RIETI Discussion Paper Series 17-E-072

Market Thickness, Input-Output Linkages, and Agglomeration

MIYAUCHI Yuhei
MIT

MIYAKAWA Daisuke
Hitotsubashi University

RIETI
Research Institute of Economy, Trade & Industry, IAA

The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

RIETI Discussion Paper Series 17-E-072

May 2017

Market Thickness, Input-Output Linkages, and Agglomeration*

MIYAUCHI Yuhei
MIT

MIYAKAWA Daisuke
Hitotsubashi University

Abstract

Existing literature documents strong empirical relationships between input-output linkages and geographic concentration of industries. This paper empirically assesses one micro-foundation of this phenomenon: geographic concentration of firms reduces the matching friction of firm-to-firm trade (i.e., thick-market externality). Using a panel of over one million firms in Japan with dynamic supply-chain linkage information, we find that (1) firms have more suppliers and customers in denser areas on average, and (2) when a supplier exits the market for unexpected reasons (identified by the reported reasons of bankruptcy), firms recover alternative suppliers more in thicker supplier markets. These two pieces of evidence suggest the importance of thick-market externality of firm-to-firm trade as a mechanism of agglomeration.

Keywords: Market thickness, Supply chain network, Agglomeration
JEL classification: R12, L14

* Miyauchi: MIT, miyauchi@mit.edu; Miyakawa: Hitotsubashi, dmiyakawa@ics.hit-u.ac.jp. This research is conducted as a part of the Research Institute of Economy, Trade and Industry (RIETI) research project (Study on Corporate Finance and Firm Dynamics). The authors are extremely grateful to Costas Arkolakis, David Atkin, Abhijit Banerjee, Arnaud Costinot, Esther Duflo and Glenn Ellison, Masayuki Morikawa, Hiroshi Ohashi, Iichiro Uesugi, and Makoto Yano for their guidance and suggestions. We thank Katsuhiro Komatsu for his great research assistance. Miyauchi gratefully acknowledges the Nakajima Foundation for their financial support. Miyakawa gratefully acknowledges financial supports from the Grant-in-Aid for Scientific Research No. 16K03736 JSPS, No.25220502 JSPS, and the grant-in-aid from Zengin Foundation for Studies on Economics and Finance.

1 Introduction

Industries are geographically concentrated. Marshall (1890) proposed three mechanisms that explain this pattern: labor market interactions, knowledge spillovers, and input-output linkages. By empirically investigating the industry co-agglomeration patterns in the US, Ellison et al. (2010) conclude that input-output linkages proxied by input-output matrix is particularly important for explaining the pattern among the three. However, there has been no consensus of what kind of *firm*-level mechanisms explains the relationship between input-output linkages and industry concentration.

This paper investigates one mechanism: geographic concentration of firms reduces the matching friction of firm-to-firm transactions (i.e. thick-market externality). Using a panel of over a million firms with dynamic supply-chain linkage information in Japan, we first document that firms have more suppliers and customers in denser locations cross-sectionally. The relationship is robust to controls of industry and employment size.

While this fact is suggestive of the presence of thick-market externality, one may wonder whether such pattern could be simply explained by the selective entry, i.e. more productive firms select into denser locations, and because of the high productivity they can acquire more suppliers and customers. To address this concern, we investigate the impact of an unexpected bankruptcies of suppliers on recovery of alternative suppliers, and whether firms recover more suppliers in thicker supplier market. We identify unexpected bankruptcies by the reported reasons of bankruptcies (accidental reasons, management failure, and spillover from other bankruptcy). To address the concern that firms in denser locations are inherently more solvent to the supplier loss shock and can recover alternative suppliers, we control for the location fixed effects (interacted with supplier bankruptcies) to utilize within-location across-supplier industry variation of supplier thickness (e.g. do firms in Tokyo recover more suppliers if they lose suppliers in thicker supplier market than in less thick market?). We confirm that our results are robust to this specification.

This paper contributes to two strands of literature. First, it contributes to the literature of agglomeration. Although thick-market externality has been extensively studied theoretically (Diamond (1982); Helsley and Strange (1990); Duranton and Puga (2004)), its empirical evidence has been mostly confined to the context of labor market (Bleakley and Lin (2012); Jäger (2016); Macaluso (2016)), and we have very limited evidence in the context of firm-to-firm trade. Second, this paper contributes to the literature of the shock propagation over supply-chain networks (e.g. Acemoglu et al. (2012); Carvalho et al. (2014); Jacobson and von Schedvin (2015); Barrot and Sauvagnat (2016); Magerman et al. (2016)).

The rest of the paper is organized as follows. In Section, 2 we describe our main data source, a panel of over a million of firms with dynamic supply-chain linkage information in Japan. In Section 3, we present our main empirical results suggestive of thick-market externality. Section 4 concludes and discusses future research direction.

2 Data

In this section, we first briefly describe our main dataset for empirical exercise: a panel of over a million Japanese firms with dynamic supply chain linkage information. Next, we provide several descriptive statistics to understand the main features of the data.

2.1 TSR Data

The dataset we use is compiled by a major credit reporting agency, Tokyo Shoko Research (TSR). We obtained the data through the support of Research Institute of Economy, Trade and Industry (RIETI), which is a governmental research institute affiliated with Japanese Ministry of Economy, Trade and Industry. The data is collected by field surveyors of TSR through face-to-face or phone interviews as well as utilizing some public resources such as financial statements, corporate registrations, and public relations documents. In addition to firm-level characteristics, the dataset reports each firm's supplier and customer firms up to 24 firms. Following the conduct of recent papers that utilize the same dataset (e.g. Carvalho et al. (2016); Bernard et al. (2016)), we define the existence of a supplier-customer relationship if at least one party reports that there is a supplier-customer relationship. To avoid the possibility that TSR only collects information of firms' own characteristics but not the supplier-customer relationship, we restrict the sample of firms to be the ones who report at least one supplier or customer.

To analyze the dynamics of firms and supply chain linkages, we utilize three periods of TSR dataset, 2006, 2011 and 2014 and construct firm-level panel data. The firm-level panel is not necessarily balanced. In the case of a firm dissapearing from a previous round, TSR reports the reasons why it happend, which include bankruptcy, closure, suspension, dissolution, merger, unknown, and excluded from the TSR database. In our paper, we define exit of firms if firms disappear from the previous round for the following four reasons: bankruptcy, closure, suspension, and dissolution. In addition, for (most) bankruptcies, the list of reasons, the exact date, and the debt amount are reported. The reasons of bankruptcies are utilized to identify unexpected exits for transaction partners for our main empirical analysis. We overview bankruptcy reasons in Section 2.2.4.

Contrary to the case of firm exits, in most of the cases where a firm is added from the previous round, firm entry into the data set is not driven by new establishment of firms, but rather due to the increased coverage of TSR dataset. This can be confirmed by checking the established years of the newly added firms.

In terms of geographic location of firms, we observe the precise address of the firms at the headquarter level, but not at the establishment level. The fact that we do not observe the establishment-level location of firms may mismeasure the supplier thickness of the location. To resolve the concern, in the main empirical analysis, we show robustness results conditioning on single-establishment firms, whose location should coincide with the headquarter location.

2.2 Preliminary Descriptive Statistics

In this subsection, we provide several descriptive statistics of the data. First, we show the geographic distribution of firms in Japan, which shows remarkable inequality. Second, we show aggregate patterns of dynamic supplier-customer linkages, to document substantial creation and destruction of supplier-customer linkages. Third, we show the distribution of the geographic distance of supplier-customer relationship, which are extremely local. Lastly, we show the list of reasons of bankruptcies and how we make use of this information in our main empirical analysis.

2.2.1 Geographic Distribution of Firms

The data exhibits a remarkable geographic inequality in industry concentration in Japan. Figure 1 shows the distribution of firm density defined at the 0.05 degree grid cells (about 5.5 kilometers). Panel (A) shows the geographic distribution of firm headquarter density at the grid-level. One could recognize that the most

dense areas are greater Tokyo area on the south-east of the graph, followed by Osaka area and Nagoya area. Panel (B) plots the distribution of 0.05 degree grids. The median of grid-level number of firms is 14, and the maximum number of firms in a grid is 21958. Panel (C), in turn, plots the distribution of the number of firms stratified by the grid-level firm density they belong to. Although a majority of grids have only a few firms (in Panel (B)), most firms are located in denser grids. In particular, the median of the number of firms in the local grid is 444, or about 14 firms per 1 square kilometers.[1]

2.2.2 Aggregate Patterns of Supplier-Customer Linkages

In this subsection, we show aggregate patterns of supplier-customer linkages, and show that substantial creation and destruction of supplier-customer relationship exists over the life cycle of firms.

Table 1 documents some cross-sectional and dynamic patterns of firm characteristics and supplier-customer linkages. Panel (A) summarize the cross-sectional feature of the data in the years of 2006, 2011, and 2014. The number of firms increases over time mainly due to the increased coverage of TSR dataset. Firms on average have about 4 to 5 suppliers and customers, and the number is stable across years. There is also large firm-level heterogeneity inferred by the large standard deviation. Sales and employment patterns are higher in 2006 than 2011 and 2014, which is partially driven by the increased coverage of TSR.

Panel (B) documents dynamic transition patterns of firm characteristics and supplier-customer linkages. First, Row (i) of Panel (B) shows the probability of exit of firms. From 2006 to 2011 (for 5 years), 10.4% of firms exited, and from 2011 to 2014 (for 3 years), 5.0% of firms exited.

Row (ii) of Panel (B) documents substantial dynamics of supply-chain linkages. Firms on average lose 0.30 suppliers and 0.40 customers from 2006 to 2011 due to exit of suppliers or customers. At the same time, 1.38 supplier relationships and 2.24 customer relationships are severed with surviving suppliers or customers between 2006 to 2011.[2] Altogether, 1.68 (=0.30+1.38) supplier relationships and 2.64 (=0.40+2.24) customer relationships are lost between 2006 to 2011, which account for 36% (=1.68/4.63) and 56% (=2.64/4.64) of suppliers and customers in 2006. In compensation, surviving firms acquire 2.85 suppliers and 3.17 customers from 2006 to 2011. The described patterns are similar in 2011 to 2014, except that the absolute magnitude of all numbers are smaller given that the time interval is shorter (3 years as opposed to 5 years).

Compared to the dynamics of supply-chain linkages, the location of firms' headquarters are surprisingly stable over time. Row (iii) of Panel (B) reports the probability of headquarter relocation of firms conditional on survival. Very few firms relocate their headquarter locations, i.e. from 2006 to 2011, only 1.4% and 0.8% of firms relocate to outside 0.5 degree grids (roughly 55 kilometers both ways). The number increases if we take smaller geographic unit (0.05 degree grids), but it is still small in magnitude, especially compared to the creation and destruction of supplier-customer relationships.

[1] Given the nature of the data coming from a credit reporting agency, one may worry about the representativeness of TSR data set relative to the population of firms. Figure 4 plots the municipality-level representativeness of TSR data (i.e. number of firms in TSR divided by that in economic census in 2014) against the density of firms (defined by total number of firms in the municipality divided by the area) for three different periods. In all of the three periods, we find some over-representation of firms in TSR dataset in denser locations. One possible way to deal with the differential selection is to weight the observations to make the observable characteristics of firms resemble the distribution of economic census. This point should be investigated in future work.

[2] Due to the nature of TSR data based on interviews, one may wonder whether this is driven by measurement error, i.e. both suppliers and customers forget to mention the relationship. We believe that this is unlikely to be the major case for the following reason. When TSR updates the database by yearly interviews, they typically have the list of suppliers and customers reported in the previous year, and ask whether the relationship is continued. Hence, the "default" option of the interview is the continuation of relationship.

2.2.3 Geographic Proximity of Supplier-Customer Relationships

Supplier-customer relationships are extremely local. Figure 2 shows the cumulative distribution of straight-line distances between suppliers and customers. The median of straight-line distance is about 26.8 km in 2006. This is much smaller than the median of distances of all possible pairs of firms in Japan, which is 464 km (Nakajima et al. (2013); Bernard et al. (2016)). This confirms that firms have strong tendencies to trade locally. It should be also noted that the distribution is stable over years. This is surprising given that there is substantial dynamics of supply-chain linkages over years as reported in Table 1.

2.2.4 Reasons of Bankruptcies

In this subsection, we explain the data of the reasons of bankruptcies. This information will be useful for looking at the impact of unexpected supplier exit and test whether firms recover more suppliers in thicker supplier market.

TSR provides the information of the reasons, exact date, and the debt amount of bankruptcies with debt of over 10 million JPY (roughly equals 110 thousand USD). This covers in reality almost all bankruptcies (39,839 firms out of 41,555 firms who exited due to bankruptcy), which in turn accounts about a third of all exits (defined by the combination of bankruptcy, closure, dissolution, and suspension, which sums up to 126,421 firms).

Table 2 lists up the reasons of bankruptcies with the numbers of bankruptcies in 2006 to 2014. The most frequently cited reasons of bankruptcies are by far the non-performing sales (65.4%), followed by the accumulation of debt (14.1%). These bankruptcies are presumably endogenous to the behavior of customer-side firms and should not be used as a variation to look at the impact of bankruptcies of suppliers. Among the list of reasons, we pick accidental reasons (death, natural disaster etc.; accounting for 615 bankruptcies), management failure (failure of projects; accounting for 1311 firms, and failure outside project; accounting for 232 bankruptcies), and spillover from other bankruptcy (accounting for 2310 bankruptcies), as bankruptcies unexpected to customers. The last category is picked to look at the impact of exit only if customer-side firm has not exited; if the customer firm has not exited, the spillover must be coming from other transaction partners.

Our placebo analysis of looking at the impact of supplier bankruptcies on the outcomes of customer-side firms preceding the bankruptcies strengthens our argument that these bankruptcies are exogenous to customer-side firms; i.e. we find no pretrend of customer-side firms on outcome variables before the supplier goes bankrupt. We report the results in the next section.

3 Reduced-Form Evidence of Thick-Market Externality

In this section, we provide reduced-form evidence of thick-market externality: (1) firms have more suppliers and customers in denser locations, and (2) upon unexpected exits of suppliers, firms recover alternative suppliers more if they lose suppliers in thicker supplier market.

3.1 Do Firms Have More Suppliers and Customers in Denser Locations?

Yes. Figure 3 shows positive relationship between firm headquarter density (measured at 0.05 grid cells) and the number of suppliers and customers per firm. Table 3 shows that the correlation is robust to various controls. In Panel (A), we regress number of suppliers on log firm density for each different year. Column

(1) is the baseline where we just control year FE, which is just a linear fit of Figure 3. To deal with the concern that this pattern is simply driven by differential industrial composition across geography, Column (2) controls for the 4-digit industry FE. The coefficients are still significantly positive, indicating that industry composition does not explain the pattern. Another concern is that firms in denser areas may have more suppliers or customers simply because they are larger. To deal with the concern, in Column (3) we further controls for the FE that represents the employment size in the multiple of 10. Although the coefficients decrease substantially, they are still positively significant. Columns (4) and (5) show that the results are robust by looking at the number of within-grid suppliers and the log of suppliers.

3.2 Do Firms Recover More Suppliers Upon an Exit of a Supplier in Thicker Market?

Although the evidence of previous subsection is suggestive of the presence of thick-market externality, it is subject to many alternative stories. In particular, it can be explained by selective entry of firms into locations, i.e. more productive firms select into denser locations, and simply because of the high productivity they can acquire more suppliers and customers. To address this concern, we investigate the impact of an unexpected bankruptcies of suppliers on recovery of alternative suppliers, and whether firms recover more suppliers in thicker supplier market.

In the following subsections, we first explain the econometric framework to investigate this hypothesis (Section 3.2.1). Next, we show the average impact of supplier exit, instrumented by the unexpected supplier bankruptcies, on the recovery of suppliers (Section 3.2.2). We find that, conditional on survival, firms who lost suppliers gain more new suppliers, and the newly acquired suppliers are concentrated around the firms' location and the exiting supplier's industries. Lastly, we show that firms recover more suppliers upon suppliers' exit in thicker supplier market (Section 3.2.3).

3.2.1 Econometric Framework

The basic idea of looking at the impact of supplier exit is to compare two comparable supplier-side firms, one exited for unexpected reasons and the other not, and look at how their customers changed the supplier linkages before and after the exit of supplier-side firms. To implement this idea, we run the following regression:

$$\frac{1}{CustomerNum_{\omega t}} \sum_{\tilde{\omega}\in\omega\text{'s customer at } t} \Delta Y_{\tilde{\omega}t} = \beta_0 \frac{1}{CustomerNum_{\omega t}} \sum_{\tilde{\omega}\in\omega\text{'s customer at } t} SupplierExit_{\tilde{\omega}t} + \beta_1 X_{\omega t}, \tag{1}$$

where t denotes the period (either 2006 or 2011), ω denotes the supplier-side firm, $\tilde{\omega}$ denotes the customers of firm ω, and $\Delta Y_{\tilde{\omega}t}$ denotes the change of outcome variables of customer-side firm $\tilde{\omega}$ from t to the next period (e.g. number of new suppliers obtained). Note that for the dependent variable, we take an average among all the customers $\tilde{\omega}$ of firm ω at period t ($CustomerNum_{\omega t}$ indicates the number of customers of firm ω at period t). The main regressor of interest is the number of exiting suppliers firm $\tilde{\omega}$ faces, including but not exclusive of the exit of ω. The last term $X_{\omega t}$ controls for the basic characteristics of ω.

This regression has an endogeneity concern of supplier's exit (of firm ω or any othe exits of other suppliers of customer-side firms $\tilde{\omega}$). For example, supplier's exit may have occurred because a customer-side firm $\tilde{\omega}$ switched to a different supplier and this lead to the exit of supplier-side firm ω. To deal with such a concern, we instrument whether ω exited for unexpected reasons. In the 2SLS framework, the first stage is specified

by

$$\frac{1}{CustomerNum_{\omega t}} \sum_{\tilde{\omega}\in\omega\text{'s customer at } t} SupplierExit_{\tilde{\omega}t} = \alpha_0 UnexpectedBankruptcy_{\omega t}. \tag{2}$$

In addition to looking at the contemporaneous impact of supplier exit from t to $t+1$ on the outcomes from t to $t+1$, using the panel nature of our data, we also investigate the pretrend preceding to the supplier exit (impact on outcomes between $t-1$ and t) and long-term effect (impact on outcomes between $t+1$ and $t+2$). The former is useful for checking whether the exits of suppliers are truely unexpected, and the latter is useful for understanding how quickly the response to supplier exit occurs. More concretely, since we have three time periods (2006, 2011, 2014), we can look at the pretrend by the impact of supplier exit from 2011 to 2014 on the outcomes between 2006 and 2011, as well as the long-term impact of supplier exit from 2006 to 2011 on the outcomes between 2011 to 2014.

To investigate whether supplier thickness matters for recovery of suppliers, we construct the measure of supplier thickness and look at the heterogeneous impact of supplier exit. We define "thick" market in the following way: for each 2-digit industry, we order all the 0.5 degree grids (there are 280 grids in Japan) in the descending order of number of firms in the grid. Then, we pick grids from the top until the cumulative sum of the number of firms reaches a half of the number of firms in the 2-digit industry in Japan, and we label the picked grids as "thick" market. With this definition, we run the following regression:

$$\begin{aligned} & \frac{1}{CustomerNum_{\omega t}} \sum_{\tilde{\omega}\in\omega\text{'s customer at } t} \Delta Y_{\tilde{\omega}t} \\ = \; & \beta_0 \frac{1}{CustomerNum_{\omega t}} \sum_{\tilde{\omega}\in\omega\text{'s customer at } t} SupplierExit_{\tilde{\omega}t} \\ & + \beta_1 \frac{1}{CustomerNum_{\omega t}} \sum_{\tilde{\omega}\in\omega\text{'s customer at } t} SupplierExit_{\tilde{\omega}t} \times Thickness_{\omega t} + \beta_2 X_{\omega t}, \end{aligned} \tag{3}$$

where $Thickness_{\omega t}$ is a dummy variable that takes 1 if firm ω's location is thick in firm ω's 2-digit industry. We again instrument by $UnexpectedBankruptcy_{\omega t}$, as well as its interaction with $Thickness_{\omega t}$. In addition to the baseline specification above, in some specifications we include $UnexpectedBankruptcy_{\omega t}$ interacted with other fixed effects (location, industry, employment size). In these specification, β_0 is not identified as it is absorbed by the fixed effects, and we simply report β_1.

Several comments are followed. First, since our time interval are not equal (5 years from 2006 to 2011 and 3 years from 2011 to 2014), we normalize all the outcome variables by dividing by the years of the interval. Second, when we define the customers of firm ω, we restrict the customer firm $\tilde{\omega}$ within the same 0.5 grid cells. This helps the interpretation of heterogeneous effect, as supplier thickness of the location of firm ω may not necessarily matter if customer-side firm $\tilde{\omega}$ are in a different location from ω. Third, to construct the dependent variable, we only take customer-side firms $\tilde{\omega}$ who survive until the next period, as most outcome variables cannot be defined if they exit.

Fourth, to construct the dependent variable of the regression, we implicitly count the same firms multiple times if customer-side firm $\tilde{\omega}$ sources from multiple suppliers. More importantly, we over-count customer-side firms $\tilde{\omega}$ with more suppliers. To avoid over-sampling of firms with extremely large number of suppliers, we

omit firms whose number of suppliers are top 5 percentile when constructing outcome variables.[3]

3.2.2 Average Impact of Supplier Exit

Table 4 reports the main regression of the average impact of supplier exit following the specification of regression equation (1) and (2) in Section 3.2.3. The two panels report the impact of supplier exit in different time interval; between 2011 to 2014 for Panel (A) and between 2006 and 2011 for Panel (B). In both panels, we stuck the outcome variables of two different periods (2006 to 2011, 2011 to 2014), and regress the outcome variables on the average supplier exit between 2011 to 2014 (for the case of Panel (A)) interacted with the dummies indicating two periods. In all regressions, we control for the 0.5 degree grid FE, 4-digit industry FE, FE of the baseline solvency score of firm ω, FE of the baseline average number of suppliers of customers of firm ω (in a multiple of 1), all interacted with period dummy (for 2006 to 2011, 2011 to 2014).[4] For example, the first row of Panel (A), "Unexpected Supplier Bankruptcy in 11-14 X 06-11," indicates the impact of unexpected bankruptcy of firm ω in 2011 to 2014 on the outcomes in 2006 to 2011.

Column (1) of Panel (A) shows the first-stage of the regression. Unexpected supplier exit of firm ω in between 2011 to 2014 increases the supplier exit that firm ω's customers faces from 2011 to 2014 almost 1 to 1, while it has no impact on exit from 2006 to 2011 with precise 0 (placebo).

The rest of the columns of Panel (A) investigate the impact of the exit of supplier-side firms ω, instrumented by the unexpected supplier bankruptcy between 2011 to 2014. Column (2) reports the impact on number of new suppliers. Exit of a supplier in between 2011 and 2014 leads to acquisition of 0.046 new suppliers per year in the same period, while there is no per-trend for the number of new suppliers preceeding to 2011. This acquisition of new suppliers is concentrated within the customer-side firms' close proximity and the industry of the exiting supplier. Column (3) shows that out of 0.046 newly acquired suppliers, 0.036 of them are within the same 0.5 degree grid as the customer-side firms (roughly 55 squared kilometer). Considering that there are 280 grids in Japan, the finding suggests that firms recover lost suppliers mostly within their proximity. This is in line with the cross-sectional pattern of linkages as shown in Figure 2. Column (4) in turn shows that 0.026 new suppliers are acquired within the same 2-digit industry as exiting supplier-side firm ω. This suggests that firms primarily find an alternative supplier to replace the lost one. Lastly, Column (5) in turn shows that impact on the number of supplier relationship conditional on those other suppliers are still alive. The coefficient implies that the supplier exit leads to 0.05 less severance with other surviving suppliers.

Panel (B) in turn reports the result of the supplier exit from 2006 to 2011. In this case, instead of not being able to look at the pre-trend, we look at the long-term effect on the outcomes between 2011 to 2014. We find qualitatively and quantitatively similar results of the contemporaneous impact (on outcomes between 2006 to 2011) as Panel (A). For the long-term impact, we find smaller but still positive effect, indicating that recovery of suppliers may take time.

3.2.3 Heterogeneous Impacts of Supplier Exit

Table 5 reports the heterogeneous impacts of supplier recovery instrumented by unexpected bankruptcies. The specification follows regression equation (3) in Section 3.2.3. In this section, we focus on the outcome

[3]The top 5 percentile of number of suppliers corresponds to10 in 2006 and 12 in 2011 and 2014. It is, of course, an ad-hoc correction of the weighting problem, because there is still a variation of number of suppliers in the remaining firms. We leave the task of solving this problem properly for future work.

[4]This, effectively, is the same as running the regression of outcome variables between 2006 and 2011 and 2011 and 2014 separately.

variable of the number of new suppliers.

Column (1) of Table 5 shows that, while the impact of supplier exit has almost no impact for less thick market (third row), firms who are in thicker supplier market acquire 0.093 more suppliers upon supplier exit relative to less thick market (fourth row). Furthermore, these results are not entirely driven by the differential pretrend of thick and not thick markets (first and second row).

The rest of the columns show robustness to various controls. One concern of Column (1) is that firms in denser areas (e.g. Tokyo) are just solvent to a loss of supplier and good at finding alternative suppliers in nature. To deal with this concern, in Column (2), we control for the 0.5 degree grid times unexpected bankruptcy FE, to make sure that the heterogeneous effects uses only the within-location variation (i.e. do firms in Tokyo regain more suppliers if they lose a supplier in a thick supplier industry versus less thick supplier industry?). Although the point estimates become noisier, we still find positive effect of supplier thickness. The results are robust to controlling for supplier industry times unexpected bankruptcy FE (Column (3)) and employment size times unexpected bankruptcy FE (Column (4)). These results suggest that more recovery of suppliers in thicker market is not explained by the supplier industry composition or the fact that firms who have suppliers in thick market are larger. Lastly, in Column (5), we restrict samples of supplier-side firms ω to be single-establishment firms. This solves the concern that our proxy of firm location by firm's headquarter may not be accurate. We confirm that our results are not driven by multi-establishment firms.

The results of the impact of supplier exit from 2006 to 2011 (Panel (B)) show similar pattern for the contemporaneous effect (for the outcomes from 2006 to 2011), albeit the magnitudes are smaller. For the long-term effect, once we control for 0.5 Degree Grid times Supplier Exit FE (in Column (2)), we find that firms gain less suppliers in thick market (fourth row) in between 2011 and 2014. One possible explanation for this is that firms who lose suppliers in thick market recover suppliers instantly (which reflects the positive instantaneous impact), and firms who lose suppliers in less thick market recover much later.

4 Conclusion and Future Work

This paper empirically investigates the thick-market externality of input-output linkages, i.e. geographic concentration of firms reduces the matching friction of firm-to-firm trade. Using a panel of over a million firms in Japan with dynamic supply-chain linkage information, we document that (1) firms have more suppliers and customers in denser areas, and (2) upon an unexpected exit of a supplier, firms recover alternative suppliers more in thicker supplier market. These two pieces of evidence suggest the potential importance of thick-market externality of firm-to-firm transactions as a mechanism of agglomeration.

Given the reduced-form empirical evidence, an important remaining question is to understand how much the thick-market externality can explain the observed industry concentration. Answering this question requires a quantitative model of firm entry and firm-to-firm trade. In an ongoing work, we are building and estimating a model where we incorporate dynamic firm-to-firm search and matching on Melitz (2003). The model allows us to quantify the importance of thick-market externality by asking what the equilibrium geographic industry concentration in Japan would look like if the thick-market externality were absent.

References

Acemoglu, D., V. M. Carvalho, A. Ozdaglar, and A. Tahbaz-Salehi (2012): "The Network Origins of Aggregate Fluctuations," *Econometrica*, 80, 1977–2016.

Barrot, J. N. and J. Sauvagnat (2016): "Input specificity and the propagation of idiosyncratic shocks in production networks," *Quarterly Journal of Economics*, 131, 1543–1592.

Bernard, A. B., A. Moxnes, and K. Helene Ulltveit-Moe (2016): "Two-sided Heterogeneity and Trade," *Working Paper 20136 , National Bureau of Economic Research*.

Bleakley, H. and J. Lin (2012): "Thick-market effects and churning in the labor market: Evidence from US cities," *Journal of Urban Economics*, 72, 87–103.

Carvalho, V. M., M. Nirei, and Y. Saito (2014): "Supply Chain Disruptions: Evidence from the Great East Japan Earthquake," *Discussion papers*.

Carvalho, V. M., M. Nirei, Y. U. Saito, and A. Tahbaz-Salehi (2016): "Supply Chain Disruptions: Evidence from the Great East Japan Earthquake," *NBER Working Paper*.

Diamond, P. A. (1982): "Aggregate Demand Management in Search Equilibrium," *Journal of Political Economy*, 90, 881–894.

Duranton, G. and D. Puga (2004): "Chapter 48 Micro-foundations of urban agglomeration economies," in *Handbook of Regional and Urban Economics*, Elsevier Inc., vol. 4, 2063–2117.

Ellison, G., E. L. Glaeser, and W. R. Kerr (2010): "What Causes Industry Agglomeration? Evidence from Coagglomeration Patterns," *American Economic Review*, 100, 1195–1213.

Helsley, R. W. and W. C. Strange (1990): "Matching and agglomeration economies in a system of cities," *Regional Science and Urban Economics*, 20, 189–212.

Jacobson, T. and E. von Schedvin (2015): "Trade Credit and the Propagation of Corporate Failure: An Empirical Analysis," *Econometrica*, 83, 1315–1371.

Jäger, S. (2016): "How Substitutable Are Workers? Evidence from Worker Deaths," *mimeo*.

Macaluso, C. (2016): "Skill remoteness and post-layoff labor market outcomes," *mimeo*.

Magerman, G., K. D. Bruyne, E. Dhyne, and J. V. Hove (2016): "Heterogeneous Firms and the Micro Origins of Aggregate," *mimeo*.

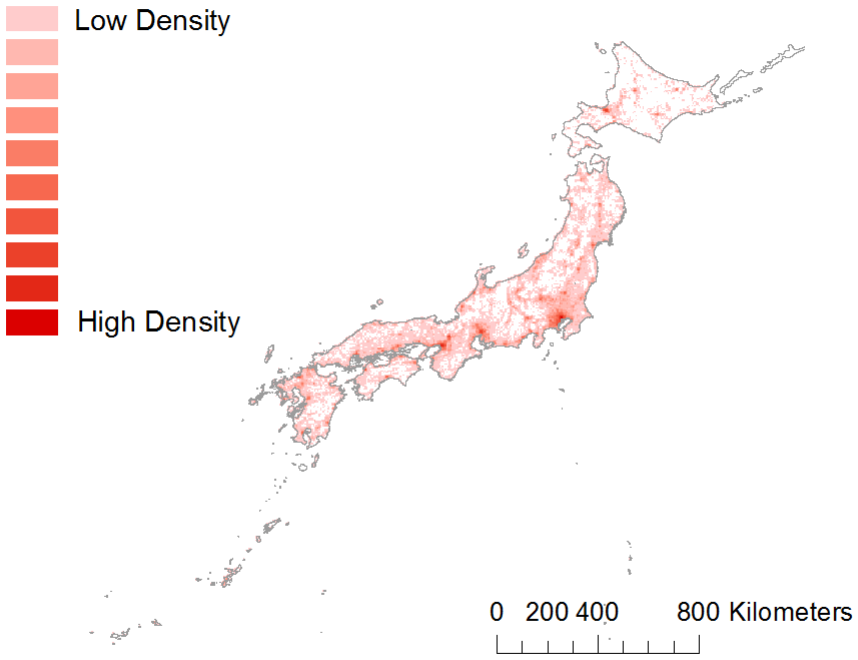
Marshall, A. (1890): *Principles of Economics*, London: MacMillan.

Melitz, M. J. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71, 1695–1725.

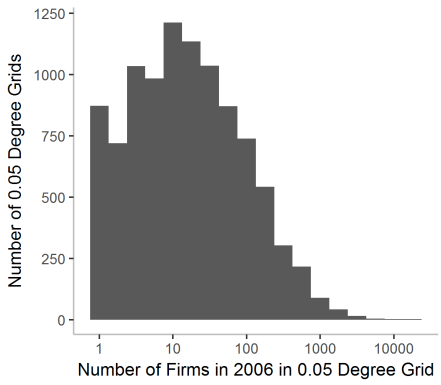
Nakajima, K., Y. Saito, and I. Uesugi (2013): "Role of Inter-firm Transactions on Industrial Agglomeration : Evidence from Japanese firm-level data," *RIETI Discussion Paper Series 13-E-021*.

Figure 1: Geographic Distribution of Firm Headquarters in Japan

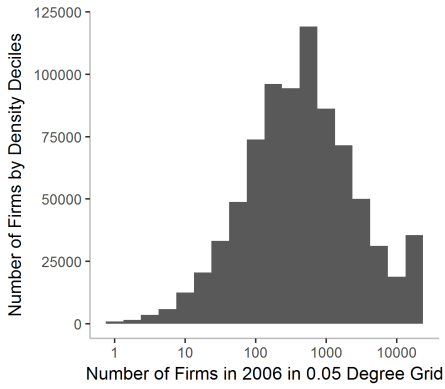
(A) Geographic Distribution of Firm Density in 2006



(B) Distribution of Grids by Number of Firms

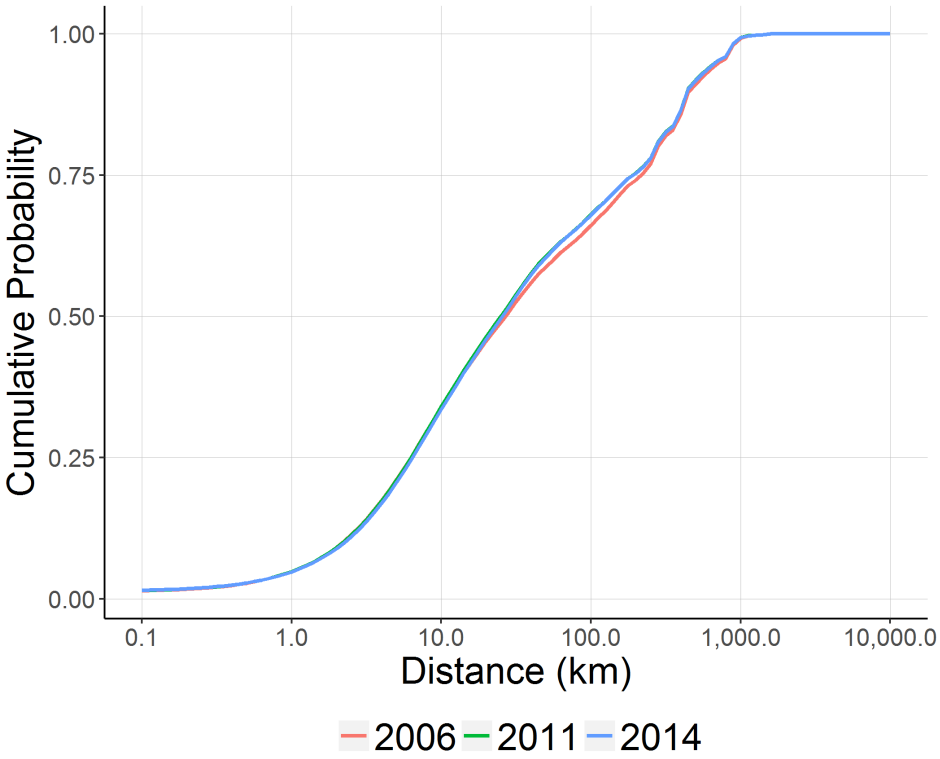


(C) Distribution of Firms Stratified by Grid Density



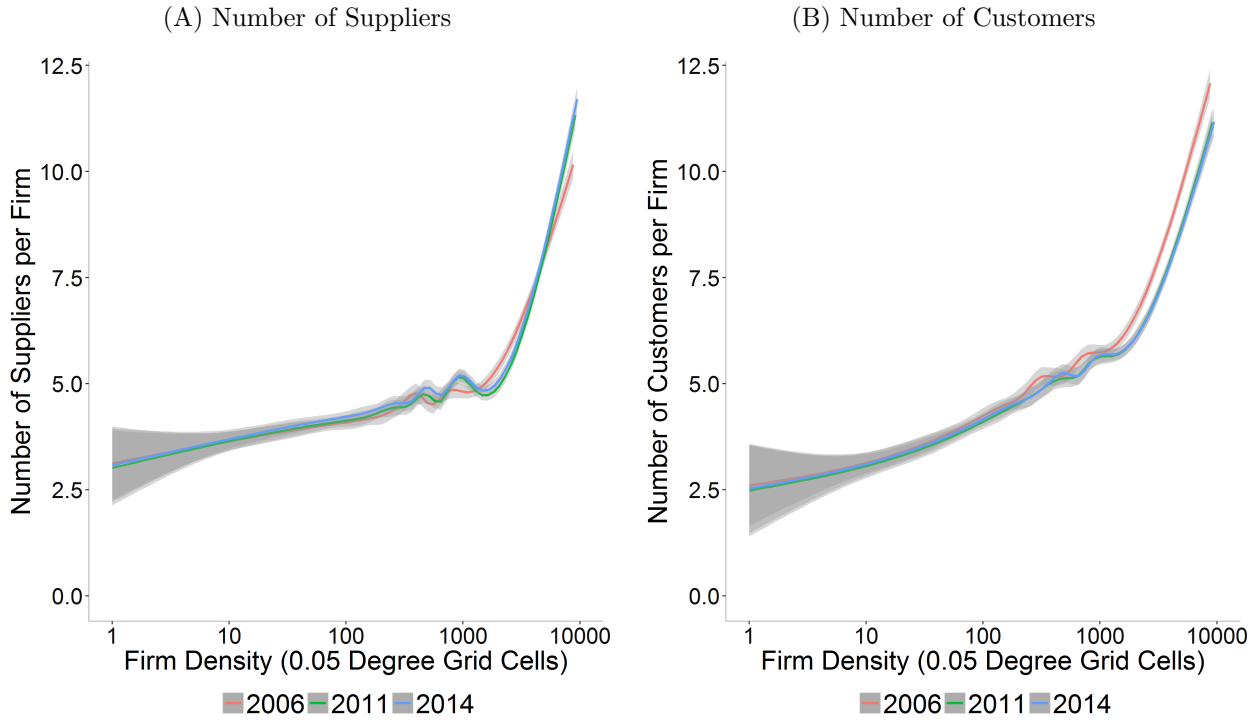
Note: Firm density is calculated as the number of firm headquarters at each 0.05 degree grid cells (roughly 5.5 km). The number of grids in 2006 with positive number of firms in Japan are 9824. The median of number of firms in each grid is 14, and the maximum number of firms in the grid is 21958 as of 2006.

Figure 2: CDF of Geodesic Distance of Supplier-Customer Linkages



Note: Median of geodesic distance supplier-customer relationships in 2006 is 26.8 km.

Figure 3: Relationship between Number of Suppliers and Customers over Firm Density



Note: Firm density is measured by the number of firm headquarters in the same 0.05 degree grids.

Table 1: Aggregate Descriptive Statistics

(A) Cross-sectional Statistics on Firm Characteristics and Supplier-Customer Linkages

	years		
	2006	2011	2014
Number of Firms	695,418	1,030,965	1,095,617
Number of Suppliers	4.63	4.48	4.50
	(29.54)	(29.74)	(29.87)
Number of Customers	4.64	4.73	4.75
	(27.19)	(32.11)	(32.87)
log10 Sales	5.274	5.084	5.059
	(0.719)	(0.720)	(0.729)
Employment	33.12	26.42	25.63
	(437.89)	(329.38)	(359.68)

(B) Dynamic Transition of Firm Characteristics and Supplier-Customer Linkages

	years	
	2006 to 11	2011 to 14
(i) Probability of Exit	10.4%	5.0%
(ii) Change of Supply-Chain Linkage		
Number of Supplier Exit	0.30	0.15
	(2.73)	(1.35)
Number of Customer Exit	0.40	0.18
	(2.88)	(1.56)
Number of Severed Relationships with Surviving Suppliers	1.38	0.74
	(8.02)	(5.58)
Number of Severed Relationships with Surviving Customers	2.24	1.19
	(10.94)	(5.96)
Number of New Suppliers	2.85	1.50
	(20.50)	(9.93)
Number of New Customers	3.17	1.62
	(29.20)	(11.04)
(iii) Probabilit of Relocation of Firms		
Outside 0.5 Grid Cells	1.4%	0.8%
Outside 0.05 Grid Cells	6.3%	3.7%

Note: Standard deviation in parentheses.

Table 2: Reasons of Bankruptcies

Reasons of Bankruptcies	Number of Bankrupcies 2006-14	Percentage
accidental reansons (death, natural disaster)*	615	1.5%
management failure		
failure of projects*	1,311	3.3%
failure outside projects*	232	0.6%
spillover from other bankruptcy*	2,310	5.8%
insufficient capital		
lack of working capital	2,075	5.2%
increase of interest rate burden	394	1.0%
deterioration of credit situation	322	0.8%
overinvestment in capital	438	1.1%
issuance of accomodation debt	155	0.4%
accumulation of debt	5,614	14.1%
non-performing sales	26,073	65.4%
difficulty in collecting account receivable	249	0.6%
over-accumulation of inventory	51	0.1%
Total	39,839	100.0%

Note: The data is based on bankruptcies with debt of over 10 million JPY (39,839 firms out of 41,555 firms who exited due to bankruptcy). * are the reasons of bankruptcies that we identify as "unexpected to customers" and used in the empirical analysis.

Table 3: Regressions of Number of Suppliers and Customers per Firm on Firm Density

(A) Number of Suppliers

	Dependent variable:				
	Suppliers			Same-Grid Suppliers	log(Suppliers)
	(1)	(2)	(3)	(4)	(5)
log Firm Density X 2006	1.889***	2.290***	0.230***	0.237***	0.006***
	(0.049)	(0.054)	(0.018)	(0.003)	(0.001)
log Firm Density X 2011	1.855***	2.179***	0.259***	0.193***	0.005***
	(0.040)	(0.045)	(0.015)	(0.002)	(0.001)
log Firm Density X 2014	1.921***	2.241***	0.279***	0.184***	0.008***
	(0.040)	(0.044)	(0.015)	(0.002)	(0.001)
Year FE	X	X	X	X	X
Year X Industry FE		X	X	X	X
Year X Employment Size FE			X	X	X
Observations	2,659,116	2,659,115	2,630,666	2,630,666	2,190,735
Adjusted R^2	0.002	0.028	0.895	0.583	0.385

(B) Number of Customers

	Dependent variable:				
	Customers			Same-Grid Customers	log(Customers)
	(1)	(2)	(3)	(4)	(5)
log Firm Density X 2006	2.570***	2.270***	0.546***	0.208***	0.030***
	(0.050)	(0.056)	(0.034)	(0.003)	(0.001)
log Firm Density X 2011	2.480***	2.202***	0.609***	0.187***	0.032***
	(0.042)	(0.046)	(0.028)	(0.002)	(0.001)
log Firm Density X 2014	2.518***	2.236***	0.608***	0.184***	0.034***
	(0.041)	(0.045)	(0.028)	(0.002)	(0.001)
Year FE	X	X	X	X	X
Year X Industry FE		X	X	X	X
Year X Employment Size FE			X	X	X
Observations	2,659,116	2,659,115	2,630,666	2,630,666	1,993,189
Adjusted R^2	0.004	0.033	0.649	0.314	0.338

Note: Firm density is measured by the number of firm headquarters in the same 0.05 degree grids. Same-grid suppliers (customers) indicate the number of firms' suppliers (customers) within the same 0.05 degree grids. Industry is measured at the 4-digit level JSIC code. Employment Size FE controls for the strata of employment in a multiple of 10. *: p<0.1; **: p<0.05; ***: p<0.01.

Table 4: Impact of Supplier Exit on Supplier Recovery

(A) Treatment: Supplier Exit between 2011 and 2014

	Dependent variable:				
	Total Supplier Exit	New Suppliers	New Suppliers (Same Grid)	New Suppliers (Same 2-digit Industry)	Severed Suppliers
	OLS	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)
Unexpected Supplier Bankruptcy in 11-14 X 06-11	−0.022				
	(0.030)				
Unexpected Supplier Bankruptcy in 11-14 X 11-14	1.007***				
	(0.020)				
Total Supplier Exit in 11-14 X 06-11		0.008	0.004	0.008	0.019
		(0.021)	(0.016)	(0.010)	(0.016)
Total Supplier Exit in 11-14 X 11-14		0.046**	0.036**	0.026**	−0.050***
		(0.021)	(0.016)	(0.010)	(0.016)
Observations	386,419	376,914	376,914	376,914	376,914
Adjusted R^2	0.084	0.311	0.269	0.222	0.288

(B) Treatment: Supplier Exit between 2006 and 2011

	Dependent variable:				
	Total Supplier Exit	New Suppliers	New Suppliers (Same Grid)	New Suppliers (Same 2-digit Industry)	Severed Suppliers
	OLS	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)
Unexpected Supplier Bankruptcy in 06-11 X 06-11	0.917***				
	(0.022)				
Unexpected Supplier Bankruptcy in 06-11 X 11-14	−0.003				
	(0.014)				
Total Supplier Exit in 06-11 X 06-11		0.044***	0.027**	0.028***	−0.078***
		(0.016)	(0.012)	(0.007)	(0.012)
Total Supplier Exit in 06-11 X 11-14		0.032*	0.020	0.015*	−0.017
		(0.017)	(0.013)	(0.008)	(0.013)
Observations	395,423	395,423	395,423	395,423	395,423
Adjusted R^2	0.090	0.112	0.105	0.084	0.218

Note: In all regressions, we control for the 0.5 degree grid FE, 4-digit industry FE, FE of the baseline solvency score of firm ω, FE of the baseline average number of suppliers of customers of firm ω (in a multiple of 1), all interacted with period dummy. See Section 3.2.2 for the precise specification. *: p<0.1; **: p<0.05; ***: p<0.01.

Table 5: Heterogeneous Impact of Supplier Exit by Supplier Thickness

(A) Treatment: Supplier Exit between 2011 and 2014

	Dependent variable:				
	New Suppliers				
	IV	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)
Total Supplier Exit in 11-14 X 06-11	−0.011				−0.010
	(0.028)				(0.032)
Total Supplier Exit in 11-14 X 06-11 X Thick Supplier Market	0.041	0.081	0.098	0.087	0.017
	(0.042)	(0.081)	(0.105)	(0.112)	(0.047)
Total Supplier Exit in 11-14 X 11-14	−0.001				−0.002
	(0.028)				(0.032)
Total Supplier Exit in 11-14 X 11-14 X Thick Supplier Market	0.093**	0.158*	0.214**	0.242**	0.092*
	(0.042)	(0.081)	(0.105)	(0.112)	(0.047)
Sample					Single Est Suppliers
0.5 Degree Grid X Unexpected Supplier Bankruptcy FE		X	X	X	
Suppliers 2-digit Industry X Unexpected Supplier Bankruptcy FE			X	X	
Employment Size X Unexpected Supplier Bankruptcy FE				X	
Observations	376,902	376,902	376,902	375,518	244,426
Adjusted R^2	0.312	0.308	0.304	0.302	0.307

(B) Treatment: Supplier Exit between 2006 and 2011

	Dependent variable:				
	New Suppliers				
	IV	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)
Total Supplier Exit in 06-11 X 06-11	0.041**				
	(0.019)				
Total Supplier Exit in 06-11 X 06-11 X Thick Supplier Market	0.022	0.038	0.080	0.068	0.072
	(0.026)	(0.044)	(0.049)	(0.050)	(0.064)
Total Supplier Exit in 06-11 X 11-14	0.015				
	(0.019)				
Total Supplier Exit in 06-11 X 11-14 X Thick Supplier Market	0.014	−0.077*	−0.047	−0.056	−0.080
	(0.027)	(0.046)	(0.051)	(0.052)	(0.067)
Sample					Single Est Suppliers
0.5 Degree Grid X Unexpected Supplier Bankruptcy FE		X	X	X	
Suppliers 2-digit Industry X Unexpected Supplier Bankruptcy FE			X	X	
Employment Size X Unexpected Supplier Bankruptcy FE				X	
Observations	403,274	403,274	395,423	394,706	224,524
Adjusted R^2	0.113	0.108	0.110	0.109	0.106

Note: In all regressions, we control for the 0.5 degree grid FE, 4-digit industry FE, FE of the baseline solvency score of firm ω, FE of the baseline average number of suppliers of customers of firm ω (in a multiple of 1), all interacted with period dummy. See Section 3.2.3 for the precise specification. *: p<0.1; **: p<0.05; ***: p<0.01.

A Additional Tables and Figures

Figure 4: Representativeness of TSR data