

Firm-level impacts of natural disasters on production networks : evidence from a flood in Thailand

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Abstract

In this paper, we explore the firm-level impacts of flooding in Thailand in 2011, specifically those on the procurement patterns at Japanese affiliates in Thailand. Our findings are as follows. First, the damaged small firms are more likely to lower their local procurement share, particularly the share of procurement from other Japanese-owned firms in Thailand. Second, damaged young firms and damaged old firms are more likely to raise the shares of imports from Japan and China, respectively. Third, there are no impacts on imports from ASEAN and other countries. These findings are useful for uncovering how multinational firms adjust their production networks before and after natural disasters.

Keywords: Natural disasters, flooding, production networks

JEL classification: D22; F23; Q54

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Firm-level Impacts of Natural Disasters on Production Networks: Evidence from a Flood in Thailand

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Abstract: In this paper, we explore the firm-level impacts of flooding in Thailand in 2011, specifically those on the procurement patterns at Japanese affiliates in Thailand. Our findings are as follow. First, the damaged small firms are more likely to lower their local procurement share, particularly the share of procurement from other Japanese-owned firms in Thailand. Second, damaged young firms and damaged old firms are more likely to raise the shares of imports from Japan and China, respectively. Third, there are no impacts on imports from ASEAN and other countries. These findings are useful for uncovering how multinational firms adjust their production networks before and after natural disasters.

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1. Introduction

Severe floods occurred in Thailand in 2011. The landfall of a historically rare

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number of typhoons or tropical storms brought an abnormal amount of rainfall. As a result, according to “EM-DAT: The OFDA/CRED International Disaster Database,” the number killed was 813, the total number affected was 10 million, and economic damage is estimated to be USD40 billion. The National Economic and Social Development Board reports that this flooding lowered real GDP growth rates by around 4%. Another important aspect of Thailand is the existence of large industrial clusters, particularly in the electronic and automobile industries, which have been developed mainly by Japanese overseas affiliates. The flooding not only destroyed such industrial clusters but also had negative impacts on production of those industries all over the world through supply chain networks.

In economics, by employing cross-country or cross-subnational region data, natural disasters have been explored from at least two perspectives. One perspective is what contributes to reducing economic damage from natural disasters. Cavallo et al. (2010), Kahn (2005), and Toya and Skidmore (2007) are the examples of such studies. The papers found the less damage in the richer countries or countries with better political and institutional systems. The other perspective is the economic impacts of natural disasters. The examples in this literature include Cavallo et al. (2013), Fomby et al. (2013), Loayza et al. (2012), Noy (2009), Skidmore and Toya (2002), and Strobl (2012). Most of the studies have examined the (short-run and long-run) impacts on GDP per capita. Their findings are that the economic impacts become either positive or negative, depending on various kinds of dimensions including disaster type (e.g., earthquake or flooding), industries, economic development of countries, the magnitude of disaster, and so on. Overall, due to the recent increase of natural disasters all over the world, the literature on natural disasters has rapidly grown. Cavallo and Noy (2011) is an excellent survey paper on this literature.

More recently, firm-level studies on natural disasters have experienced a gradual increase. The examples include Cole et al. (2013), De Mel et al. (2012), Leitter et al. (2009), and Todo et al. (2013). Leitter et al. (2009) explored firms in Europe and found that employment growth is higher in firms in flooded regions. Cole et al. (2013) investigated the earthquake in Japan in 1995 and found a lower probability of survival and greater reduction of employment and value-added in firms in the more damaged regions. Employing field survey data, De Mel et al. (2012) focused on the tsunami in Sri Lanka in 2004 and found that direct aid such as cash grants play a significant role in the resilience of firms, particularly in services sectors. Todo et al. (2013) emphasizes the role of supply chain networks in such resilience. They examined the resilience of manufacturing firms after the Great East Japan Earthquake in 2011 and found the

positive role played by diversified supply chain networks.

This paper also examines the economic impacts of natural disasters at the firm level. Specifically, we explore the economic impacts of flooding in Thailand in 2011 on Japanese affiliates in Thailand. Japan has established sophisticated international production networks in Southeast Asia since the 1990s. Within the production networks, overseas affiliates in Thailand have played a central role. Indeed, Japan has been the largest investor in Thailand,¹ while Thailand has been the top host country for Japanese investors among Southeast Asian countries.² In this paper, focusing on the impacts of flooding on procurement patterns at Japanese affiliates in Thailand, we examine how natural disasters affect production networks in multinational enterprises (MNEs). To do that, we employ a unique dataset for the period 2009-2013 collected by the Japan External Trade Organization (JETRO) in the “Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania.”

More specifically, we first examine the changes in the share of local procurement before and after the flooding period. The direct damage to capital goods by the flooding forced the damaged firms to stop their production activities. On the other hand, during that time, undamaged firms that used to trade with such damaged firms needed to change their procurement partners. As a result, it was an open question whether or not flooding would yield differences in procurement patterns between damaged and undamaged firms. To examine this question, we investigate the share of local procurement before and after the flooding period and compare changes in local procurement at damaged and undamaged affiliates. Namely, by examining the changes in local participation in the production networks, we explore how MNEs adjust their production networks differently according to the existence of physical damage from flooding.

Then, we more closely examine the changes in procurement patterns at damaged firms before and after the flooding. For example, we investigate whether such changes in local procurement differ even among damaged firms, e.g., according to the number of years in operation or firm size. We also examine whether different patterns of changes in local procurement can be observed if damaged firms dispatch Thai workers to factories in Japan in order to ensure a workforce for alternate production in Japan. Furthermore, we decompose the local procurement into procurements from other

¹ According to the Board of Investment, Japanese investments accounted for 64% of total foreign investments in 2012.

² According to the “Survey of Overseas Business Activities” by the Ministry of Economy, Trade and Industry (METI), the number of Japanese manufacturing affiliates in 2011 was 864, accounting for 36% of the total number of Japanese manufacturing affiliates in Southeast Asian countries.

same-nationality firms (i.e., Japanese-owned firms) and from other local firms. Finally, we examine the changes in imports from Japan, ASEAN, China, and other countries. Based on the above, this paper seeks to reveal the overall picture of the impacts of flooding on procurement behavior in international production networks.

This paper contributes to the literature in at least two ways. First, this paper is the first to examine the impacts of natural disasters on firm-level procurement patterns. As introduced above, there are several recent firm-level studies on the economic impacts of natural disasters. However, those previous studies have focused on the impacts on profitability, employment, value-added, and so on. Thus, our analysis will add some new evidence on the impacts of natural disasters on other firm-level performance indicators. Second, our focus on the procurement patterns in foreign-owned firms, i.e., Japanese affiliates in Thailand, may provide new insights on the effects of disasters on international production networks at MNEs. Some studies such as Hanson et al. (2005) and Kiyota et al. (2008) have examined the determinants of imports at MNEs' overseas affiliates. In this paper, we investigate how natural disasters affect their procurement patterns and how MNEs change their international production networks before and after natural disasters. The resulting information will be helpful for MNEs that have never suffered from natural disasters as it will enable them to reconstruct their production networks in preparation for future disasters. The resulting information might also be useful for policy makers in countries with a large number of foreign-owned firms because it provides clues to predict what happens to national exports and imports before and after natural disasters.

The remainder of this paper is organized as follows. The next section provides a brief overview of flooding in Thailand in 2011. Its impacts on procurement patterns are overviewed in Section 3. Section 4 specifies our empirical framework for examining the firm-level impacts of flooding on procurement patterns. After presenting our estimation results in Section 5, we conclude this paper in Section 6.

2. Industries in the Aftermath of the Flooding³

The industrial parks in the north area of Bangkok suffered serious damage from flooding. Figure 1 shows the major industrial parks around Bangkok. The flood deluged the Saha Rattana Nakhon Industrial Park located in the northern part of Ayutthaya Province on 4th October 2011. Then, it engulfed Rojana Park, in which a large number

³ This section benefited highly from several short reports written by Seiya Sukegawa (JETRO) in Japanese.

of Japanese affiliates are located. In consequence, seven major industrial parks were flooded. There were also some firms, including Japanese affiliates, located outside of these industrial parks that were also flooded. According to JETRO Bangkok's investigation, more than 550 Japanese affiliates were damaged directly by flooding. At those affiliates, the ground floors in their factories had suffered from water exposure for one or two months. As a result, production facilities such as capital goods and buildings per se were seriously damaged.

=== Figure 1 ===

A large number of firms in non-flooded areas also suffered from indirect damage through supply chain networks. Examples of industrial parks in which such firms locate are also depicted in Figure 1, i.e., Bangchan, Ladkrabang, Bangpoo, and Banglee. The firms in non-flooded areas that trade with firms in flooded areas were forced to adjust the magnitude of production or stop production because those in flooded areas could not engage in production activities. A typical case is Toyota Motor Thailand, Co., Ltd. It has production factories in Samrong, Gateway, and Ban Pho, none of which were flooded. However, it was unable to purchase some automobile parts from firms in flooded- and non-flooded areas. As a result, its factories stopped production activities for around one month. Furthermore, this stoppage of production in Thailand led to stoppage of production at Toyota factories in Indonesia, Malaysia, and Viet Nam and to the adjustment of production volume at Toyota factories in Pakistan, North America, and South Africa.

As a result of the flooding, almost all Japanese affiliates in Thailand suffered from direct or indirect damage. More specifically, according to "Survey of Business Trends in Second Half of 2011" by the Japanese Chamber of Commerce in Bangkok, while around 20% of Japanese manufacturing firms in Thailand were directly damaged by floods, around 80% suffered from indirect damage. During the flooding, while directly damaged firms switched production to their other factories, particularly in those in Japan or third countries, indirectly damaged firms changed their procurement partners to those not only in Thailand but also in Japan or third countries. Interestingly, the new procurement partners in Thailand are not only Japanese affiliates but also firms with nationalities other than Japanese. According to "Urgent Survey on Restoration State of Supply Chains Following Damages by Thai Flooding" by Japan's Ministry of Economy, Trade and Industry, among 17 Japanese affiliates whose alternate procurement partners are in Thailand, 50% of such partners are existing partners, 40% are new partners with

nationalities other than Japanese, and 10% are new partners of Japanese affiliates.

While indirectly damaged firms could restart their production activities by changing their procurement partners as mentioned just above, most of the directly damaged firms also recovered soon. According to JETRO Bangkok's interview with the Industrial Estate Authority of Thailand, as of 10th December 2012, while nearly 10% of factories in the above-mentioned seven flooded industrial parks decided to relocate to other areas in Thailand or other countries, around 80% of those restarted their production activities without relocating to other regions in Thailand or to other countries. This non-relocation of the restarting factories was because relocation would entail significant time and cost and because they prefer an earlier restart of product supply to their customers. However, the production magnitude in some of the restarting factories was below the pre-flood level in order to lower the risk of negative impacts from future flooding.

Some special supports from governments contributed to the recovery of firms in Thailand. The support from the Japanese government was to allow directly damaged Japanese factories to send Thai workers to Japan in order to conduct alternate production in Japan during the flood. In order to smoothly ensure a workforce for production in Japan, a large number of Thai workers were sent to Japan under this scheme. According to an announcement by Japan's Ministry of Justice, as of the end of September 2012, 5,342 Thai workers entered Japan under this scheme. The Thai government also provided several supports. For example, by issuing courtesy visas, foreign people such as Japanese workers were allowed to engage in recovery work at damaged firms. Also, Thailand's Board of Investment allowed duty-free imports of alternate capital goods. It also offered more benefits (e.g., an eight-year exemption from corporate tax) for new or expansive investment, particularly in flooded areas such as Ayutthaya Province. These supports contributed to the quicker recovery of damaged firms.

3. Data Overview

In this section, we provide an overview of some performance indicators at Japanese affiliates in Thailand. To do this, we employ a unique dataset for 2009-2013 collected by JETRO in the "Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania" which includes some basic affiliate characteristics such as employment, detailed sources of procurements, detailed destinations of sales, and so on. In each year of this period, questionnaires were sent to around 5,000 Japanese affiliates operating in

those regions. The survey received more than 2,000 valid responses (a response rate near 50%). We focus on Japanese affiliates in Thailand in this survey. In 2010, for example, 533 responses were from Japanese manufacturing affiliates in Thailand.⁴ Using the information on location, we classify the affiliates into those in flooded or non-flooded regions. In this paper, we define the three provinces of Nonthaburi, Pathum Thani, and Ayutthaya as flood regions. Affiliates in any of these three provinces are classified as directly-damaged affiliates.

Here we take a brief look at the changes in Japanese affiliates' procurements. The number of affiliates included in the following figures is reported in the Appendix. One noteworthy point is that their number is rather small in 2012 because of flooding. Figure 2 depicts the transition in the average local procurement share. It shows the dramatic decrease in local procurement shares at both affiliates in flooded and non-flooded regions in 2012 though this decrease is partly because of the differences in the number of sample affiliates among the sample years. However, it is noteworthy that such shares in 2013 quickly recovered to the level of 2011. Thus, the impacts of flooding on local procurement are rather temporary. Figures 3 and 4 show the transitions in the average procurement shares from other Japanese-owned affiliates in Thailand and from other firms, respectively. Such decomposed shares show a qualitatively similar trend with the share of local procurement.

=== Figures 2-4 ===

Next, we provide an overview of the changes in imports. Figures 5 through 8 depict the transition in the average import shares from Japan, ASEAN, China, and other countries, respectively. There are three noteworthy points. First, the changes in the import shares look qualitatively similar in the cases of Japan and ASEAN and in the cases of affiliates in flooded and non-flooded regions. Those rose in 2012 but returned to the level of 2011 in 2013. Second, while the share of imports from China at affiliates in non-flooded regions remains constant during the sample period, the affiliates in

⁴ According to the "Survey of Overseas Business Activities" by METI, there were 877 Japanese manufacturing affiliates in Thailand in 2010. The JETRO survey includes more than half of the Japanese affiliates in Thailand covered by the METI data. One crucial advantage of the JETRO survey is the availability of data for the post-flood period. As of January 2014, the latest data in the JETRO survey and the METI survey are those for 2013 and 2011, respectively. On the other hand, since the mean values of employment are 661 in the METI data and 736 in the JETRO survey, our dataset includes relatively large Japanese manufacturing affiliates in Thailand. Also, the JETRO dataset does not include usual items such as sales or productivity in addition to parent firms' performance indicators such as productivity, sizes, and the location of their overseas affiliates.

flooded regions dramatically raised their share of imports from China in 2012. This share at affiliates in flooded regions decreased from 2012 to 2013 but still remained at a higher level in 2013. Third, the shares of imports from other countries showed asymmetric changes in 2012 at affiliates in flooded regions (down) and non-flooded regions (up). However, such shares return to the level of 2011 in 2013.

=== Figures 5-8 ===

4. Empirical Framework

This section specifies our empirical framework for examining the impacts of flooding on the procurement patterns. To this end, following the previous studies such as Leiter et al. (2009) and Cole et al. (2013), we employ the difference-in-difference (DID) approach. So, our sample has two dimensions. One is a time dimension (i.e., before and after flooding), while the other is a region dimension (i.e., flooded and non-flooded regions). As mentioned in the previous section, the flooded regions are the three provinces of Nonthaburi, Pathum Thani, and Ayutthaya. Our estimation sample is Japanese affiliates in Thailand and includes the four kinds of affiliates from each quadrant of the dimensions. With such sample affiliates, we examine how the change in the local procurement share before and after flooding differs between affiliates in flooded and non-flooded regions.

Specifically, the estimation equation is simply given by:

$$LProc_{it} = \beta_1 Damage_{it} + \beta_2 \ln Employment_{it-1} + u_i + u_t + \varepsilon_{it}, \quad (1)$$

$LProc_{it}$ is affiliate i 's share of the local procurement out of total procurements in year t . The most important explanatory variable, $Damage$, is a binary variable that takes the value one if affiliate i locates in any of the flooded regions and year t is a post-flood year. As control variables, we also include the employment size ($Employment$). u_i and u_t are the affiliate and year fixed effects, respectively. The data on all variables are drawn from the same data source as in the previous section, i.e., "Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania." We estimate this model by the ordinary least square (OLS) method.

It is worth discussing more about what the coefficients for $Damage$ indicate. As mentioned in the previous section, not only firms in flooded regions but also those in non-flooded regions have a non-production period due to flooding. However, the reason for such non-production period differs between these two kinds of firms. The firms in flooded regions suffered from physical damage to their production facilities such as

capital goods, and some could not even enter their factories because of water damage. In other words, firms in flooded regions could not realistically engage in production activities, while those in non-flooded regions could technically do so. Thus, firms in non-flooded regions could start production by changing their procurement partners. As a result, the coefficients indicate whether or not there are persistent differences in procurement patterns according to the existence of significant non-production periods in Thailand.

We set the year 2012 as a flooding year. Namely, the periods of 2009-2011 and 2013 are pre- and post-flooding periods, respectively. Thus, the variable *Damage* takes the value of one only for affiliates in Nonthaburi, Pathum Thani, or Ayutthaya in 2013. As a result, our sample years for estimation include 2009, 2010, 2011, and 2013.⁵ The inclusion of 2011 is to increase the number of observations and because firms were damaged by flooding only in the fourth quarter in the case of 2011. Also, we already confirmed in the previous section that firms were significantly affected by flooding in 2012. Using similar specifications, we later examine the impacts on the shares of local procurement from other Japanese-owned firms in Thailand and from other firms in Thailand. The impacts on imports from Japan, ASEAN, China, and other countries are also explored.

We also examine some interaction effects in the impacts of flooding. The estimation equation is modified to the following.

$$\begin{aligned} \text{LProc}_{it} = & \beta_1 \text{Damage}_{it} + \text{Damage}_{it} \mathbf{X}_{it-1} \boldsymbol{\gamma} \\ & + \beta_2 \ln \text{Employment}_{it-1} + u_i + u_t + \varepsilon_{it}, \end{aligned} \quad (2)$$

\mathbf{X} includes various elements. First, we examine the interaction with the number of operation years in Thailand (*Age*) and the size in terms of (a log of) employment. Second, we include the interaction term with a *Dispatch* dummy variable, which takes the value of one if firms dispatch Thai workers to factories in Japan and zero otherwise. This dummy variable is constructed based on an interview with each directly-damaged Japanese affiliate by JETRO Bangkok. By exploring these interaction terms, we investigate whether or not there are heterogeneous impacts of flooding among damaged firms.

5. Empirical Results

This section reports our estimation results. We first estimate our specifications (1) and (2) for the local procurement share and then decompose the share of local

⁵ In the sample for 2013, we use an explanatory variable, a log of *Employment*, for 2011.

procurement into those from other Japanese-owned firms and those from other firms in Thailand. Finally, we also examine the impacts of flooding on imports from various countries or regions. The basic statistics are provided in Table 1.

==== Table 1 ====

We first estimate the simple equation, which does not include an affiliate dummy but only a year dummy. The result is reported in column (I) in Table 2. The coefficient for Damage is estimated to be insignificant, indicating that there are no significant differences in the local procurement share between damaged and undamaged firms. More precisely, regardless of any non-production periods due to the flooding, firms do not change their share of local procurement before and after flooding. While firm size in terms of employment has insignificant impacts, the coefficient for Age is estimated to be significantly positive. The latter result implies that the older Japanese affiliates in Thailand have a higher share of local procurement.

==== Table 2 ====

These results are basically unchanged even when various kinds of dummy variables are included. Column (II) includes an industry dummy in addition to a year dummy and shows the insignificant impacts of flooding though the size has a significantly positive coefficient. In column (III), we estimate this model by employing a fractional logit estimation technique (Frac) proposed by Papke and Wooldridge (1996) because our dependent variable lies in the unit interval, i.e., $[0, 1]$.⁶ The results are qualitatively unchanged from those produced by OLS, i.e., (II). Last, column (IV) includes an affiliate dummy in addition to a year dummy (i.e., a two-way component fixed effect model, FE). Both Damage and size have insignificant coefficients.

Next, we introduce the above-mentioned interaction terms for the model with affiliate and year dummy variables. The results are reported in columns (V)-(VIII). We find significantly heterogeneous impacts of flooding according to firm size. As found in columns (V) and (VIII), on average, the direct damage by flooding lowers the share of local procurement. In particular, small firms lower their share more significantly. In

⁶ The fractional logit model ensures that, unlike the OLS method, the predicted values of the dependent variable are in the unit interval. Also, unlike the log-odds ratio model and the beta regression model, it can naturally define dependent variables for the boundary values of 0 and 1. It imposes less restrictive assumptions than the Tobit model (which requires the normality and homoskedasticity of the dependent variables). For more details, see Ramalho et al. (2011).

other words, the damaged small firms are more likely to change their procurement sources from local ones to imports from other countries. This result might indicate that the large firms have more knowledge of local suppliers and thus more easily find other suppliers in Thailand. On the other hand, we cannot find any significant differences in the local procurement share according to ages and the existence of Thai worker dispatch.

In order to more closely investigate the impacts of flooding on local procurement, we also estimate our model for the shares of local procurement from Japanese-owned firms in Thailand and from other firms in Thailand separately. The results are reported in Table 3. There are mainly two noteworthy points. First, the heterogeneous impacts on the local procurement share according to firm size can be found in the inputs from Japanese-owned firms in Thailand. Namely, the damaged small firms are more likely to change their procurement sources from other Japanese-owned firms in Thailand to imports from other countries. Second, we cannot find robust impacts of flooding on inputs from other firms in Thailand though the larger firms have a higher share of inputs from other firms in Thailand. Thus, unlike the case with a small number of observations (i.e., 17 affiliates) in Section 2, on average, we cannot see a significant increase in inputs from other firms in Thailand in the case of a larger number of observations.

==== Table 3 ====

Last, we investigate the impacts on imports. Tables 4 through 7 report the results for imports from Japan, ASEAN, China, and other countries, respectively. We only estimate for the model with affiliate and year dummy variables. There are two noteworthy findings in these tables. One is that, as found in Tables 5 and 7, there are no impacts on imports from ASEAN and other countries. Thus, damaged firms do not change their procurement shares from ASEAN and other countries. The lack of changes in imports from ASEAN may be because Japanese MNEs have developed sophisticated production networks in ASEAN according to the location advantages in each country. In other words, based on the differences in location advantages, production lines are highly differentiated across ASEAN countries. Thus, it might be difficult to find inputs with a similar technology level in other ASEAN countries.

==== Tables 4-7 ====

The other noteworthy finding is that, as found in Tables 4 and 6, damaged young

firms and damaged old firms are more likely to raise their shares of imports from Japan and China, respectively. The young Japanese-owned affiliates may not have much knowledge concerning suppliers not only in Thailand but also in other neighboring countries and thus may rely on those in their home country, Japan. On the other hand, the old Japanese-owned affiliates in Thailand may have such knowledge and further may have affiliates in other countries, particularly China. As a result, such old firms may increase their inputs from China.⁷ Indeed, in contrast to the above case of ASEAN, Japanese MNEs have a segmented market between ASEAN and China. As is consistent with this view and as is mentioned in Section 2, the stoppage of Toyota Motor Thailand's production activities was observed in Indonesia, Malaysia, and Viet Nam but not in China. Thus, they may be able to find inputs with a similar technology level in China. In short, this difference between young and old firms may be due to the difference in the knowledge level concerning suppliers in other neighboring countries.

6. Concluding Remarks

In this paper, we explore the firm-level impacts of flooding in Thailand in 2011, specifically those on the procurement patterns at Japanese affiliates in Thailand. Our findings can be summarized as follows. First, the damaged small firms are more likely to lower their local procurement share, particularly the share of procurement from other Japanese-owned firms in Thailand. Second, damaged young firms and damaged old firms are more likely to raise their share of imports from Japan and China, respectively. Third, there are no impacts on imports from ASEAN and other countries. As a result, these results might indicate that the adjustment of procurement sources at MNEs depends on the knowledge concerning suppliers in their host country and neighboring countries. In short, overseas affiliates with less knowledge rely on their home country, while those with the greater knowledge procure from other partners in host countries or from neighboring countries which can supply inputs with a similar technology level as the host countries. Therefore, it is important for MNEs, particularly small or young MNEs, to have a list of alternative procurement sources.

⁷ Unfortunately, as mentioned in footnote 4, we could not directly examine this hypothesis.

References

- Cavallo, E. and Noy, I., 2011, Natural Disasters and the Economy - A Survey, *International Review of Environmental and Resource Economics*, **5**(1), 63-102.
- Cavallo, E., Galiani, S., Noy, I., and Pantano, J., 2013, Catastrophic Natural Disasters and Economic Growth, Forthcoming in *Review of Economics and Statistics*.
- Cavallo, E., Powell, A., and Becerra, O., 2010, Estimating the Direct Economic Damages of the Earthquake in Haiti, *Economic Journal*, **120**(546), F298-F312.
- Cole, M., Elliott, R., Okubo, T., and Stroble, E., 2013, Natural Disasters and Plant Survival: The Impact of the Kobe Earthquake, RIETI Discussion Paper Series 13-E-63.
- De Mel, S., McKenzie, D., and Woodruff, C., 2012, Enterprise Recovery Following Natural Disasters, *Economic Journal*, **122**, 64–91.
- Fomby, T., Ikeda, Y., and Loayza, N., 2013, The Growth Aftermath Of Natural Disasters, *Journal of Applied Econometrics*, **28**(3), 412-434.
- Hanson, G., Mataloni, R., and Slaughter, M., 2005, Vertical Production Networks in Multinational Firms, *Review of Economics and Statistics*, **87**(4), 664-678.
- Kahn, M., 2005, The Death Toll from Natural Disasters: The Role of Income, Geography, and Institutions, *Review of Economics and Statistics*, **87**(2), 271-284.
- Kiyota, K., Matsuura, T., Urata, S., and Wei, Y., 2008, Reconsidering the Backward Vertical Linkages of Foreign Affiliates: Evidence from Japanese Multinationals, *World Development*, **36**(8), 1398-1414.
- Leiter, A., Oberhofer, H., and Raschky, P., 2009, Creative Disasters? Flooding Effects on Capital, Labour and Productivity Within European Firms, *Environmental and Resource Economics*, **43**(3), 333-350.
- Loayza, N., Olaberría, E., Rigolini, J., and Christiaensen, L., 2012, Natural Disasters and Growth: Going Beyond the Averages, *World Development*, **40**(7), 1317-1336.
- Noy, I., 2009, The Macroeconomic Consequences of Disasters, *Journal of Development Economics*, **88**(2), 221-231.
- Papke, L.E. and Wooldridge, J.M., 1996, Econometric Methods for Fractional Response Variables with an Application to 401(k) Plan Participation Rates, *Journal of Applied Econometrics*, **11**(6): 619-632.
- Ramalho, E.A., Ramalho, J.J.S., and Murteira, J.M.R., 2011, Alternative Estimating and Testing Empirical Strategies for Fractional Regression Models, *Journal of Economic Surveys*, **25**(1): 19-68.
- Skidmore, M. and Toya, H., 2002, Do Natural Disasters Promote Long-Run Growth?,

Economic Inquiry, **40**(4), 664-687.

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.

Todo, Y., Nakajima, K., and Matous, P., 2013, How Do Supply Chain Networks Affect the Resilience of Firms to Natural Disasters? Evidence from the Great East Japan Earthquake, RIETI Discussion Paper Series 13-E-28.

Toya, H. and Skidmore, M., 2007, Economic Development and the Impacts of Natural Disasters, *Economics Letters*, **94**(1), 20-25.

Table 1. Basic Statistics

	Obs	Mean	Std. Dev.	Min	Max
LProc	676	0.535	0.332	0	1
From Japanese-owned Firms	676	0.301	0.283	0	1
From Other Firms	676	0.234	0.264	0	1
Imports from Japan	676	0.329	0.304	0	1
Imports from China	676	0.036	0.102	0	1
Imports from ASEAN	676	0.040	0.109	0	1
Imports from the Other Countries	676	0.061	0.153	0	1
Damage	676	0.031	0.174	0	1
* Dispatch	676	0.012	0.108	0	1
* Age	676	0.473	2.844	0	25
* ln Employment	676	0.190	1.099	0	9.38
ln Employment	676	5.365	1.433	1.39	9.68
Age	676	16.766	9.813	1	53

Table 2. Impacts on Local Procurement Share

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Damage	-0.106	-0.060	-0.250	-0.051	-0.433*	-0.069	-0.127	-0.435**
	[0.068]	[0.064]	[0.263]	[0.048]	[0.223]	[0.067]	[0.108]	[0.209]
* Dispatch					-0.005	0.041		
					[0.070]	[0.084]		
* Age					0.000		0.005	
					[0.008]		[0.006]	
* In Employment					0.062**			0.061**
					[0.027]			[0.029]
In Employment	0.015	0.026**	0.111**	0.005	0.003	0.006	0.005	0.003
	[0.009]	[0.011]	[0.047]	[0.104]	[0.104]	[0.104]	[0.104]	[0.103]
Age	0.004***	0.004**	0.016**					
	[0.001]	[0.001]	[0.006]					
Affiliate	NO	NO	NO	YES	YES	YES	YES	YES
Industry	NO	YES	YES	NO	NO	NO	NO	NO
Year	YES	YES	YES	YES	YES	YES	YES	YES
Method	OLS	OLS	Frac	FE	FE	FE	FE	FE
Number of Obs.	676	676	676	676	676	676	676	676
R-squared	0.0320	0.1481		0.0041	0.0092	0.0044	0.0046	0.0092
Log pseudolikelihood			-352					

Notes: The dependent variable is the share of local procurement. ***, **, and * show 1%, 5%, and 10% significance, respectively.

Table 3. Impacts on Local Procurement Share: Japanese-owned Firms and Other Firms

	Japanese-owned Firms in Thailand					Other Firms in Thailand				
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(VIV)	(X)
Damage	-0.030 [0.062]	-0.480** [0.232]	-0.011 [0.063]	-0.185 [0.203]	-0.437** [0.186]	-0.022 [0.043]	0.047 [0.126]	-0.058* [0.034]	0.058 [0.131]	0.002 [0.111]
* Dispatch		-0.092 [0.117]	-0.043 [0.125]				0.087 [0.088]	0.085 [0.085]		
* Age		0.003 [0.010]		0.011 [0.012]			-0.004 [0.007]		-0.006 [0.007]	
* In Employment		0.071*** [0.026]			0.065*** [0.025]		-0.009 [0.026]			-0.004 [0.015]
In Employment	-0.078 [0.092]	-0.082 [0.092]	-0.079 [0.092]	-0.077 [0.092]	-0.079 [0.092]	0.083* [0.043]	0.086** [0.043]	0.085** [0.043]	0.083* [0.043]	0.083* [0.043]
Affiliate	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Method	FE	FE	FE	FE	FE	FE	FE	FE	FE	FE
Number of Obs.	676	676	676	676	676	676	676	676	676	676
R-squared	0.0071	0.0158	0.0075	0.0092	0.0137	0.0127	0.0161	0.0154	0.0136	0.0127

Notes: The dependent variable is the share of procurement from Japanese-owned firms in Thailand or from other firms in Thailand. ***, **, and * show 1%, 5%, and 10% significance, respectively.

Table 4. Impacts on the Share of Imports from Japan

	(I)	(II)	(III)	(IV)	(V)
Damage	-0.008 [0.063]	0.471 [0.303]	-0.004 [0.101]	0.242** [0.101]	0.369 [0.338]
* Dispatch		0.008 [0.095]	-0.011 [0.110]		
* Age		-0.013* [0.007]		-0.018*** [0.006]	
* ln Employment		-0.047 [0.045]			-0.060 [0.049]
ln Employment	-0.013 [0.093]	-0.012 [0.094]	-0.013 [0.094]	-0.014 [0.094]	-0.011 [0.093]
Affiliate	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Method	FE	FE	FE	FE	FE
Number of Obs.	676	676	676	676	676
R-squared	0.0139	0.0232	0.0140	0.0200	0.0201

Notes: The dependent variable is the share of imports from Japan. ***, **, and * show 1%, 5%, and 10% significance, respectively.

Table 5. Impacts on the Share of Imports from ASEAN

	(I)	(II)	(III)	(IV)	(V)
Damage	-0.008	0.052	-0.016	-0.013	0.064
	[0.022]	[0.081]	[0.016]	[0.034]	[0.092]
* Dispatch		0.036	0.020		
		[0.051]	[0.048]		
* Age		0.003		0.000	
		[0.003]		[0.002]	
* ln Employment		-0.018			-0.011
		[0.016]			[0.014]
ln Employment	-0.004	-0.002	-0.003	-0.004	-0.003
	[0.014]	[0.015]	[0.015]	[0.014]	[0.014]
Affiliate	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Method	FE	FE	FE	FE	FE
Number of Obs.	676	676	676	676	676
R-squared	0.0034	0.0066	0.0040	0.0035	0.0048

Notes: The dependent variable is the share of imports from ASEAN. ***, **, and * show 1%, 5%, and 10% significance, respectively.

Table 6. Impacts on the Share of Imports from China

	(I)	(II)	(III)	(IV)	(V)
Damage	0.065 [0.042]	-0.129 [0.131]	0.084 [0.070]	-0.104** [0.042]	-0.043 [0.169]
* Dispatch		-0.040 [0.087]	-0.045 [0.075]		
* Age		0.011** [0.004]		0.012** [0.005]	
* ln Employment		0.01 [0.029]			0.017 [0.028]
ln Employment	-0.018 [0.022]	-0.018 [0.022]	-0.019 [0.022]	-0.017 [0.023]	-0.018 [0.022]
Affiliate	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Method	FE	FE	FE	FE	FE
Number of Obs.	676	676	676	676	676
R-squared	0.0357	0.0552	0.0387	0.0529	0.0389

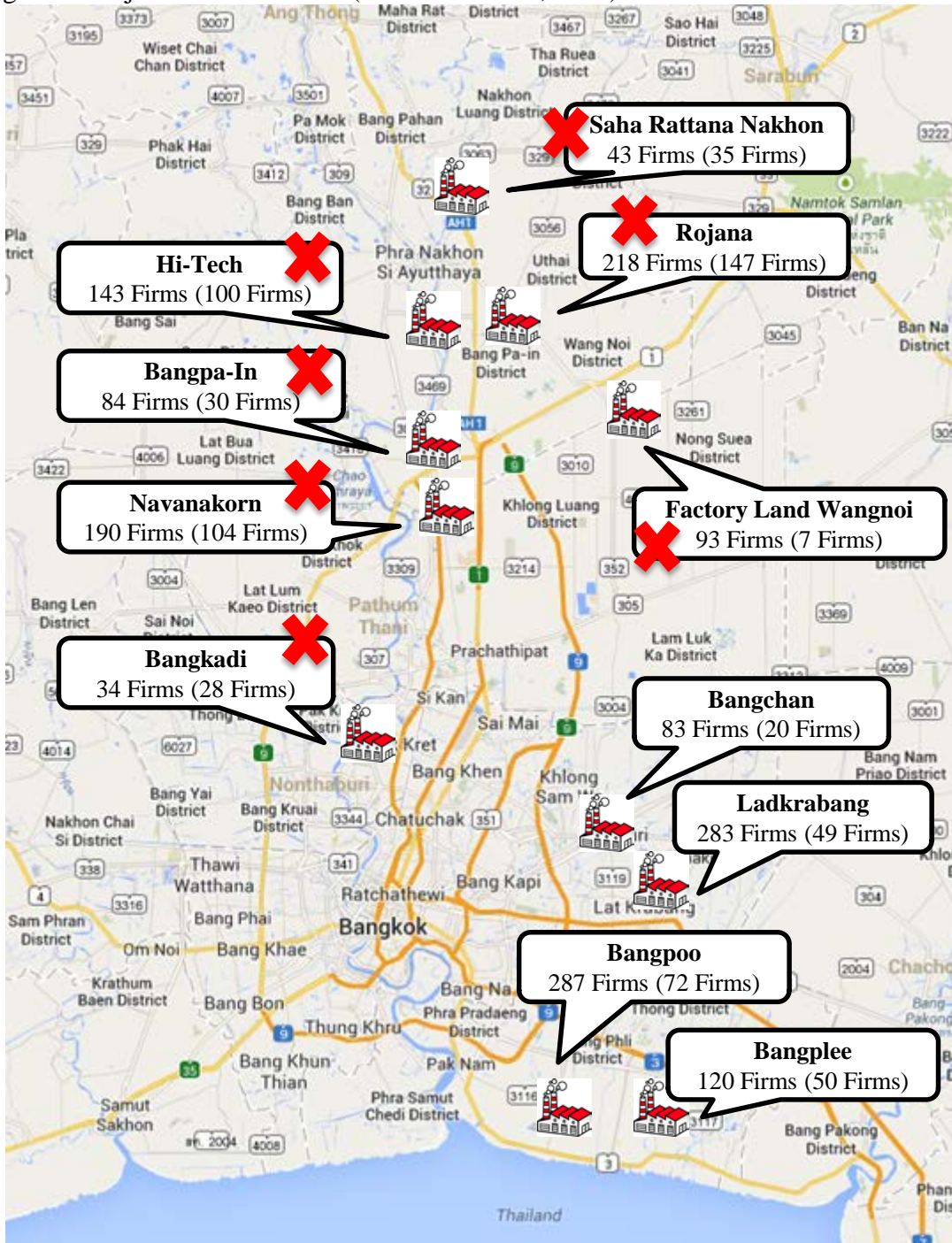
Notes: The dependent variable is the share of imports from China. ***, **, and * show 1%, 5%, and 10% significance, respectively.

Table 7. Impacts on the Share of Imports from Other Countries

	(I)	(II)	(III)	(IV)	(V)
Damage	0.003 [0.013]	0.039 [0.040]	0.005 [0.011]	0.001 [0.020]	0.045 [0.043]
* Dispatch		0.001 [0.024]	-0.005 [0.025]		
* Age		0.001 [0.001]		0.000 [0.001]	
* ln Employment		-0.008 [0.006]			-0.007 [0.007]
ln Employment	0.029 [0.020]	0.030 [0.021]	0.029 [0.021]	0.029 [0.021]	0.029 [0.020]
Affiliate	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Method	FE	FE	FE	FE	FE
Number of Obs.	676	676	676	676	676
R-squared	0.0226	0.0231	0.0227	0.0226	0.0231

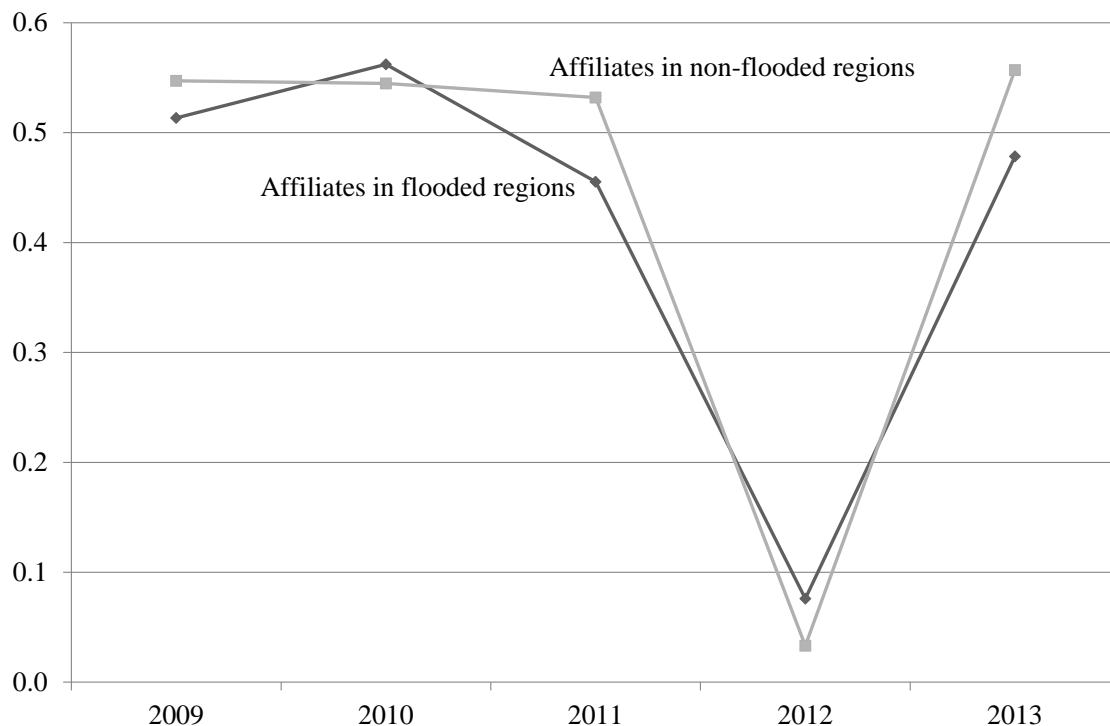
Notes: The dependent variable is the share of the other countries. ***, **, and * show 1%, 5%, and 10% significance, respectively.

Figure 1. Major Industrial Parks (as of November, 2011)



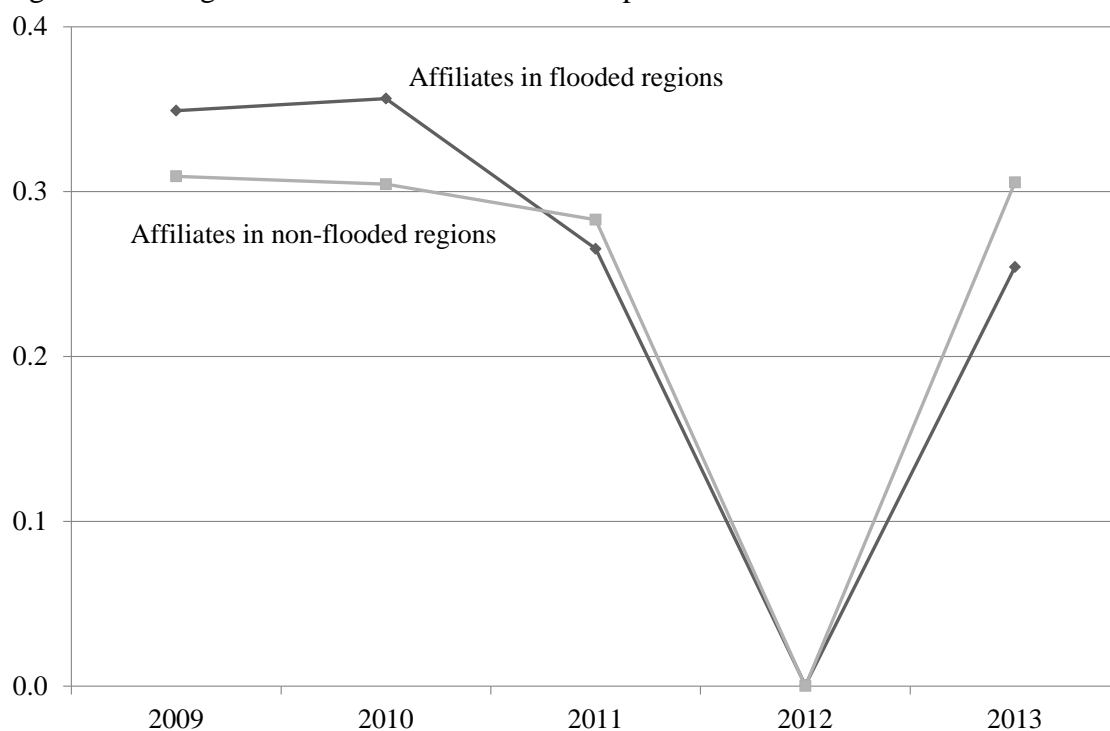
Source: Authors' compilation using the information from JETRO Bangkok and the Google map
 Notes: "X" indicates damages by flooding. The number of all firms in each industrial park is reported. The figure in parentheses is the number of Japanese firms.

Figure 2. Average Local Procurement Share



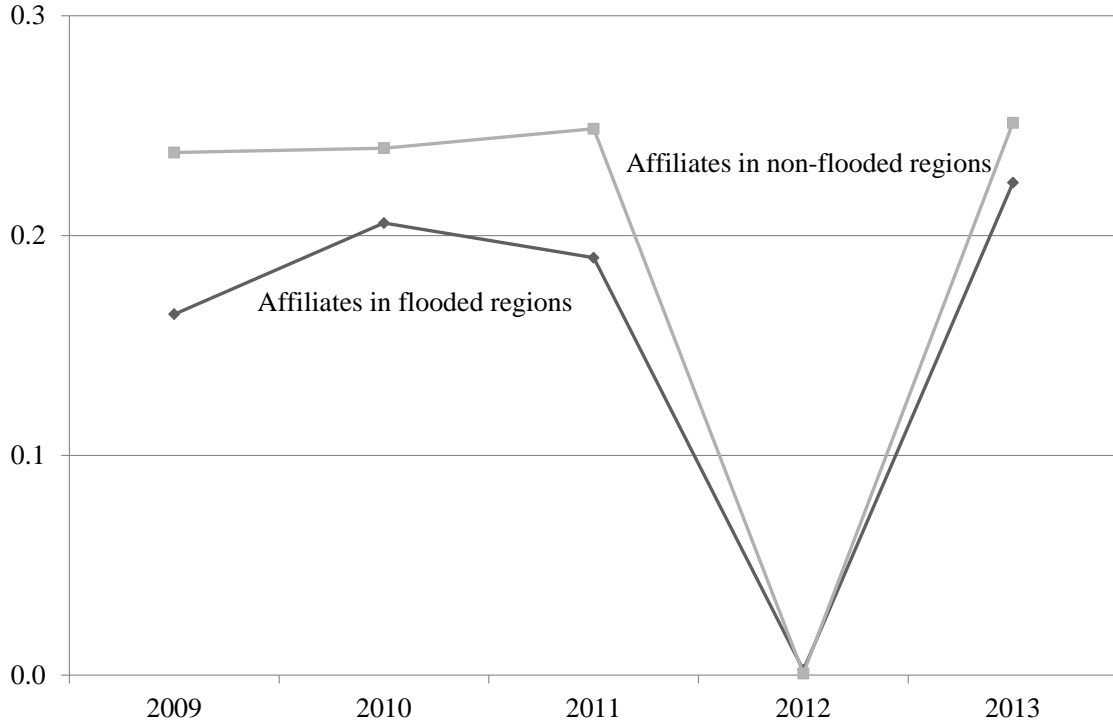
Source: Authors' calculation using "Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania"

Figure 3. Average Share of Procurement from Japanese-owned Firms in Thailand



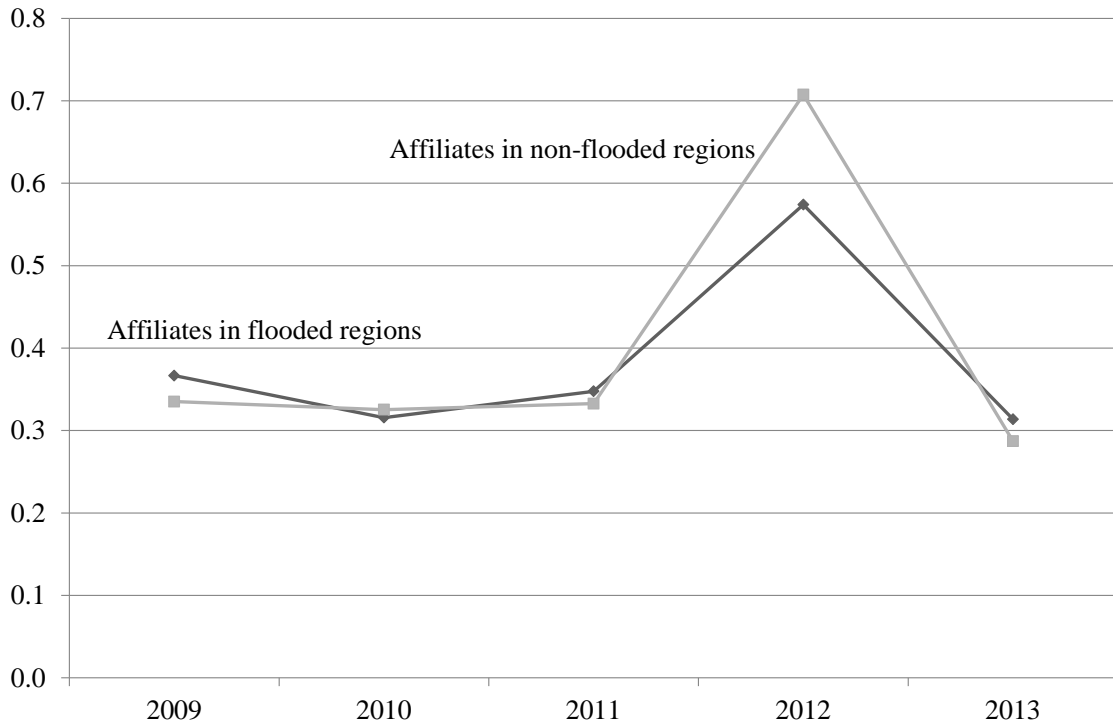
Source: Authors' calculation using "Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania"

Figure 4. Average Share of Procurement from Other Firms in Thailand



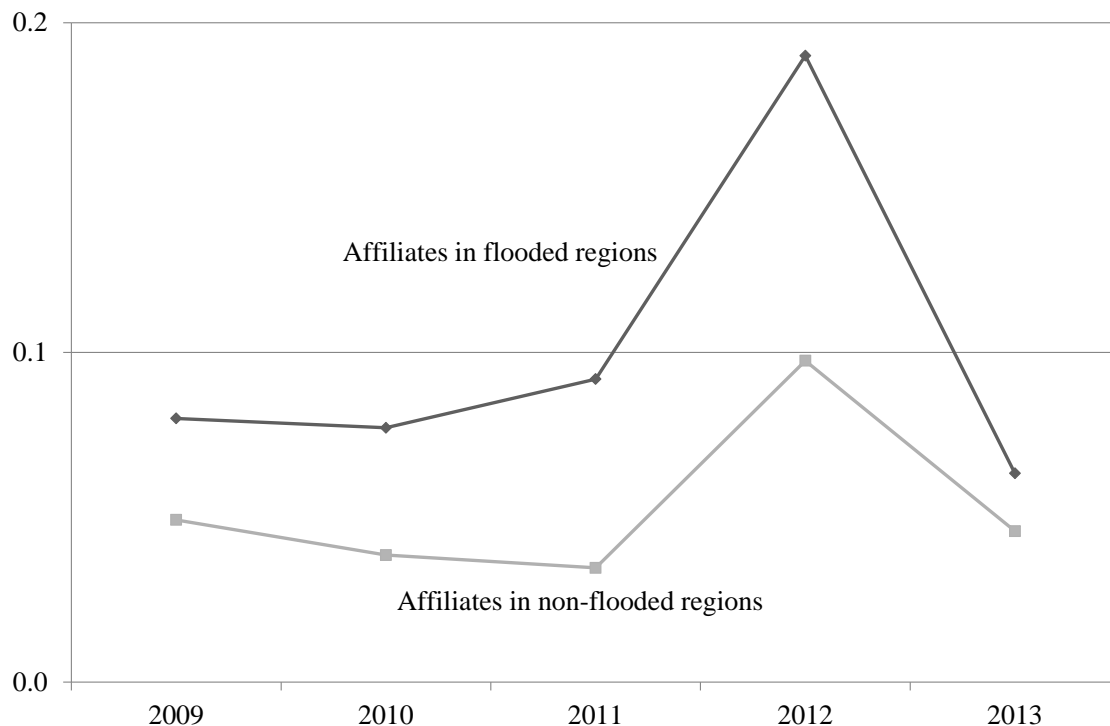
Source: Authors' calculation using "Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania"

Figure 5. Average Share of Imports from Japan



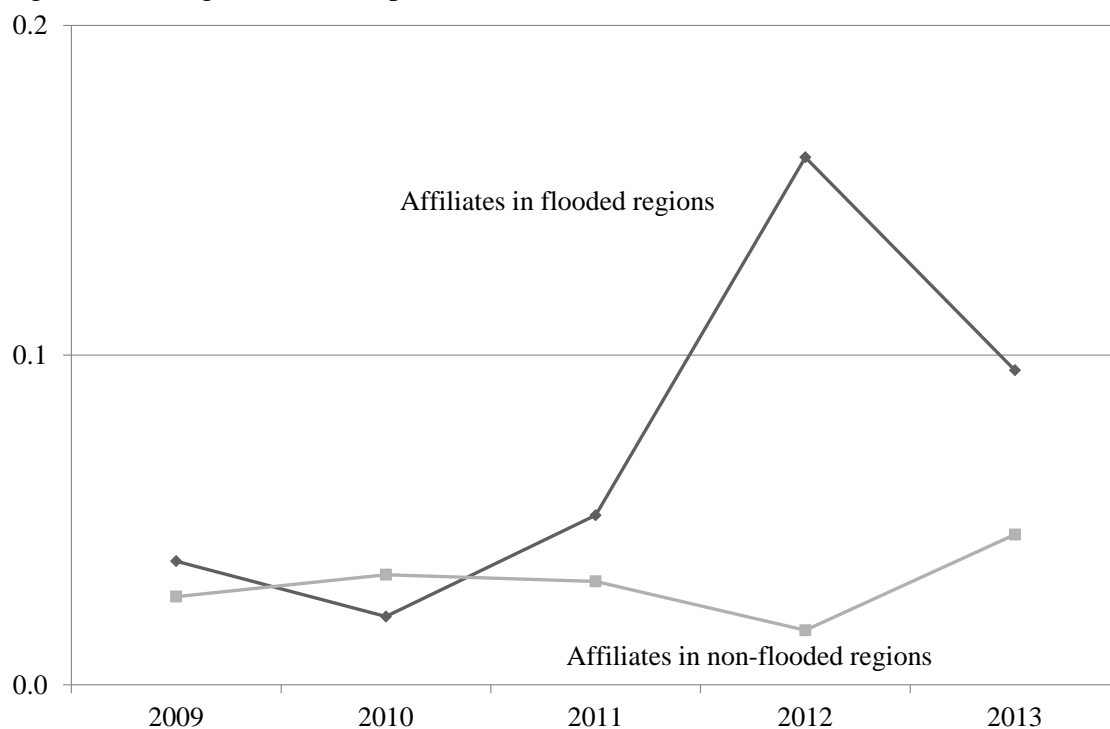
Source: Authors' calculation using "Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania"

Figure 6. Average Share of Imports from ASEAN



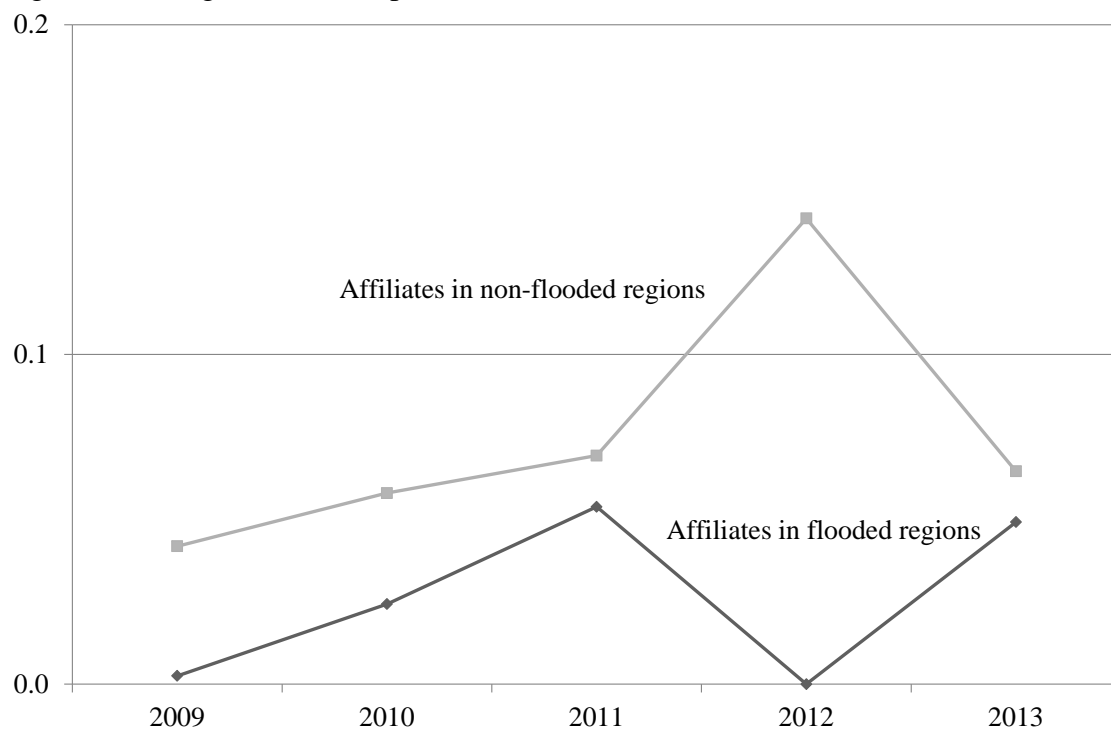
Source: Authors' calculation using "Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania"

Figure 7. Average Share of Imports from China



Source: Authors' calculation using "Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania"

Figure 8. Average Share of Imports from Other Countries



Source: Authors' calculation using "Survey of Japanese-Affiliated Firms in ASEAN, India, and Oceania"

Appendix A. Number of Sample Affiliates in Figures

	Flooded	Non-flooded
2009	12	164
2010	14	215
2011	21	255
2012	5	32
2013	24	308