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Global Sourcing in the Wake of Disaster: Evidence from the Great East Japan Earthquake[1]

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Abstract

While global sourcing by multinational firms has changed the landscape of international trade, little is known as to how firms alter their global sourcing pattern when facing uncertainty or negative shocks. In this paper, we use the Great East Japan Earthquake as an exogenous shock to identify the macro fluctuation on firms' offshoring. Using Japanese firm-level data from 2010-2013, we show that the earthquake increases offshoring in terms of yen value. By decomposing total offshoring into goods and service offshoring, we find the positive effect of earthquake is statistically significant for manufacturing offshoring, but not for service offshoring.

Keywords: Global sourcing, Offshoring, Great East Japan Earthquake

JEL classification: F12, F14, C13, C23

[1] This study is conducted as a part of the Joint Research Project "Research on Trade Structure and Firms' international activity" undertaken by Research Institute of Economy, Trade and Industry (RIETI) and Kyoto University in 2017 Fiscal Year. Authors acknowledge the great support from RIETI for the joint research. Authors are also grateful for the helpful comments from Makoto Yano, Masayuki Morikawa, Yukiko Saito and other participants of the seminar at RIETI. This study utilizes the micro data of the questionnaire information based on "the Basic Survey of Japanese Business Structure and Activities" which is conducted by the Ministry of Economy, Trade and Industry (METI). Regarding the use of the data, the authors are grateful for the help of Quantitative Analysis and Database Group of RIETI.

1. Introduction

Global sourcing by multinational firms has changed the landscape of international trade. Cross-border transactions of intermediate inputs have increased substantially in recent decades. Hummels, Ishii, and Yi (2001) provide evidence from data for ten OECD and four emerging market countries that trade in intermediate goods accounts for about 21% of these countries' exports. In a recent study, Johnson and Noguera (2014) use data for 52 countries from 1970--2009 and find that international fragmentation increased by about 10%.

The rapid growth of global sourcing has received an enormous amount of attention in the academia. Antràs and Helpman (2004) document the importance of contractual frictions in determining firm's organization choices. In their theoretical model, they show that (i) firms with higher productive are more likely to engage in intrafirm trade; (ii) capital and skill-intensive firms are more likely to have intrafirm trade; (iii) capital-intensive countries or countries with better institutional quality are more likely to engage in intrafirm trade.

While the determinants of intrafirm trade are becoming more apparent, there is a challenge in identifying the causal effect on international fragmentation.[2] More importantly, little is known as how firms alter their global sourcing pattern when facing uncertainty or negative shocks. This paper fill this gap by using the Great East Japan earthquake that happened on March 11 2011 as a natural experiment and study how this macroeconomic shock affects firm's global sourcing pattern.

We use Japanese firm-level data from 2010--2013, and our differences-in-difference estimator shows that the earthquake has a positive effect on firm's total offshoring. The result is robust to checks on various estimation specifications. As the Japanese firm-level data contain information on both goods and service offshoring, we further decompose firm's total offshoring into two components and find that the positive earthquake effect is only statistically significant in manufacturing offshoring. Next, we study whether the positive effect on offshoring is due to the

[2] Previous studies face the reverse causality problem in identifying the determinants of intrafirm trade. A firm may benefit from the global sourcing for many reasons. First, when a firm engages in global sourcing, it chooses to offshore less skill-intensive of its production stage, and focus on the more skill-intensive parts of the production. Therefore, it is expected offshoring generates firm productivity. Second, for a firm that conducts global sourcing, it makes production more efficiently by using varieties of materials and service inputs. Third, offshoring helps a firm learn new technology through importing foreign inputs.

disruption of domestic networks. We find the effect of earthquake on domestic sourcing is insignificant, with magnitude close to 0.

This paper is related to the recent literature on global sourcing (for reviews, see Antràs and Rossi-Hansberg, 2009; Yeaple, 2013; Antràs and Yeaple, 2014). In a seminal work, Antràs and Helpman (2004) use the property-rights framework to investigate how firms with different productivity levels choose their organizational structures, i.e., domestic versus global sourcing.[3] The theoretical findings are tested by Tomiura (2007), Corcos, Irac, Mion, and Verdier (2013), Defever and Toubal (2013), Nunn and Trefler (2013), and others. Antràs and Chor (2013) consider how firms choose their organizational structures when their production entails multiple sequential stages. They show that the choice depends on the relationships among different production stages and the location on the production chain.

This study fits into the literature on earthquake and firm's networks. Carvalho, Nirei, and Saito (2014) use the buyer-supplier network data and show that there is a significant effect of disruptions along the supply chain by the earthquake. Todo, Nakajima, and Matous (2015) study the effect of supply chain networks on the resilience of firms to the Great East Japan Earthquake. They show that supply chain networks have positive effects on the recovery of firms through network disruption, while negatively influencing recovery through partners and regional agglomeration.

The rest of the paper is organized as follows. Section 2 describes the empirical strategy. Section 3 reports our empirical findings. Section 4 discusses the implications of our findings, and Section 5 concludes.

2. Empirical Strategy

2.1 Great East Japan Earthquake

The Great East Japan Earthquake, also known as the 2011 Tohoku Earthquake, occurred on

[3] This research framework has been expanded in several dimensions. For example, Du, Lu, and Tao (2009) and Schwarz and Suedekum (2014) further extend the theoretical framework to show the existence of hybrid sourcing structures, i.e., firms that outsource and produce their components in-house at the same time.

Friday 11 March 2011. The earthquake was reported a magnitude scale of 9.0. It was the fourth largest earthquake since modern record-keeping in the world, and the most powerful earthquake on record in Japan. The earthquake triggered powerful tsunami, and caused 15,893 deaths, 6,152 injured, and 2,572 people missing across twenty prefectures (Japanese National Police Agency, 2015). The earthquake and tsunami also caused severe damage to buildings in north-eastern Japan: 127,290 buildings were totally collapsed, 272,788 buildings were half-collapsed, and 747,989 buildings were partially damaged (Japanese National Police Agency, 2014).

Figure 1 depicts the areas that were severely damaged by the earthquake. These areas include three Tohoku prefectures: Miyagi, Fukushima, and Iwate.

[Insert Figure 1 here]

2.2 Data

Firm-level panel data.——The main data used in this study come from the Basic Survey of Japanese Business Structure and Activities (BSJBSA), conducted by the Ministry of Economy, Trade and Industry for 2010-2013.[4]

The surveys cover all firms with more than 50 employees and 30 million yen of assets (about US$251,000). The data includes a firm's basic profile, e.g., its identification number, industry affiliations, firm location, and its financial and operational information, such as sales, employment, total assets, and offshore activities (which allows us to distinguish global sourcing into manufacturing and service offshoring activities in yen values).

Table 1 reports the summary statistics of the main variables. Specifically, the mean of logarithm of total offshoring is 0.32. The corresponding number for logarithm of manufacturing and service offshoring is 0.25 and 0.09, respectively.

[Insert Table 1 here]

[4] BSJBSA was first conducted in 1992, and then annually from 1995 onwards. For our study, data on service offshoring is only available from 2010. This restricts our analysis period from 2010 to the most recent year 2013.

3. Estimation Specification

The benchmark model to examine the effect of earthquake on firm offshoring is:

$$y_{frit} = \alpha_f + \gamma_{it} + \eta\ Treatment_r \times Post2011_t + \mathbf{X'}_{frit}\boldsymbol{\beta} + \varepsilon_{frit},$$

where *f*, *r*, *i* and t denote the firm, prefecture, industry, and year, respectively; y_{frit} is logarithm of total offshoring, i.e., the sum of manufacturing and service offshoring, of firm *f* of prefecture *r* of industry *i* in year *t*; α_f and γ_{it} are firm and industry-year fixed effects, respectively; $\mathbf{X}_{frit}$ is a vector of control variables including firm size, output-labor ratio, capital-labor ratio, firm age, number of plants, export and import dummies; ε_{frit} is the error term. To address the potential serial correlation and heteroscedasticity issues, we cluster the standard errors at the prefecture level.

Our regressor of interest,$Treatment_r \times Post2011_t$, captures the effect of earthquake on firm offshoring. Specifically, $Treatment_r$ indicates whether the prefecture in which the firm is located was affected by the earthquake (the treatment group), i.e., $Treatment_r = 1$ if the firm was located in in the prefecture Miyagi, Fukushima, or Iwate, and 0 otherwise.[5] $Post2011_t$ is a dummy indicating the post-earthquake period, i.e., $Post2011_t = 1$ if $t \geq 2011$, and 0 if $t < 2011$.

4. Estimation Result

The baseline regression results are presented in Table 2. We start with a simple DID specification that includes only firm and industry-year fixed effects in Column 1. The regressor of interest, $Treatment_r \times Post2011_t$, is statistically significant and positive, indicating that the Great East Japan earthquake increases firm's total offshoring.

[Insert Table 2 here]

In Column 2, we add time-varying firm-level characteristics, which include firm employment,

[5] The results (available upon request) remain robust when we use prefectures Miyagi, Fukushima, Tochigi, Iwate, and Ibaraki as the treatment group.

output-labor ratio, capital-labor ratio, firm age, number of plants of the firm, exports and imports. The result remains robust to these additional controls.

In Column 3, we check whether the treatment group and the control group is comparable before the earthquake, we replace $Post2011_t$ with year dummies. It is found that the interaction between $Treatment_r$ and 2010 year dummy (*Year2010*) is statistically insignificant and the magnitude is almost zero, which rules out the concern that our treatment and control group is different in offshoring after the earthquake.

5. Discussion

Manufacturing versus Service Offshoring.——In the aforementioned DID estimation, we find that the Great East Japan Earthquake increases firm's total offshoring. After the earthquake, what are changes in the composition of firm's offshoring? To further shed light on the underlying mechanisms, we decompose firm's total offshoring into manufacturing and service offshoring. Specifically, we replace the dependent variable in equation (1) with logarithm of manufacturing offshoring and service offshoring, respectively, and conduct the analysis based on our main results as in Column 3 of Table 2.

The decomposition results are presented in Table 3. As in Column 1, there is a statistically positive effect of earthquake on firm's manufacturing offshoring. In Column 2, the effect of earthquake on service offshoring is insignificant, with magnitude close to 0. Combined, manufacturing offshoring plays a larger role in explaining the effect of earthquake on firm's offshoring than service offshoring.

[Insert Table 3 here]

Single-Plant Firms.——As the data used in this study is at the firm-level, it is possible that for multi-plant firms, some plants located in the Tohoku area were affected by the earthquake, and some were not, which may bias our estimation results.[6] To rule out this concern, we restrict the sample to single-plant firms and re-do the estimation for total, manufacturing, and service offshoring.

The regression results are presented in Table 4. It is found that our results are robust in terms of manufacturing offshoring: the earthquake has a large and significant effect on manufacturing components.

[Insert Table 4 here]

One-Shot Effect.——One may argue that there is a one-shot effect of earthquake on firm's offshoring. To examine this possibility, we interact $Treatment_r$ with 2011 year dummy (*Year2011*), and check whether our results are robust. The estimation result is presented in Table 5. We find consistent result that for manufacturing offshoring, the effect of earthquake is positive and statistically significant.

[Insert Table 5 here]

Domestic Sourcing.−−−In the aforementioned results, we find a positive effect of earthquake on firm's offshoring. To figure out whether the positive effect on firm's offshoring is due to the disruption of domestic networks, we study how the earthquake would affect firm's domestic sourcing. The estimation results are present in Table 6. It is found that the effect of earthquake on firm's domestic sourcing is insignificant, indicating that the positive effect of earthquake on firm's offshoring cannot be explained by the changes in domestic sourcing.

[Insert Table 6 here]

[6] BSJBSA data includes address of firms' headquarter but not addresses of plants.

6. Conclusion

In this paper, we use the Great East Japan Earthquake as an exogenous shock to identify the macro fluctuation on firm's offshoring. Using Japanese firm-level data from 2010--2013, we show that the earthquake increases firm's offshoring. By decomposing total offshoring into manufacturing and service offshoring, we find the positive effect of earthquake is statistically significant for manufacturing offshoring, but not service offshoring.

One possible reason why the difference happens is that intermediate goods used by both sectors are different. If a manufacturing firm conduct outsourcing, it usually requires to transport physical intermediate goods with contractors. The damaged transport network in Tohoku area possibly forced some manufacturing firms to replace domestic contractor by foreign contractors. In contrast, outsourcing of service firms, as often seen in software industry, can be implemented without transportation of intermediate goods and therefore the effect of the earthquake is insignificant.

The fact that the effect of the earthquake is one-shot implies that manufacturing firms might increase the offshoring as an immediate response to the earthquake. The efforts in a normal period to facilitate offshoring, such as tariff reduction on intermediate goods, will support firms' action in emergency.

Our study contributes to the literature on the determinants of international fragmentation. As natural disasters and risks are prevalent over the world, this result helps us better understand how firms will change their sourcing pattern when facing uncertainty or risks.

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Figure 1 Areas Damaged by the Great Earthquake

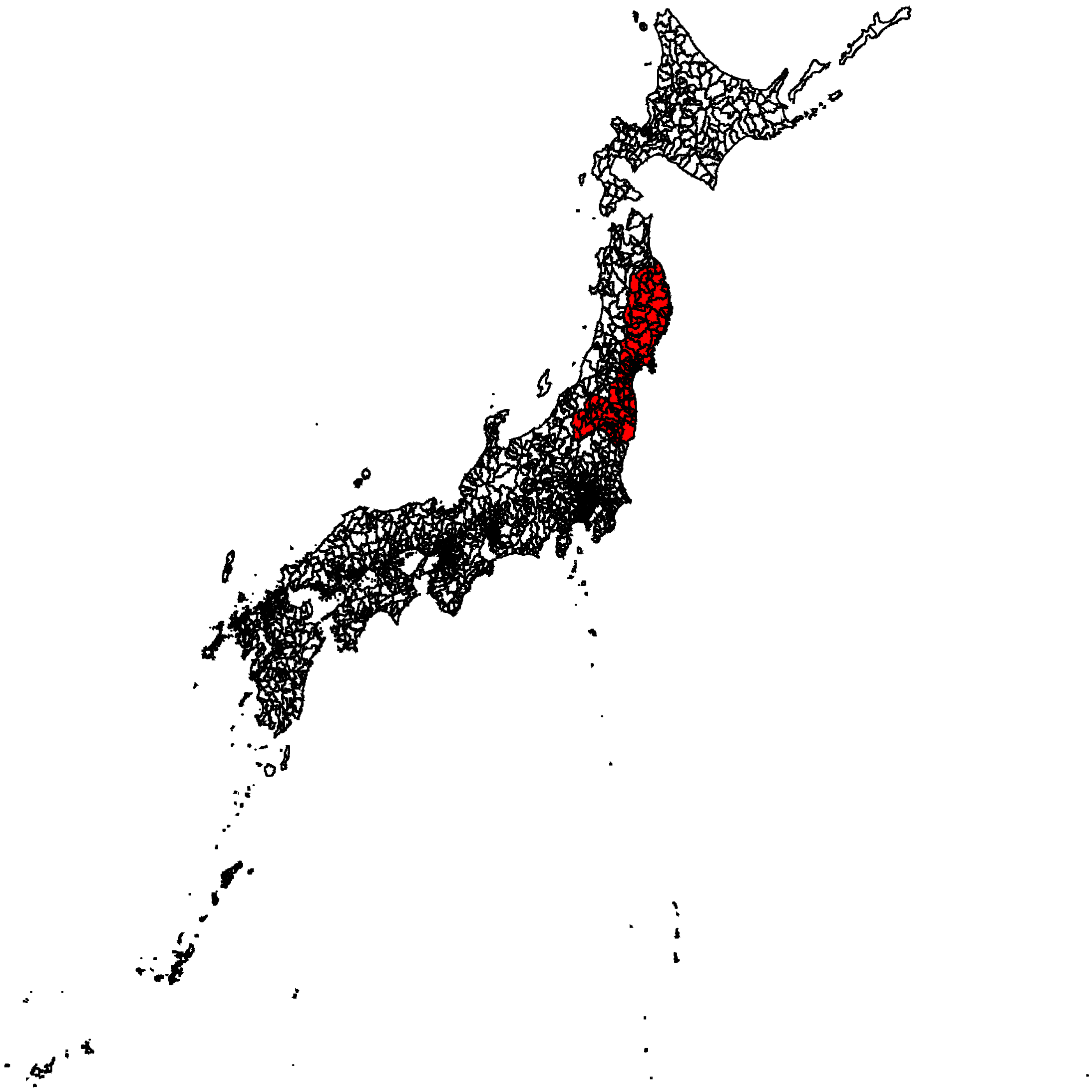

Table 1: Summary Statistics

Variable	Observations	Mean	Std. Dev.
Total offshoring	119,897	0.318	1.293
Manufacturing offshoring	119,897	0.246	1.165
Service offshoring	119,897	0.092	0.652
Employment	119,897	4.169	1.188
Output-labor ratio	119,897	4.354	1.403
Capital-labor ratio	119,897	4.082	1.418
Firm age	119,897	40.993	20.726
Number of plants	119,897	0.025	0.134
Exports	119,897	1.260	2.670
Imports	119,897	1.241	2.576

Note: "Mean" shows the average of logarithm of the variables except "Firm age." The mean of "Firm age" is the average.

Table 2: Earthquake and Offshoring

Dependent variable: Total offshoring	(1)	(2)	(3)	(4)
$Treatment_r \times Post2011_t$	0.022*	0.023*	0.023*	
	(0.012)	(0.013)	(0.013)	
$Treatment_r \times Year2010$				-0.005
				(0.020)
$Treatment_r \times Year2011$				0.027*
				(0.015)
$Treatment_r \times Year2012$				0.014
				(0.012)
Time-varying firm controls	No	Yes	Yes	Yes
Time-varying village controls	No	No	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes
Observations	11,652	11,651	11,651	11,651

Note: Standard errors are clustered at the prefecture level in parentheses. ***, ** and * denote significance at the 1, 5 and 10% level respectively.

Table 3: Manufacturing and Service Offshoring

Dependent variable	Manufacturing offshoring	Service offshoring
	(1)	(2)
Earthquake	0.031***	−0.002
	(0.009)	(0.010)
Time-varying firm controls	Yes	Yes
Time-varying village controls	Yes	Yes
Firm fixed effects	Yes	Yes
Industry-year fixed effects	Yes	Yes
Observations	115,651	115,651

Note: Standard errors are clustered at the prefecture level in parentheses. ***, ** and * denote significance at the 1, 5 and 10% level respectively.

Table 4: Single-Plant Firms

Dependent variable	Total offshoring	Manufacturing offshoring	Service offshoring
	(1)	(2)	(3)
Earthquake	0.003	0.008***	0.001
	(0.002)	(0.002)	(0.003)
Time-varying firm controls	Yes	Yes	Yes
Time-varying village controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes
Observations	111,129	111,129	111,129

Note: Standard errors are clustered at the prefecture level in parentheses. ***, ** and * denote significance at the 1, 5 and 10% level respectively.

Table 5: One-Shot Effect

	Total offshoring	Manufacturing offshoring	Service offshoring
	(1)	(2)	(3)
Earthquake	0.005	0.006**	0.003
	(0.003)	(0.002)	(0.004)
Time-varying firm controls	Yes	Yes	Yes
Time-varying village controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes
Observations	115,651	115,651	115,651

Note: Standard errors are clustered at the prefecture level in parentheses. ***, ** and * denote significance at the 1, 5 and 10% level respectively.

Table 6: Domestic Sourcing

Dependent variable	Total domestic sourcing	Manufacturing domestic sourcing	Service domestic sourcing
	(1)	(2)	(3)
Earthquake	0.012	−0.014	0.015
	(0.041)	(0.038)	(0.016)
Time-varying firm controls	Yes	Yes	Yes
Time-varying village controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes
Observations	115,651	115,651	115,651

Note: Standard errors are clustered at the prefecture level in parentheses. ***, ** and * denote significance at the 1, 5 and 10% level respectively.