Std. Dev.	Min	Max	# of Country
<i>Panel Dataset A (aggregated): Full sample (194 countries)</i>						
<i>Export</i>	3,686	2.874356	13.11945	0	277.8935	194
<i>Import</i>	3,686	3.004393	12.66732	0	188.5004	194
<i>Y</i>	3,686	54.61277	242.6453	0.000013	2480.657	194
<i>E</i>	3,686	57.08347	230.3807	0.000827	2623.037	194
<i>D</i>	3,686	10048.15	3510.385	1156.67	18587.08	194
<i>dmy_ex2016</i>	3,686	0.2105263	0.4077378	0	1	194
<i>dmy_im2017</i>	3,686	0.1578947	0.3646917	0	1	194
<i>dmAfrica</i>	3,686	0.2731959	0.4456611	0	1	194
<i>dmJMTP</i>	3,686	0.2113402	0.4083145	0	1	194
<i>Panel Dataset B (disaggregated): Target markets (70 countries)</i>						
<i>Export</i>	8,197,094	0.0122183	0.4898016	0	277.8935	70
<i>Import</i>	8,197,094	0.0107927	0.430841	0	188.5004	70
<i>Y</i>	8,197,094	1.44E+08	4.41E+08	15966	24806.57	70
<i>E</i>	8,197,094	1.27E+08	3.92E+08	1609	26230.37	70
<i>D</i>	8,197,094	10748.06	3686.465	951.7373	14433.92	70
<i>dmy_ex2016</i>	8,197,094	0.2105263	0.4076825	0	1	70
<i>dmy_im2017</i>	8,197,094	0.1578947	0.3646423	0	1	70
<i>dmAfrica</i>	8,197,094	0.7847835	0.4109725	0	1	70
<i>dmJMTP</i>	8,197,094	0.2152165	0.4109725	0	1	70

Note: This table reports summary statistics of the cross-section data from 2001 to 2019, with the average values for each country included in the panel data. dependent and independent variables were divided by 100000 due to the naïve estimates of Poisson/PPML.

Table A3: Comparing of the Interaction Between Regions, Pooled Estimates of OLS and PPML in Aggregated-Level Data

VARIABLES	Export		Import		Export		Import	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>dmy_ex2016</i>	1.461** (0.621)	0.558*** (0.183)			1.116*** (0.411)	0.517*** (0.165)		
<i>dmy_im2017</i>			1.971*** (0.724)	0.743*** (0.118)			1.292*** (0.438)	0.555*** (0.112)
<i>dmAfrica</i>	0.103** (0.0494)	-	0.268*** (0.0493)	-				
<i>dmJMTP</i>					-0.880*** (0.139)	-	-0.396*** (0.123)	-
<i>dmy_ex2016#dmAfrica</i>	-0.389* (0.235)	-0.179 (0.109)						
<i>dmy_im2017#dmAfrica</i>			-0.671** (0.320)	-0.584*** (0.201)				
<i>dmy_ex2016#dmJMTP</i>					1.128 (0.779)	0.0473 (0.0762)		
<i>dmy_im2017#dmJMTP</i>							2.351** (1.016)	0.257*** (0.0695)
<i>Estimator</i>	OLS	PPML	OLS	PPML	OLS	PPML	OLS	PPML
<i>Region</i>	(Africa)	(Africa)	(Africa)	(Africa)	(JMTP)	(JMTP)	(JMTP)	(JMTP)
<i>Equation</i>	Eq.4	Eq. 5	Eq.4	Eq. 5	Eq.4	Eq. 5	Eq.4	Eq. 5
<i>Sample</i>	Panel A	Panel A	Panel A	Panel A	Panel A	Panel A	Panel A	Panel A
<i>Period</i>	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19
<i>Y, E, and D</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Country FE</i>		✓		✓		✓		✓
<i>Country Dummy</i>	✓		✓		✓		✓	
<i>Year Dummy</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Cluster/Robust</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Observations</i>	3,686	3,686	3,686	3,686	3,686	3,686	3,686	3,686
<i>R-squared</i>	0.949	-	0.920	-	0.949	-	0.921	-
<i># Country</i>	194	194	194	194	194	194	194	194

Note:(1)***, **, * represent significance at 1%,5% and 10% level respectively; (2) standard errors in parentheses. Y, E, and D are, respectively output, expenditure, and distance of trade partners.

Source: Autor's calculation

Table A4: Comparing of the Interaction Between Regions, Pooled Estimates of OLS and PMML in Product-Level Data

VARIABLES	Export		Import		Export		Import	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>dmy_ex2016</i>	0.0101** (0.00466)	0.544*** (0.199)			0.00435** (0.00190)	0.289 (0.184)		
<i>dmy_im2017</i>			0.0155*** (0.00579)	0.730*** (0.138)			0.00420** (0.00188)	0.153 (0.218)
<i>dmAfrica</i>	0.000792 (0.000714)	-3.579*** (0.587)	0.00168** (0.000668)	-4.284*** (0.596)				
<i>dmJMTP</i>					0.0485*** (0.000478)	3.579*** (0.587)	0.0246*** (0.000417)	4.284*** (0.596)
<i>dmy_ex2016#dmAfrica</i>	-0.00572* (0.00309)	-0.256*** (0.0954)						
<i>dmy_im2017#dmAfrica</i>			-0.0113*** (0.00420)	-0.576*** (0.187)				
<i>dmy_ex2016#dmJMTP</i>					0.00572* (0.00309)	0.256*** (0.0954)		
<i>dmy_im2017#dmJMTP</i>							0.0113*** (0.00420)	0.576*** (0.187)
<i>Estimator</i>	OLS	PPML	OLS	PPML	OLS	PPML	OLS	PPML
<i>Region</i>	(Africa)	(Africa)	(Africa)	(Africa)	(JMTP)	(JMTP)	(JMTP)	(JMTP)
<i>Equation</i>	Eq.4	Eq. 5	Eq.4	Eq. 5	Eq.4	Eq. 5	Eq.4	Eq. 5
<i>Sample</i>	Panel B	Panel B	Panel B	Panel B	Panel B	Panel B	Panel B	Panel B
<i>Period</i>	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19	2001-19
<i>Y, E, and D</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Country Dummy</i>	✓		✓		✓		✓	
<i>Year Dummy</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Cluster/Robust</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Observations</i>	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094	8,197,094
<i>R-squared</i>	0.006	-	0.006	-	0.006	-	0.006	-
<i># Country</i>	70	70	70	70	70	70	70	70

Note:(1)*** ** * represent significance at 1%,5% and 10% level respectively; (2) standard errors in parentheses. Y, E, and D are, respectively output, expenditure, and distance of trade partners.

Source: Autor's calculation

Acknowledgements

Author is grateful for feedback and suggestions from Dr. Nabeshima, N and Dr. Saito, K and from participations at the 38th EBES Conference and the African Productivity Conference.

Author's contributions

Single author: I calculated collected data, developed theoretical framework, designed and performed computation, analyzed the data, interpreted the results, and wrote the manuscript.

Funding

The author declare that they received no specific funding for this work.

Availability of data and materials

Data and materials used in this study (Panel A) are available and stored in digital repositories https://figshare.com/articles/dataset/ORJNL_dta/19235769

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

No potential competing interests was reported by the author.

Author detail

PhD Program, Graduate School of Asia-Pacific Studies, Waseca University, 1-21-1 Nishiwaseda, Shinjuku, Tokyo, Japan, 165-0051 (biyik-onur@fuji.waseda.jp).

References

- Acemoglu, D., Akcigit, U., & Kerr, W. (2016). Networks and the macroeconomy: An empirical exploration. *Nber Macroeconomics Annual*, 30(1), 273-335.
- Acemoglu, D., Carvalho, V. M., Ozdaglar, A., & Tahbaz-Salehi, A. (2012). The network origins of aggregate fluctuations. *Econometrica*, 80(5), 1977-2016.
- Acemoglu, D., Ozdaglar, A., & Tahbaz-Salehi, A. (2015). Systemic risk and stability in financial networks. *American Economic Review*, 105(2), 564-608.
- Acemoglu, D., Ozdaglar, A., & Tahbaz-Salehi, A. (2017). Microeconomic origins of macroeconomic tail risks. *American Economic Review*, 107(1), 54-108.
- Anderson, J. E., & Van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *American Economic Review*, 93(1), 170-192.
- Ando, M., & Kimura, F. (2012). How did the Japanese exports respond to two crises in the international production networks? the global financial crisis and the great east Japan earthquake. *Asian Economic Journal*, 26(3), 261-287.
- Baier, S. L., & Bergstrand, J. H. (2007). Do free trade agreements actually increase members' international trade? *Journal of International Economics*, 71(1), 72-95.
- Baqaei, D. R., & Farhi, E. (2019). The macroeconomic impact of microeconomic shocks: Beyond Hulten's theorem. *Econometrica*, 87(4), 1155-1203.
- Barrot, J., & Sauvagnat, J. (2016). Input specificity and the propagation of idiosyncratic shocks in production networks. *The Quarterly Journal of Economics*, 131(3), 1543-1592.
- Beck, N., & Katz, J. N. (1995). What to do (and not to do) with time-series cross-section data. *American Political Science Review*, 89(3), 634-647.
- Bell, A., Fairbrother, M., & Jones, K. (2019). Fixed and random effects models: Making an informed choice. *Quality & Quantity*, 53(2), 1051-1074.
- Biyik, O. (2021). Japan-AfCFTA integration through economic impacts of alternative EPA scenarios-examination of the GTAP 10A MRIO database. doi:10.21203/rs.3.rs-762313/v1.
- Boehm, C. E., Flaaen, A., & Pandalai-Nayar, N. (2019). Input linkages and the transmission of shocks: Firm-level evidence from the 2011 tōhoku earthquake. *Review of Economics and Statistics*, 101(1), 60-75.
- Cameron, A. C., Gelbach, J. B., & Miller, D. L. (2011). Robust inference with multiway clustering. *Journal of Business & Economic Statistics*, 29(2), 238-249.
- Carvalho, V. M., Nirei, M., Saito, Y. U., & Tahbaz-Salehi, A. (2021). Supply chain disruptions: Evidence from the great east Japan earthquake. *The Quarterly Journal of Economics*, 136(2), 1255-1321.
- Cavallo, A., Cavallo, E., & Rigobon, R. (2014). Prices and supply disruptions during natural disasters. *Review of Income and Wealth*, 60, S449-S471.
- Correia, S., Guimarães, P., & Zylkin, T. (2020). Fast poisson estimation with high-dimensional fixed effects. *The Stata Journal*, 20(1), 95-115.
- Egger, P. H., & Tarlea, F. (2015). Multi-way clustering estimation of standard errors in gravity models. *Economics Letters*, 134, 144-147.
- Fally, T. (2015). Structural gravity and fixed effects. *Journal of International Economics*, 97(1), 76-85.
- Gómez-Herrera, E. (2013). Comparing alternative methods to estimate gravity models of bilateral trade. *Empirical Economics*, 44(3), 1087-1111.

- Head, K., & Mayer, T. (2014). Gravity equations: Workhorse, toolkit, and cookbook. *Handbook of international economics* (pp. 131-195) Elsevier.
- Higuchi, Y., Inui, T., Hosoi, T., Takabe, I., & Kawakami, A. (2012). The impact of the great east japan earthquake on the labor market—need to resolve the employment mismatch in the disaster-stricken areas. *Japan Labor Review*, 9(4), 4-21.
- Kajitani, Y., Chang, S. E., & Tatano, H. (2013). Economic impacts of the 2011 Tohoku-Oki earthquake and tsunami. *Earthquake Spectra*, 29(1_suppl), 457-478.
- Larch, M., Wanner, J., Yotov, Y. V., & Zylkin, T. (2019). Currency unions and trade: A PPML re-assessment with high-dimensional fixed effects. *Oxford Bulletin of Economics and Statistics*, 81(3), 487-510.
- Mayer, T., & Zignago, S. (2011). Notes on CEPII's distances measures: The GeoDist database.
- Mundlak, Y. (1978). On the pooling of time series and cross-section data. *Econometrica*, 46(1), 69-85.
- Noy, I. (2009). The macroeconomic consequences of disasters. *Journal of Development Economics*, 88(2), 221-231.
- Raddatz, C. E. (2009). The wrath of God: Macroeconomic costs of natural disasters. *World Bank Policy Research Working Paper*, (5039)
- Santos Silva, J. M. C., & Tenreyro, S. (2006). The log of gravity. *The Review of Economics and Statistics*, 88(4), 641-658.
- Santos Silva, J. M. C., & Tenreyro, S. (2010). On the existence of the maximum likelihood estimates in Poisson regression. *Economics Letters*, 107(2), 310-312.
- Santos Silva, J. M. C., & Tenreyro, S. (2011). Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator. *Economics Letters*, 112(2), 220-222.
- Strobl, E. (2012). The economic growth impact of natural disasters in developing countries: Evidence from hurricane strikes in the central american and caribbean regions. *Journal of Development Economics*, 97(1), 130-141.
- Yonemoto, K. (2016). Changes in the input–output structures of the six regions of fukushima, japan: 3 years after the disaster. *Journal of Economic Structures*, 5(1), 1-20.
- Yotov, Y. V., Piermartini, R., Monteiro, J., & Larch, M. (2016). *An advanced guide to trading policy analysis: The structural gravity model* World Trade Organization Geneva.