Offshoring, Relationship-Specificity, and Domestic Production Networks*

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Abstract

An economy is an interlinked web of production units. This paper examines both theoretically and empirically how firms' offshoring decisions lead to reorganization of domestic production networks. We build a buyer-seller model that features supplier heterogeneity in efficiency and distance, as well as intermediate inputs that vary in the degree of specificity to the relationship with the buyer. Sourcing inputs from more regions requires additional up-front fixed costs, but reduces variable costs due to the use of more efficient suppliers. More productive buyers source inputs from a larger range of domestic regions, especially for generic inputs. Inputs that are more relationship-specific are more likely to be insourced and less likely to be outsourced from distant regions or foreign countries. A drop in offshoring costs will induce the more productive buyers to replace some of the less efficient domestic suppliers with foreign suppliers, with generic input suppliers more likely to be dropped despite their higher productivity. The resulting reduction in input costs will induce buyers to expand the geographic scope of domestic outsourcing. Using unique and exhaustive data on the buyer-seller network in Japan, we find evidence supporting the main predictions of the model.

Key Words: Production Networks; Offshoring; Relationship Specificity

JEL classification: F10, F14, L14

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1 Introduction

There is ample evidence about the micro and macro economic effects of foreign outsourcing.[1] Recent research has turned to micro-level data to examine these effects, with a particular focus on the labor market.[2] Despite the large and growing literature, the focus has been so far about the effects on the industry or the firm that offshores. Little research has been done to assess how offshoring reshapes the domestic buyer-supplier network, and thus the macroeconomy. After all, an economy is an interlinked web of production units, each relying on inputs provided by its suppliers to produce output, which will then be sold to other firms further downstream.

This paper studies both theoretically and empirically how downstream firms' offshoring decisions are linked to the reorganization of their domestic production networks. To this end, we use unique and exhaustive Japanese firm-level data on buyer-supplier links for analysis. Our network data cover over half of the firms operating in Japan, in both manufacturing and non-manufacturing sectors. In addition to the rich data set, Japan provides an interesting case for a study on the effects of offshoring for various reasons. First, the Japanese economy is well known for its reliance on long-term relationships along the production chains. Anecdotal evidence suggests that relationship-specific investments, facilitated by long-term relationships, are reasons for Japan's success in manufacturing.[3] Second, existing empirical studies focus on the effects of offshoring on the manufacturing sector and largely overlook the effects on the service sectors, which are significantly more important for developed nations and increasingly so for emerging markets. Finally, in addition to the direct contribution of suppliers' productivity to buyers, how the choices of suppliers can affect buyers' productivity have not been fully understood. Such understanding is particularly important in light of Japanese firms' increasing participation in global value chains.[4] A detailed analysis on the reorganization of domestic production networks in Japan during a period of increasing offshoring can shed light on all these issues.

To guide our empirical analysis, we extend the models of Antràs, Fort, and Tintelnot (2014) and Bernard, Moxnes, and Saito (2015) to study the pattern of foreign outsourcing in a world with two-sided heterogeneity in efficiency across both buyers and sellers. Our extension considers multiple types of inputs, which differ from each other in the degree of relationship specificity to final-good production. Such extension permits a systematic analysis of how domestic production

[1] See Feenstra (2008) for a comprehensive summary of the literature.

[2] There is a large and growing literature about the effects of offshoring on labor market outcomes (e.g. Ebenstein, et al. 2014; Hummels et al., 2014, etc.). The effects of offshoring on firms' productivity, the focus of this paper, receives relatively little attention in the empirical literature (Olsen, 2006). A notable exception is Antràs, Fort, and Tintelnot (2014), which theoretically and quantitatively examines how offshoring, due to a decline in offshoring costs, raises firm productivity.

[3] See Liker and Choi (2004) for a thorough discussion on the feature of long-term relationships in the Japanese production network, which is in sharp contrast to the one in the U.S.

[4] For instance, a Nikkei Sangyo Shimbun article on August 31, 2011 reported that Kubota Corporation, a large industry machinery manufacturing firm in Japan, announced the plan to increase its overseas parts and components procurement share form 25% in 2011 to 70 % in 2021. A new overseas procurement base will be built in India, in addition to their existing bases in Thailand and China. As part of this offshoring plan, the company would need to reorganize the procurement relationships with the existing domestic suppliers.

networks evolve due to offshoring, along both the sectoral and geographic dimensions.

In the model, buyers need to incur fixed search and coordination costs to first find and then maintain relationships with suppliers from different domestic regions and foreign countries. Such fixed costs rise in the distance from the seller, more so for the more relationship-specific inputs.[5] As a result, buyers are less likely to outsource relationship-specific inputs in the first place and are more likely to outsource them to nearby suppliers, even though they are less productive than some suppliers in other input sectors located farther away. Since sourcing inputs from more regions requires additional up-front fixed costs, the more productive firms, who find incurring the extra fixed costs to search in additional regions profitable, will end up having a larger geographic scope of domestic outsourcing. As such, the profits of the more productive firms are higher not only because of their higher efficiency, but also because of lower variable costs due to the use of more efficient domestic suppliers.

When offshoring costs, either fixed or variable, decline, final good producers that have been outsourcing domestically may start outsourcing to foreign suppliers. This is true especially for buyers that have relatively higher core productivity. A firm that starts offshoring inputs will drop the less productive suppliers of the same input in every domestic region. This restructuring of the domestic production network will lead to an increase in the firm's profits and measured productivity, inducing the buyer to outsource more inputs and to further replace the less efficient suppliers with the more efficient ones located farther away. Our model also predicts that the inputs that are offshored tend to be less relationship-specific. Hence, the domestic input suppliers that are directly displaced by offshoring tend to be farther away and potentially more productive, compared to those suppliers that continue to sell to the same buyer.

We then empirically examine the theoretical predictions using unique and exhaustive data that cover close to 4 million buyer-supplier relationships of 800 thousands firms in the Japanese domestic production network for two years – 2005 and 2010. The data set is the most comprehensive we are aware of for a study on domestic production chains.[6] We find evidence largely supporting the main theoretical predictions. Specifically, we find that the more productive firms source inputs from more suppliers, from more regions, and from the more distant regions, confirming the recent theoretical and empirical findings by Bernard, Moxnes and Saito (2014, 2015). Distant suppliers are more productive on average, while productive firms are more likely to offshore input production. Above and beyond this geographic pattern of outsourcing, we also uncover evidence about the pattern of outsourcing based on the relationship-specificity of inputs. In particular, the negative distance effects on domestic sourcing are magnified for the more relationship-specific inputs. Hence, firms

[5] The idea that monitoring and communication costs increase in distance and shape relationship-specific investments has been empirically verified in the finance literature, such as Lerner (1995) and Petersen and Rajan (2002).

[6] The closest counterpart that we can think of is the paper by Atalay, et al. (2011), who analyze the buyer-seller network in the U.S. using Compustat data that over only publicly listed firms and their top 5 customers. Our data set covers half of the registered firms in Japan, and information about their top 24 buyers and top 24 sellers. We use the information reported by both buyers and sellers to maximize the number of links (see Section 3 below). Recent research by Bernard, Moxnes and Saito (2015) and Carvalho, Nirei, and Saito (2014) also use the same network data to study different research questions.

are less likely to source relationship-specific inputs from the more distant regions or from foreign countries.

In addition to empirically portraying the pattern of domestic and foreign outsourcing based on the model, we also find that firms that start offshoring become more productive. The net effect of offshoring on the buyers' domestic outsourcing is nuanced. This can be because on the one hand, some existing domestic suppliers are displaced by foreign suppliers producing the same input but on the other hand, offshoring enhances firms' productivity, raising the sustainability of existing supplier-buyer relationships and the likelihood of forming new ones. We find a marginally significant effect of offshoring on the buyers' likelihood of dropping domestic suppliers, and a much more significant effect on the buyers' likelihood of adding new domestic suppliers.

Our paper is related to various strands of literature in network and international trade. First, it relates to the burgeoning literature on the relation between network and trade, which is well summarized by a recent review article by Chaney (2014b). The literature goes back to the seminal paper by Rauch (1999), who shows that colonial ties and common languages between two countries induce trade, especially for differentiated products. In another seminal study, Rauch and Trindade (2002) show that the presence of ethnic Chinese immigrants in the destination countries facilitates imports from China, particularly so for differentiated products. The authors attribute these findings to the importance of network and search frictions in international trade. Recent studies seek to develop micro-founded models to study the dynamics and patterns of international trade networks. Bernard, Moxnes and Ulltveit-Moe (2014) develop an importer-exporter network model and use Norwegian data to establish important and novel stylized facts about international trade at the importer-exporter level. Such facts highlight the importance of the buyer margin of trade adjustments in response to economic shocks and policy changes. Chaney (2014a) develops a model to study the dynamics of exporters' penetration into foreign markets, through establishing new contacts and expanding existing trade networks.

Second, our paper contributes to the growing literature on the domestic production networks. Oberfield (2013) develops a general-equilibrium theory of the structure of production based on buyers' optimal choices of suppliers to study how the endogenous network formation shapes the productivity and organization of production. Carvalho and Gabaix (2013) study how the input-output linkages in an economy propagate and multiply underlying firm-level and sector-level idiosyncratic shocks to macro volatility. The recently available data on the domestic buyer-supplier links in Japan has engendered a series of interesting papers about the pattern and dynamics of production networks. Using the same data set as ours, Bernard, Moxnes and Saito (2015) develop a network model that features two-sided heterogeneity in efficiency and distance. Exploiting an arguably exogenous extension of the high-speed train line (Shinkansen), the authors empirically examine the model predictions that feature negative assortative matching between domestic buyers and sellers, and show that a reduction in search costs after the opening of a new train line induces the addition of new suppliers that are farther away and less productive. Their model also endogenizes a firm's performance as a function of the diversity and quality of its suppliers. Carvalho, Nirei, and Saito

(2014) quantitatively assess the propagation of shocks, such as earthquakes, through the domestic production chains. They show that external shocks on downstream firms affect not only the directly linked upstream firms, but also firms that are two or three degrees away from the affected firms.

Third, our paper is related to the literature that studies the non-efficiency aspect of firm performance. In particular, a recent paper by Holmes and Stevens (2015) shows that small firms specialize in the niche segment of a product market, while large firms specialize in the generic segment to take advantage of the economies of scale of production. Our focus on the relationship-specificity of inputs is conceptually similar to the niche segment in their study. Both of us emphasize that the traditional concept of efficiency is only one dimension to determine the heterogeneous firm performance in response to import competition or offshoring. We show that the specificity of inputs to the buyer has been largely overlooked and can play a significant role in determining how firms are affected by offshoring.[7] These findings also shed light on our understanding of the tradability of jobs (e.g., Jensen and Kletzer, 2005), which also hinges on the importance of face-to-face interactions and thus communication costs that increase in distance.

The paper proceeds as follows. Section 2 presents a theoretical model. Section 3 discusses the data used in the paper. Section 4 presents our empirical design and results. The final section concludes.

2 A Model of Firms' Domestic and Foreign Outsourcing

2.1 Setup

We build an industry equilibrium model that features domestic and foreign outsourcing of inputs to input suppliers from multiple regions, including a foreign country. In essence, our model is a simple extension of Antràs, Fort and Tintelnot (2014) and Bernard, Moxnes and Saito (2015) into the one with multiple types of inputs that differ from each other in relationship-specificity to the buyer's industry. After characterizing the equilibrium input sourcing pattern, we will then examine how the reduction of offshoring costs affect final good producers' choices of outsourcing to domestic suppliers.

For simplicity, we consider an industry with only domestic demand. There are N final good producers that produce differentiated products. An individual consumer's utility function is

$$u = \left[\sum_{i=1}^{N} y_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}},$$

where y_i and $\sigma > 1$ denote the consumption of final good variety i and the elasticity of substitution

[7] Another dimension of firm performance is product quality, which has been studied by a large and growing literature, such as Khandelwal (2010), Baldwin and Harrigan (2011), and Hallak and Sivadasan (2013), among others.

between different varieties, respectively. The aggregate demand for variety i therefore is

$$y_i = \frac{p_i^{-\sigma} E}{P^{1-\sigma}},$$

where $P = \left[\sum_{i=1}^{N} p_i^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$ denotes the price index and E represents the exogenously-given total expenditure on the final goods. Assuming that firms are all small and take P as given, we have the usual mill pricing with markup equal to $\sigma/(\sigma-1)$.

Production of the final good requires K different types of inputs, which differ in the degree of relationship-specificity to the production of a final good. As we will formulate shortly, we order inputs in such a way as relationship-specificity increases with index $k \in \{1, 2, \cdots, K\}$ (i.e., inputs of type 1 are the most generic while inputs of type K are the most relationship-specific). For each input type k, there is a continuum of differentiated inputs with a mass of 1. Each input $j_k \in [0, 1]$ should be insourced or outsourced to an input producer located in one of M regions of the country or in the foreign country, which we identify as region $M + 1$. We assume that in each region, there is only one producer for each input j_k of type k. Since there is a continuum of inputs, $[0, 1]$ for each type of input, there is a mass $K \times [0, 1]$ of input producers in each domestic region as well as in the foreign country. From the viewpoint of a final good producer, it can source each differentiated input j_k of input type k to itself or to one of $M + 1$ firms, located in $M + 1$ separate regions.

For each input j_k of type k, each of the final good producers and $M+1$ input producers draws its own productivity z from the Fréchet distribution, with a cumulative distribution function defined on $(0, \infty)$ by

$$F_k(z) = e^{-T_k z^{-\theta_k}},$$

where $T_k > 0$ is positively related with the likelihood of a high-productivity draw while $\theta_k > 1$ governs the variance of the draw. An input producer with productivity z has a unit cost of production $w_r c_k/z$, where w_r is a region-specific cost parameter such as the wage rate and c_k is a cost parameter that is specific to the input type. We assume that $w_r = 1$ for any domestic region $r = 1, \cdots, M$, and $w_{M+1} = w^* < 1$. The unit cost of production of input j_k equals $w_0 c_k/z$ in the case of insourcing; it is likely that $w_0 > 1$ since specialized input producers tend to enjoy cost advantage. Note that insourcing is represented by $r = 0$ and that each final good producer draw its productivity z independently for each individual input of type k.

Shipping an input entails an iceberg transport cost of $\tau_k(d) > 1$, where d denotes the distance of the shipment, defined broadly to include coordination or communication costs. As such, the iceberg transport cost may depend on the type of inputs being shipped. Intuitively, we assume that the slope of $\tau_k(d)$, $\tau_k'(d)$, increases with the relationship-specificity of inputs (i.e., k). In other words, distance matters more for shipping the more relationship-specific inputs. Moreover, we assume only for simplicity that for every domestic region where a buyer is located, the foreign country is the farthest away.

Production of a final good involves two stages. The first stage is to make K composite inputs, each produced from input varieties of $j_k \in [0,1]$. Specifically, a final good producer i can produce x_{ik} units of a composite input k with the following constant returns to scale (CES) production function:

$$x_{ik} = \left[\int_0^1 x_{ik}(j_k)^{\frac{\rho_k - 1}{\rho_k}} dj_k \right]^{\frac{\rho_k}{\rho_k - 1}}.$$

where ρ_k is the elasticity of substitution between different input varieties in the production of the composite input k.

The second stage is to assemble the composite inputs into final goods. Assembly technology of final good producer i can be expressed by the Cobb-Douglas function:

$$y_i = \varphi_i \Pi_{k=1}^K \left(\frac{x_{ik}}{\beta_k} \right)^{\beta_k},$$

where final good producers are different in their core productivity, φ_i, for $i = 1, 2, \cdots, N$.

Given supplier heterogeneity and varying iceberg costs that depend on the sector characteristics and the distance from the suppliers, individual final good producers choose for each input whether they outsource input production and to whom they outsource the input if they outsource it at all. Borrowing the insights from Antràs, Fort, and Tintelnot (2014), we assume that a final good producer needs to pay a fixed search cost of $f_k(d)$ to find a prospective supplier of inputs of type k in a region with the distance d; final good producers do not incur any fixed costs for insourcing. This search cost naturally depends on the degree of relationship-specificity of inputs such that the search cost is higher for any given distance and is increasing faster in distance, the higher the relationship-specificity of the input is (i.e., both $f_k(d)$ and $f'_k(d)$ increases with k). Because search is costly, firms may not buy input varieties from all regions, including the foreign country. With Ω_{ik} defined as the set of regions from which firm i sources its inputs of type k, this means that Ω_{ik} is not just a subset but may be a proper subset of $\{1, 2, \cdots, M, M+1\}$. Since insourcing entails no fixed costs, however, firm i always considers insourcing as an option when it chooses a supplier for any input.

Finally, we assume for simplicity that final good producers have all the bargaining power against input producers, such that the price of an input equals its unit cost.[8]

2.2 Firms' Optimal Sourcing Strategies

In this subsection, we first derive each final good producer's profits as a function of parameters that describe the sourcing environment. We first take the sets of firm i's sourcing regions, $\{\Omega_{ik}\}_{k=1}^K$, as given, before solving for the final good producers' sourcing decisions. Finally, we summarize the main theoretical results about the firms' sourcing strategies, which will be tested in the empirical section below.

For each variety $j_k \in [0,1]$ of input type k, firm i searches the regions in Ω_{ik} for an input producer that offers the lowest price for the input j_k. Since the assumptions of supplier productivity

[8] Introducing explicit negotiation between buyer and seller would not change the results qualitatively.

distribution and the production structure are the same as Eaton and Kortum (2002), we can directly apply their results here to show that the input-price probability distribution for every input variety of type k is

$$G_{ik}(p) = 1 - e^{\Phi_{ik} p^{\theta_k}}, \tag{1}$$

where

$$\Phi_{ik} = T_k(w_0 c_k)^{-\theta_k} + \sum_{r \in \Omega_{ik}} T_k(w_r c_k \tau_k(d_{ir}))^{-\theta_k} \tag{2}$$

with d_{ir} being the distance between region r and firm i. Note that our interpretation of transport cost allows us to neglect it in the case of insourcing, as reflected in the first term of the right-hand side of (2).[9] The share of inputs insourced is

$$s_{ik0} = \frac{T_k(w_0 c_k)^{-\theta_k}}{\Phi_{ik}} = \frac{w_0^{-\theta_k}}{w_0^{-\theta_k} + \sum_{l \in \Omega_{ik}} (w_l \tau_l(d_{il}))^{-\theta_k}},$$

while the share of inputs sourced from region $r \in \{1, 2, \cdots, M+1\}$ is given by

$$s_{ikr} = \frac{(w_r \tau_k(d_{ir}))^{-\theta_k}}{w_0^{-\theta_k} + \sum_{l \in \Omega_{ik}} (w_l \tau_l(d_{il}))^{-\theta_k}}. \tag{3}$$

Furthermore, the input price index for the inputs of type k is given by

$$p_{ik} = \gamma_k \Phi_{ik}^{-\frac{1}{\theta_k}}, \tag{4}$$

where

$$\gamma_k = \Gamma \left(\frac{\theta_k + 1 - \rho_k}{\theta_k} \right)^{\frac{1}{1-\rho_k}} ; \quad \rho_k < 1 + \theta_k,$$

where $\Gamma(x) = \int_0^\infty t^{x-1} e^{-t} dt$ is the gamma function.

Now, we are ready to derive the profit function for final good producer i. For a given set of input price indices, the optimal levels of composite input k to produce y_i units of final good equals

$$x_{ik} = \frac{\beta_k y_i}{\varphi_i p_{ik}} \Pi_{j=1}^K p_{ij}^{\beta_j}.$$

Consequently, the unit cost of a final good is given by

$$\psi_i = \frac{1}{y_i} \sum_{k=1}^K p_{ik} x_{ik} = \frac{1}{\varphi_i} \Pi_{k=1}^K p_{ik}^{\beta_k} = \frac{1}{\varphi_i} \Pi_{k=1}^K \gamma_k^{\beta_k} \Phi_{ik}^{-\frac{\beta_k}{\theta_k}}.$$

[9] Bernard, Moxnes and Saito (2015) characterize insourcing in the same manner.

It immediately follows that firm i's profit can be expressed as

$$\pi_i(\varphi_i) = B\psi_i^{1-\sigma} - \sum_{k=1}^{K} \sum_{r\in\Omega_{ik}} f_k(d_{ir}), \tag{5}$$

where

$$B = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} P^{\sigma-1}E; \quad P = \left[\sum_{i=1}^{N}\left(\frac{\sigma\psi_i}{\sigma-1}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}.$$

The profit function (5) provides a lot of information about a firm's optimal sourcing. Adding a new region r for sourcing inputs of type k comes with an additional fixed cost $f_k(d_{ir})$, but confers a benefit of lowering the marginal cost of production, due to an expansion of the supplier set (i.e., an increase in Φ_{ik}). The optimal choice of the set of sourcing regions, described by $\{\Omega_{ik}\}_{k=1}^{K}$, is an optimal decision based on balancing these costs and benefits.

To find a firm's optimal sourcing strategy, we derive from (5) the first-order approximation of a change in $\pi_i(\varphi_i)$ when firm i adds region r' to its set of sourcing regions for inputs of type k', $\Omega_{ik'}$:

$$\begin{aligned} &\pi_i(\varphi_i)|_{\Omega_{ik'}\cup\{r'\}} - \pi_i(\varphi_i)|_{\Omega_{ik'}} \\ &= \tilde{\pi}_i(\varphi_i)\frac{T_{k'}(w_{r'}c_{k'}\tau_{k'}(d_{ir'}))^{-\theta_{k'}}}{\Phi_{ik'}(\Omega_{ik'})} - f_{k'}(d_{ir'}), \end{aligned} \tag{6}$$

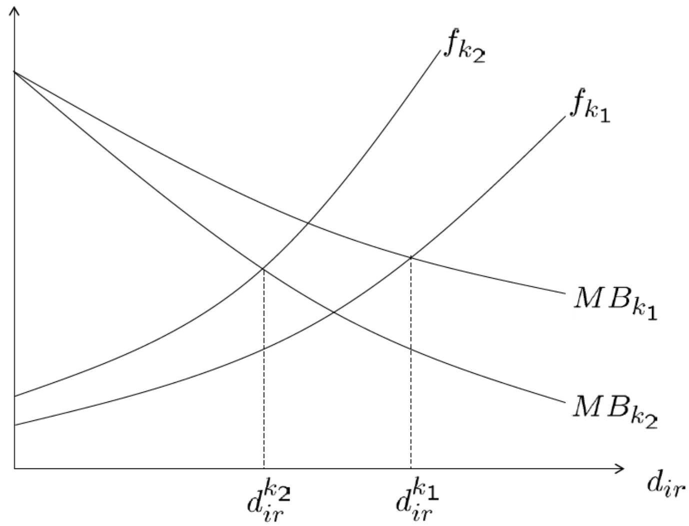
where $\tilde{\pi}_i(\varphi_i) \equiv B\varphi_i^{\sigma-1}\Pi_{k=1}^{K}\gamma_k^{\beta_k(1-\sigma)}\Phi_{ik}^{\frac{\beta_k(\sigma-1)}{\theta_k}}$ denotes firm i's operating profits. Notice that $\Phi_{ik'}$ depends on the set of sourcing regions that does not include region r' in question.

The first result that we obtain is to confirm the nesting property of sourcing observed by Antràs, Fort, and Tintelnot (2014). It follows immediately from (5) that $\tilde{\pi}_i(\varphi_i)$ is supermodular in Φ_{ik} and φ_i so that the marginal benefit of expanding the regions of search increases with firm i's core productivity φ_i. Thus, our counterpart of their nesting property is summarized by the following proposition.

Proposition 1 *A firm with a higher core productivity outsources more input varieties and from more regions. With the optimal set of sourcing regions, Ω_{ik}, expressed as a function of a firm's core productivity, we have $\Omega_{ik}(\varphi_i) \subseteq \Omega_{ik}(\varphi_{i'})$ for $\varphi_i < \varphi_{i'}$.*

The model also delivers results about the relationship between input sourcing and distance. It is evident from (3) that the share of domestic region r as a source of input outsourcing, s_{ikr}, decreases with the distance from r, d_{ir}. This, of course, is not surprising in the presence of iceberg transport costs. Since the input price equals $w_r c_k \tau_k(d_{ir})/z$ while the input price distribution for the inputs sourced from region r equals $G_{ik}(p)$ regardless of r, as shown by Eaton and Kortum (2002), inputs supplied from more distant regions tend to be produced by the more efficient input producers. We summarize these findings in the following proposition, similar to the key predictions of Bernard, Moxnes and Saito (2015).

Figure 1: Relationship-specificity and optimal sourcing



Proposition 2 *Final good producers buy inputs from a larger mass of firms in closer domestic regions. Moreover, the more distant suppliers are on average more productive.*

We also find that the relationship-specificity affects the sourcing pattern. Both marginal benefit and marginal cost of expanding the sourcing regions vary with input types as (6) indicates. Figure 1 illustrates two marginal benefit curves that correspond to two input types, k_1 and k_2, with $k_1 < k_2$.[10] We see from (2) and (6) that if $\Omega_{ik'}$ is a singleton, the marginal benefit equals $\pi_i(\varphi_i)$ for any input type k'. Since the slope of $\tau_k(d_{ir})$ is higher for a larger k, however, $T_{k'}(w_{r'}c_{k'}\tau_{k'}(d_{ir'}))^{-\theta_{k'}}/\Phi_{ik'}(\Omega_{ik'})$ decreases faster with $d_{ir'}$ if k' is higher. Thus, the marginal benefit of adding a sourcing region r decreases with distance d_{ir}, and at a faster rate for the more relationship-specific inputs. Figure 1 also depicts two schedules of the fixed search costs, capturing the marginal costs of adding a region in search, for both k_1 and k_2. Since k_2 is more relationship-specific, the curve for f_{k_2} lies above that for f_{k_1} and is also steeper. It is clear that in equilibrium, firm i searches for a supplier over a wider range of regions, the less relationship specific the type of input is. Thus, we have established another, novel nesting property, $\Omega_{i1} \supseteq \Omega_{i2} \supseteq \cdots \supseteq \Omega_{iK}$, for any final good producer i.

Proposition 3 *Firms source the less relationship-specific inputs from more regions.*

To find the optimal sourcing pattern for every input type k, each final good producer i ranks regions according to the value of $T_k(w_r c_k \tau_k(d_{ir}))$ and purchases its inputs from all regions with $T_k(w_r c_k \tau_k(d_{ir}))$ below a certain threshold.

In addition, we see from (2) that firm i does not only search a wider range of regions for less relationship-specific inputs, but also sources rather evenly to firms across regions. Equivalently, inputs with high relationship-specificity tend to be sourced disproportionately more to firms in regions that are closer to the final good producer, i.e., s_{ikr} decreases faster with d_{ir}, the larger k is.

[10] Note that these curves are drawn as if regions are continuous rather than discrete.

Since the closest to a final good producer is the firm itself, the final good producers insource more varieties of inputs, the more relationship-specific are the inputs.

Proposition 4 *The more relationship-specific inputs tend to be insourced and also outsourced disproportionately more to firms in nearby regions. The less relationship-specific inputs tend to be sourced more evenly across a wider range of regions.*

2.3 Offshoring and Firms' Network of Input Transaction

In this section, we examine how a reduction in offshoring costs affects firms' offshoring and their domestic sourcing strategies.

Propositions 1 shows that the more efficient firms tend to outsource input production to more domestic regions. Notice that despite the fact that the foreign country is farthest away from firm i, it is not necessarily the last to be included in its set of sourcing region since $w_{M+1} < w_r$ for all $r = 1, 2, \cdots, M$. Indeed, since $\tau_k(d_{ir})$ increases less significantly with d_{ir} for generic inputs, the ranking of the foreign country in the list is higher for lower k. We can naturally extend Proposition 3 to obtain the following proposition.

Proposition 5 *While the more productive firms are more likely to offshore inputs, the more relationship-specific inputs are less likely to be offshored.*

Recall that our model incorporates two types of offshoring costs: the fixed search and coordination costs in the foreign country, $f_k(d_{iM+1})$, and the (marginal) variable offshoring costs, $w_{M+1}\tau_k(d_{iM+1})$. A reduction of offshoring costs can take a reduction of either type of the costs.

Let us first consider the impact of a reduction of $f_k(d_{iM+1})$ for all k. It follows from (2) and (6) that a reduction of $f_k(d_{iM+1})$ will result in more offshoring. There are two types of new offshoring. The first one is about the first-time offshoring by the relatively more efficient firms that had not offshored any input production before. The second one is about increasing the offshoring scope to the less generic inputs by firms that have already offshored some inputs. For both cases, we know from Proposition 5 that the inputs that are newly offshored should be those that are the least relationship-specific of all the inputs that had not been offshored.

How does a firm that starts or expands offshoring change its domestic sourcing pattern? Suppose firm i begins offshoring some of type-k inputs. It follows immediately from (3) that some suppliers of input k in each region, in particular the less efficient ones, will be directly replaced by foreign firms. In addition to this direct effect, offshoring has an indirect productivity effect on the firm's sourcing strategy. We see from (2) and (4) that offshoring increases Φ_{ik} and hence lowers the input price index, p_{ik}. This entails an increase in the marginal profits of increasing Φ_{ij} for all $j \neq k$, which in turn lead to an expansion of Ω_{ij} for some j. If that happens, some input producers from distant regions are added to the input supplier network of firm i, while some less productive firms in every sourcing region will be dropped. Firms that start or expand offshoring also switch from insourcing some inputs to outsourcing.

A reduction of the fixed search and coordination costs also affect the firms that do not change their individual sourcing strategies. As some firms expand the scope of offshoring, the final good price index falls due to the productivity effect. This adversely affects the firms that do not change their sourcing strategies. While they experience no direct effect of offshoring, they will experience negative indirect effects due to increased competition from the newly offshoring firms in the goods market.

Proposition 6 *A firm that starts or expands offshoring due to a reduction in the fixed offshoring cost drops the less productive suppliers who produce the same type of inputs across all domestic regions. As its unit production cost decreases due to offshoring, the firm may also increase outsourcing and expand sourcing regions for other types of inputs. As such, distant suppliers with higher productivity replace the less productive suppliers in every sourcing region for those input types. In contrast, firms that do not change offshoring strategy may reduce the scope of search by dropping distant suppliers of certain input types and add the less productive suppliers in every remaining region.*

Next, we consider a reduction in the variable offshoring costs: either w_{M+1} or $\tau_k(d_{iM+1})$ decreases for all k. This is a type of reduction in offshoring costs investigated by Grossman and Rossi-Hansberg (2008, 2012). Similar to the case discussed above, some final good producers will expand the scope of offshoring as a result of declining variable offshoring costs. The direct and indirect effects of this induced change on firms are the same as in the previous case, as summarized by Proposition 6. The adverse effect of not engaging in offshoring is also identical to the previous case.

However, the effects are different for the final good producers that have already offshored some inputs before the reduction in w_{M+1} or $\tau_k(d_{iM+1})$. Different from the previous case when there is an adverse competition effect, existing offshorers benefit from the reduction in variable offshoring costs. According to (3), they will offshore more input varieties of the types of inputs that have already been offshored, and drop less efficient firms in every domestic region. They may also reshape the supplier-buyer network for other input types such that they drop the closer and less efficient suppliers, and add more distant and efficient suppliers.

Proposition 7 *Offshoring firms do not benefit from a reduction in the fixed search and coordination costs for foreign suppliers unless it is optimal for them to expand the scope of offshoring to include new input types. In contrast, a reduction in the variable offshoring costs always benefits such firms and induces them to expand the scope of offshoring and drop the less productive firms in all domestic regions for the already-offshored input types. They may also drop the closer, less efficient suppliers and add the more distant, efficient suppliers for other types of inputs.*

3 Data

We confront the theoretical predictions with a unique buyer-supplier data set for the Japanese firms' buyer-seller network. We will first discuss the data source and a few key patterns of the data set, before presenting the regression specifications and empirical results in Section 4.

3.1 Data Sources

This paper uses two data sets for analysis. The first data set, compiled by the Tokyo Shoko Research, Ltd. (TSR), contains basic firm-level balance sheet information of over 800,000 firms in Japan, for two years - 2005 and 2010.[11] It records information on firms' employment, sales, location, up to three main industries (4-digit), establishment year, number of factories, among others.[12] Crucial to our analysis, the TSR data also provide information on between-firm relationships, specifically the names of a firm's main suppliers, buyers, and shareholders. On both the buyer and supplier sides of a firm, a maximum of 24 firm names are collected.[13] We use a two-way matching method to construct the domestic production network in Japan. Specifically, we use information reported by a buyer about their sellers, and information reported by a seller about their buyers, to maximize the number of buyer-supplier links. Since a buyer of a seller can be identified on both ends, the number of buyers (sellers) of a seller (buyer) can be way above 24. The top seller in our constructed network data in Japan has over 11,000 buyers in 2010, while the top buyer has close to 8,000 suppliers. Most of the firms in the sample have substantially fewer buyers and sellers. This skewed distribution of the buyer-supplier links will be described below. To calculate the distance between each buyer-supplier pair, we identify the longitude and latitude of each firm based on detailed address available in the TSR data, using the geocoding service from the Center for Spatial Information Science at the University of Tokyo to compute the distance.

The second data set is from the Basic Survey on Japanese Business Structure and Activities (BSJBSA), collected annually by Japan's Ministry of Economy, Trade and Industry (METI). The survey data set covers all firms with at least 50 employees or 30 million yen of paid-in capital in the Japanese manufacturing, mining, wholesale and retail, and several other service sectors. Firms' responses to the surveys are mandatory. The data set contains detailed information on firms' business activities, such as their main industry (3 digit), number of employees, sales, purchases, exports, and imports (including a breakdown of the regional destination of exports and the origin of purchases and imports). This data set covers 22,939 and 24,892 firms in 2005 and 2010, respectively.

We obtain sellers' information from the TSR data and buyers' information, in particular several measures of offshoring, from the BSJBSA data. We then merge the two data sets using firms' names, addresses, and telephone numbers. The merged data contain over 800,000 buyer-supplier pairs. In this paper, we use the subsample that has manufacturing firms in the downstream.

[11] The surveys were conducted in 2006 and 2011, respectively. We use both TSR Company Information Database and TSR Company Linkage Database in this paper.

[12] According to Carvalho, Nirei and Saito (2014), the TSR data cover more than half of all firms in Japan.

[13] In addition, the names of the three major banks a firm borrows from are also recorded.

3.2 Data Summary

Before discussing our main empirical findings, let us describe several key features of our network data. Table 1 reports the summary statistics of the number of buyer-supplier links. There are two sets of numbers. The first set, solely from the Tokyo Shoko Research (TSR) data, shows that there are about 3.6 million buyer-supplier links in Japan in 2005. The number of links increased to 4.5 million in 2010. The increase can be due to an increase in the number of buyers or sellers, or just an increase in the number of links per buyer. While assessing the reasons for the increase in the density of the domestic production network is beyond the scope of this paper, we find evidence that the mean number of sellers of a buyer in Japan has increased from 4.9 to 5.5 between 2005 and 2010, while the median number of sellers per buyer has increased from 2 to 3. The large difference between the mean and the median number of sellers per buyer suggests that the distribution of the number of buyer-supplier links is highly skewed. Figure 1, which plots the log number of sellers per buyer against the fraction of buyers having at least that many sellers, shows a power-law distribution, as highlighted by Bernard, Moxnes, and Saito (2015).

A potential reason for the increase in the number of buyer-supplier links can be measurement error, due to firms reporting more customers or suppliers in the 2010 survey compared to that in 2005. To avoid such measurement errors from biasing our empirical results, we will use a balanced panel of suppliers and buyers that exist in both 2005 and 2010 in the regression analysis below. Moreover, our model treats buyers and sellers as independent firms. In reality, firms may optimally choose to vertically integrate with upstream suppliers to strike a balance between providing incentives and control (see, for instance, Antràs and Chor, 2013). To deal with both data issues, we use a restricted data sample by excluding observations for suppliers or buyers that only exist in either 2005 or 2010, as well as all headquarter-subsidiary links. Panel B of Table 1 shows the corresponding statistics for the restricted sample. The number of buyer-supplier links drops to less than half a million. Not surprisingly, the mean and the median number of sellers per buyer both increase, implying that the firms that are retained in our regression sample tend to be larger.

The TSR data only contain information on some basic balance-sheet variables and whether two firms have a buyer-supplier relationship. In addition to removing observations that may cause estimation biases, we merge our network data to the BSJBSA, using a common firm identifier. We can therefore obtain a sample that provides detailed balance-sheet data for our regression analyses. In particular, we have information about a buyer firm's imports, material purchased, capital, and labor. With all these information, we can then estimate a buyer's total factor productivity (TFP). Panel C in Table 1 shows the summary statistics of the number of links in the merged data set. About 40% of the pairs in the restricted TSR sample (Panel B of Table 1) can be merged. Not surprisingly, since BSJBSA covers mainly large firms, the mean and the median numbers of sellers per buyer based on the merged data are both higher. In the sample of downstream manufacturing firms and their suppliers that we use in our regression analysis below, the mean and the median numbers of sellers per buyer are about 22 and 10 for the year 2010, respectively. One could be concerned about our focus on large firms, but if the goal of the study is to assess the effects of offshoring on the domestic production network, our large-firm focus should be fine as on average, only large firms would engage in direct offshoring due to the higher associated fixed costs compared to domestic outsourcing. Figure 2 confirms how our merged sample is skewed toward the larger downstream firms. The fraction of firms that have at least n links is also larger due to the fact that firms with a small number of links are underrepresented in our merged sample. That said, the power-law distribution of the (log) number of sellers per buyer is preserved. The slope of the distribution of the number of links based on the merged sample is very close to that based on the original TSR sample.

Table A1 in the appendix shows the summary statistics of the numbers of buyer-supplier links by a buyer's broad sector. According to the original TSR data, the top 3 sectors that have the highest number of buyer-supplier links are manufacturing, wholesale and retail trade, and information services. In our regression analysis below, we will focus on the effects of offshoring by manufacturing firms in the downstream on supplier dropping and adding across all sectors. Table A2 shows the same set of summary statistics reported in Panels B and C of Table 1, but by a buyer's manufacturing sector.

Table 2 shows the basic characteristics of importers in the BSJBSA sample. The fraction of manufacturing firms that import is 29.7% in 2005, and increases to 30.8% in 2010. Importers' average import intensity, measured in terms of the firm's imports divided by total intermediate input purchases, also increases slightly from 16.3% to 19.2% during the same period. Asia is a very important input source for Japanese importers. Among importers, the average share of imports from Asia in total imports is over 80 percent in both 2005 and 2010.

Table 3 further shows the summary statistics of the main variables of interests used in the regression analyses. Reading horizontally across columns, we report the summary statistics for different subsamples used in our regressions, namely all manufacturing buyers; those that already imported (offshored) in 2005, those that did not import in 2003-2005; those among non-importers that started importing between 2005 and 2010; and those that remain non-importers throughout 2005-2010; and finally, those that imported in both 2005 and 2010. Reading vertically across rows, we reported the mean, median, minimum, and maximum for 1) the numbers of buyers (Panel A); 2) the number of sellers per buyer (Panel B); 3) the number of sellers' prefectures per buyer (Panel C), all based on the 2005 data sample. We then report the corresponding numbers using the 2010 sample.

In the sample of all manufacturing firms, the mean and median number of domestic suppliers per buyer is 19.3 and 8, respectively. The mean and median number of prefectures that a buyer will source from is 4.83 and 4 (out of a total of 47), respectively. By comparing these numbers across groups of buyers and years, we discover a few important facts. First, the number of sellers per buyer, in terms of both mean and median, increases from 2005 to 2010.[14] Second, importers have more domestic suppliers in both years on average. Third, among importers, those that imported

[14] As explained above, some of these increases are possibly caused by measurement and reporting errors, which will be addressed once we restrict our sample to include buyers and sellers that exist in both years of our sample.

in both 2005 and 2010 have more domestic suppliers than those that just started importing since 2005.

Before conducting formal regression analysis, we graphically illustrate whether the propositions presented in the previous section tend to hold or not. First, according to Proposition 1, we expect that the more productive buyers tend to source from more suppliers. In Figure 3, we examine the relationship between the buyer-supplier distance and suppliers' characteristics. In Panel A of Figure 3, we explore the relationship between the buyer-supplier distance and supplier productivity (Proposition 1). We first group buyer-supplier pairs into ten deciles, based on their distance. We then compute the average labor productivity of suppliers, measured as sales per employee for each decile.[15] We then partial out any industry-specific effects by demeaning these productivity measures from their corresponding industry averages. There is a U-shaped relationship between the buyer-supplier distance and average seller productivity, contrary to a positive relationship predicted by Proposition 1. However, excluding suppliers which are fairly close to buyers (less than 30 percentile of the distance distribution), we observe a positive relationship between the two, as we expected.

In Panel B, we use the same method to illustrate any potential relationship between the buyer-supplier distance and the relationship-specificity of inputs purchased from upstream suppliers, suggested by Proposition 3. In particular, we first group buyer-supplier pairs based on their distance decile, then compute the average fraction of buyer-supplier links with inputs from the differentiated sectors. In order to identify suppliers which provide differentiated inputs, we use the Rauch measures at the 4-digit industry level, which equals one for the differentiated-good industries and zero otherwise (Rauch, 1999). Since the Rauch measure is not available for most of the service industries, for each buyer, we calculate the fraction of differentiated-good suppliers in the total number of manufacturing suppliers only. There is a weakly negative relationship between relationship-specificity and distance for 2010, as predicted by our model.

Finally in Panel C, we provide another illustration of a possible relationship between buyer-supplier distance and the relationship-specificity of inputs, using the share of trade that is handled by intermediaries of each sector from Bernard, Jensen, Redding, and Schott (2010) (BJRS hereafter). We interpret a higher share of intermediation as an indication of a lower degree of input relationship-specificity. There appears to be a U-shaped relationship between distance and the intermediation index across deciles. Notice that the three graphs illustrated here provide only preliminary evidence about the potential relationship between the domestic sourcing patterns. In the next section, we will conduct formal regression analyses, controlling for key confounding factors.

4 Regression Analyses and Results

In this section, we empirically examine the propositions presented in Section 2. For notational clarity, let us denote buyer, seller, industry (3-digit), and region (one of 47 prefectures) by i, j, s, and r respectively. Notice that when industry and region fixed effects are included, we will be clear

[15] Information required to calculate value added is not available for suppliers.

about whether they are for the buyer's (i) or the seller's (j) industry or region.

4.1 On Firms' Domestic Sourcing Patterns

Proposition 1 is about the final good producer's (buyer's) productivity and the geographic scope of domestic outsourcing. To empirically examine this proposition, we estimate the following specification:

$$\ln(\#prefecture)_i = \alpha + \beta \ln(TFP)_i + FE_s^i + FE_r^i + \varepsilon_i, \tag{7}$$

where $\ln(\#prefecture)_i$ stands for the number of regions buyer i sources from; $\ln(TFP)_i$ represents buyer i's productivity. Buyer's industry and region fixed effects are included (FE_s^i and FE_r^i). According to Proposition 1, there should be a positive relation between a buyer's productivity and the number of regions that it will outsource input production to. Thus, β is estimated to be positive.

Table 4 reports the estimation results. Columns (1) through (4) show the results for estimating eq. (7) using the 2005 cross-sectional data on the buyer-supplier network, while columns (5) through (8) use that from 2010. Standard errors are always clustered at the buyer's industry level. In column (1), when we estimate a buyer's total factor productivity (TFP) using the standard Olley-Pakes method, we find a positive and significant correlation between a buyer's TFP and the number of regions (prefectures) that it purchases inputs from, after controlling for buyer industry and region fixed effects. Specifically, the coefficient of 0.447 implies that a one standard deviation increase in a buyer's $\ln(TFP)$ (i.e., 0.41) is associated with about 20% increase (0.18 log points) in the number prefectures the buyer will buy inputs from. This positive correlation between buyer productivity and the geographic scope of outsourcing is observed when productivity is estimated using the index method (column (2)), or sales-based or value-added based output per worker (columns (3) and (4), respectively). When we use the data sample from 2010 in columns (5) through (8), we continue to find that more productive buyers sourced from more domestic regions, confirming Proposition 1. Notice that the magnitude of the correlation is smaller when the 2010 sample is used. For the 2010 sample, the coefficient of 0.149 implies that a one standard deviation increase in $\ln(TFP)$ (i.e., 0.53) is only associated with about 8% increase in the number prefectures the buyer will buy inputs from. The reason for the decline in the magnitude of the relation between firm productivity geographic scope of outsourcing could be related to the lower costs of offshoring, which we will explore next.

Now let us turn to Proposition 2, which is about the distance between a buyer and a region and the number of suppliers used in the region. To this end, we first estimate the following specification at the buyer-prefecture level:

$$\ln(\#sellers)_{ir} = \alpha + \beta \ln(dist)_{ir} + \{FE\} + \varepsilon_{ir}, \tag{8}$$

where $\ln(\#sellers)_{ir}$ is the (log) number of sellers buyer i purchase inputs from in region r. $\ln(dist)_{ir}$

is the log distance between buyer i and its seller's (j) prefecture.[16] One is added to distance for same-prefecture outsourcing, which by definition has a zero distance. $\{FE\}$ includes various fixed effects, which can include buyers' prefecture fixed effects to capture any unobserved characteristics of a buyer's location (e.g., infrastructure of agglomeration effects), buyers' industry fixed effects to capture any sector-specific differences (e.g., complexity of the final-good production), and sellers' prefecture fixed effects to capture any unobserved characteristics of the seller's location. Since the unit of observation is at the buyer-(seller)prefecture level, we have enough degree of freedom to include buyer fixed effects as well, which will control for all buyer-specific unobserved characteristics. In that case, we examine the relationship between the seller-buyer distance and the scope of domestic sourcing by exploring any cross-region variation within a buyer.

We estimate eq. (8) using our network data for 2005 and 2010.[17] According to Proposition 2, $\beta < 0$. Table 5 presents the regression results. Based on the sample for the cross-section of the buyer-supplier network from 2005, Column (1) shows a negative and statistically significant correlation between $\ln(dist)_{ir}$ and the number of sellers in region r, after controlling for buyers' prefecture, buyers' industry, and sellers' prefecture fixed effects. This finding confirms Proposition 2. In column (2), we control for buyer fixed effects and seller's prefecture fixed effects instead. The correlation remains negative and statistically significant. Importantly, the magnitude of the coefficient increases from -0.09 in column (1) to -0.15 in column (2). What it implies is that cross-buyer heterogeneity in firm efficiency and other attributes matter. When controlling for all buyer-specific attributes, within-firm variation in sourcing patterns across regions becomes even more pronounced. In columns (3) and (4), we use the network data from the 2010 cross-section. We continue to find a strongly negative relationship between distance and the number of suppliers sourced from different regions. The size of the coefficients of β are of similar magnitude to those for the 2005 sample, regardless of the set of fixed effects included.

Now let us examine Proposition 3, which predicts that the negative distance effect on firms' outsourcing is stronger for relationship-specific inputs. To verify this prediction, we estimate the following specifications at the buyer-prefecture-industry level:

$$\ln(\#sellers)_{irs} = \alpha + \beta \ln(dist)_{ir} + \gamma \ln(dist)_{ir} \times RS_s^j + FE_i + FE_r^j + FE_s^j + \varepsilon_{irs} \qquad (9)$$

where $\ln(\#sellers)_{irs}$ is the (log) buyer i's number of sellers in region r and sector s. Like before, $\ln(dist)_{ir}$ is the log distance between buyer i and sellers' region r, and RS_s^j measures the degree of relationship-specificity of sector s inputs. According to Proposition 3, the number of sellers of each buyer in a sector-region should be lower from prefectures that are farther away, more so for the more relation-specific (seller) sectors. Therefore, $\beta < 0$ and $\gamma < 0$.

Table 6 reports the regression results. Column (1) shows that the distance between a buyer and its sellers' prefectures is negatively correlated with the number of sellers from the prefecture. Moreover, the coefficient on the interaction between $\ln(dist)_{ir}$ and the proxy for the RS_s^j, the

[16] We use capital city of the prefecture to compute the distance.

[17] For this regression, we use the sample of Panel B of Table 1.

intermediation index adopted from BJRS (2010), is positive and significant. These results suggest that while buyers will buyer from few sellers from a more distant region, such negative effect is alleviated in sectors where inputs are less relationship-specific (i.e., those that tend to be handled by intermediaries).

In column (2), we repeat the same regression by using the famous Rauch index to proxy for the inputs' relationship-specificity. We find confirming results that distance has a negative effect on the scope of outsourcing, more so for inputs that are more relationship-specific (a negative coefficient on the interaction term). Qualitatively identical results are obtained when the 2010 cross-sectional data are used in columns (3) and (4).

Proposition 2 also predicts that the more distant suppliers are on average more productive due to fixed costs of offshoring that are increasing in distance. To verify this claim, we estimate the following equation at the buyer-supplier level:

$$\ln\left(Sales/Emp\right)_j = \alpha + \beta\ln(dist)_{ij} + FE_i + FE_r^j + FE_s^j + \varepsilon_{ir}, \tag{10}$$

where $\ln\left(Sales/Emp\right)_j$ stands for seller j's labor productivity and $\ln(dist)_{ij}$ is the log distance between buyer i and seller j, instead of the distance from the capital of the seller's prefecture. Buyer (FE_i), sellers' prefecture (FE_r^j), and sellers' industry (FE_r^j) fixed effects are included to deal with, for instance, any agglomeration effects and economic geographic factors that affect a firm's sourcing pattern. Notice that the same value of $\ln\left(Sales/Emp\right)_j$ may repeat multiple times in the regression sample, as a seller can be selling to different buyers.

According to Proposition 2, $\beta > 0$. Table 7 reports the results of estimating eq. (10). Standard errors are clustered at the buyer level. We find a negative and statistically significant correlation between the buyer-seller distance and seller labor productivity. This result is observed regardless of using the network data from 2005 or 2010.

4.2 Determinants of Firm's Offshoring Decisions

Now let us turn to empirically examining the determinants of firm's offshoring. According to Proposition 5, the more productive buyers are more likely to offshore. To empirically examine this claim, we estimate the following specification using our two-year panel data on Japan's production networks (2005 and 2010):

$$\Delta imp\_d_{it} = \alpha + \beta\ln(TFP)_{i,t-1} + FE_s^i + FE_r^i + \varepsilon_i, \tag{11}$$

where Δimp_d_{it} indicates the change in buyer i's offshoring status between $t-1$ (2005) and t (2010), which equals 1 if it didn't import in all years over the 2003-2005 period, and start importing in both 2010 and 2011, 0 otherwise. The decision to consider import starters that import in both 2010 and 2011 is to remove noisy one-time (occasional) importers (see Blum et al., 2013). We continue to include both buyer industry (FE_s^i) and region (FE_r^i) fixed effects.

Table 8 reports the estimation results. Similar to Table 4, we continue to use four different ways to measure a buyer's productivity: Olley-Pakes TFP, index TFP, sales-based and value-added-based productivity, respectively. Standard errors are clustered at the buyer's industry level. With the exception of column (1) when the TFP estimated based on the Olley-Pakes method is used, we find that a buyer's productivity in 2005 is positively and significantly correlated with the likelihood of its offshoring between 2005 and 2010, confirming Proposition 1.

Proposition 5 also predicts that the more relationship-specific inputs are less likely to be offshored. To this end, we estimate the following regression specification:

$$imp\_d_{is} = \alpha + \beta RS_s + FE_i + FE_s^j + \varepsilon_{is}, \tag{12}$$

where imp_d_{is} is an offshoring dummy, which is equal to 1 if buyer i is currently importing something in sector s, 0 if it does not but is sourcing something from another local supplier.[18]

Table 9 reports the estimation results. In column (1) when the (inverse) relationship-specificity of inputs is measured by the BJRS intermediation index, we find a positive correlation between the (inverse) measure of relationship-specificity of the input sector and the likelihood of the buyer's offshoring in the same sector. In column (2) when relationship-specificity is measured by the Rauch index, we find a negative correlation between the measure and the likelihood of the buyer's offshoring.

Finally, we examine Proposition 6, which is about how offshoring firms change their domestic sourcing patterns, which will result in an improvement in productivity. The resulting productivity increase will lead to another round of supplier churning. In particular, distant suppliers with higher productivity will be added.

To test these predictions, we estimate the following specifications:

$$\begin{aligned} \Delta \ln (sales)_i &= \alpha + \beta \Delta imp\_d_i + FE_s^i + FE_r^i + \varepsilon_i, & (13)\\ \Delta \ln (\#prefecture)_i &= \alpha + \beta \Delta imp\_d_i + FE_s^i + FE_r^i + \varepsilon_i, & (14)\\ Avg\left(\ln(dist)_i\right) &= \alpha + \beta \Delta imp\_d_i + FE_s^i + FE_r^i + \varepsilon_{i,} & (15) \end{aligned}$$

where buyer's sector and region fixed effects are included (FE_s^i and FE_r^i), since buyer fixed effects cannot be included.

In this regressions, we are looking for indirect effects of offshoring, due to increased buyer's productivity, which induces the buyer to increase search effort over a larger range of domestic regions. Thus, $\beta > 0$ in all three specifications. Notice that the indirect effect is only realized after the firm has become more productive. So if we control for the change in sales, $\Delta \ln(sales)_i$ from 2005 and 2010, we should expect no significant relationship.

Table 10 reports the estimation results. In columns (1)-(2), we find a positive and significant correlation between the change in the firm's offshoring status and the firm's sales growth. In

[18] To construct the importing dummy, we need to construct a new data set with a offshoring dummy equal to 1 if there are positive imports in sector s by buyer i, 0 otherwise. Notice that we do not fill in 0 for all possible supplying industries. We only do that for the industries in which buyer i is currently sourcing something domestically.

columns (3)-(4), we find a positive and significant correlation between the change in the firm's offshoring status and the firm's measured TFP. However, in columns (5) through (8), we find no net effect on the number of prefectures that the new offshorer will source inputs from, or outsourcing to more distant suppliers.

4.3 On the Relation between Offshoring and Supplier Churning

The final part of the paper examines the proposition 7, which describes the supplier adding and dropping patterns by firms that offshore. We first examine whether a buyer's decision of offshoring are associated with the likelihood of dropping its existing domestic suppliers. To this end, we estimate the following specification using our two-year panel data on Japan's production networks (2005 and 2010):

$$\begin{aligned} Drop_{ijt} &= \alpha + \beta \triangle Imp_{it} + \gamma_1 Sales\_Gr_{it} + \gamma_2 \log(Size_{it-1}) \\ &\quad + X_{ij,t-1} + \{FE\} + \varepsilon_{ijt}, \end{aligned} \tag{16}$$

where i, j, and t stand for domestic buyer, domestic seller, and year, respectively. $Drop_{ijt}$ is a dummy variable, which is equal to 1 if seller j was dropped by buyer i after 2005 and before 2010 (inclusive), 0 otherwise. The variable of interest, $\triangle Imp_{it}$, is a dummy indicating the firm's switching from no offshoring (in 2003-2005) to offshoring (in both 2010 and 2011). In other words, this specification uses a sample of firms that did not offshore in 2005, and aims to gauge the effect of the extensive margin of offshoring on the firms' original domestic suppliers.

To control for buyer-specific changes in input demand, we include buyer i's sales growth between 2005 and 2010, $\triangle Sales\_Gr_{it}$, and (log) firm size in 2005, $\log(Size_{it-1})$, measured either by sales or employment. On the seller's side, we also control for its initial sales in 2005 and sales growth. These controls capture situations like suppliers' unexplained drop in performance, in the absence of any changes on the buyer's side. If buyer i's starting to offshore input production is associated with a higher likelihood of seller dropping, a positive estimate of β is expected. $\{FE\}$ includes four fixed effects: seller and buyer industry and region (prefecture) fixed effects, respectively. The buyer's and seller's industry fixed effects are included to ensure that any increased incidence of supplier dropping is independent of the trend of structural change in the Japanese economy. The buyer's and seller's region fixed effects control for any agglomeration effects and any region-specific business cycles.

To examine whether downstream firms' offshoring decisions are related to the probability of adding suppliers, we run the same set of regressions but with the dependent variable replaced by Add_{ijt}, a dummy variable equal to 1 if domestic supplier j was newly added by buyer i after 2005 and before 2010 (inclusive), 0 otherwise. While our theory is relatively silent about the pattern of adding suppliers, such findings can enhance our understanding of how offshoring by buyers can change the domestic production network.

We first examine how offshoring by a firm affects its probability of dropping existing suppliers.

Table 11 reports the results of estimating specification (16), using the sample of downstream manufacturing firms that purchase inputs from domestic suppliers but not foreign suppliers in 2005. All regressions include sellers' and buyers' industry and region (prefecture) fixed effects. In columns (1) and (2), we find a positive and marginally significant (at the 10% level) relationship between a buyer's offshoring participation and the probability of dropping its domestic suppliers. These results are obtained after controlling for the buyer-seller distance, the initial size (in terms of sales or employment) of both the buyer and seller, and the growth rate of the buyer and seller's sales (or employment), in addition to the four fixed effects.

The last two columns in Table 11 reports the results of estimating specification (16), using Add_{ijt} as the dependent variable, which is equal to 1 if a new buyer-supplier relationship was formed between 2005 and 2010 (inclusive). Column (3) shows a positive and significant relation between offshoring participation and the buyer's probability of adding new suppliers, after controlling for the buyer's and seller's industry fixed effect, buyer's and seller's region fixed effects, and a host of controls. This positive correlation is unlikely to be driven by the underlying demand or supply shocks hitting the buyer as we already control for its sales growth. The robust findings about the strong positive correlation between buyers' offshoring and supplier adding, conditional on sales growth, provides indirect evidence that offshoring has a significantly positive effect on the buyer's productivity.

In summary, we find a marginally significant correlation between buyers' offshoring and the likelihood of dropping domestic suppliers. By no means that these results imply causality. In research in progress, we will repeat the same analysis using instruments for firms' offshoring decisions.

5 Concluding Remarks

In this paper, we study both theoretically and empirically how downstream firms' offshoring decisions lead to the reorganization of the domestic production network. We build a buyer-seller model that features supplier heterogeneity in efficiency and distance, as well as intermediate inputs that vary in the degree of specificity to the relationship with the buyer. The model predicts that the more productive buyers will source inputs from a larger range of geographic regions, especially for generic inputs. Inputs that are more relationship-specific are less likely to be sourced from distant regions or foreign countries. Starting from these equilibrium sourcing patterns, a decline in offshoring costs leads to dropping of the less productive suppliers that are closer to the buyers, which are to be replaced by the more distant and productive suppliers due to the indirect productivity effect of offshoring. Less relationship-specific suppliers are more likely to be dropped, despite their higher productivity.

Using unique and exhaustive data that cover close to 4 million buyer-seller links in Japan, we find evidence largely supporting the main theoretical predictions. In particular, we find that the more productive firms source inputs from more suppliers, from more regions, and from the more distant regions. We also find that the more productive firms are also more likely to offshore input production. As predicted by the model, distant suppliers are also more productive on average. Above and beyond this geographic pattern of outsourcing, we also uncover evidence about the sectoral pattern of outsourcing, along the dimension of relationship-specificity of inputs. In particular, firms are less likely to source relationship-specific inputs from the more distant regions or from foreign countries. The negative distance effects are also more pronounced for the more relationship-specific inputs. Preliminary evidence shows that offshoring improves firms' productivity, which induces supplier churning, especially on the margin of adding new suppliers.

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Table 1: Summary Statistics of the Network Data and the Merged Sample

A. Full Sample of the Network Data from Tokyo Shoko Research (TSR)

	Nb Obs	Mean nb of sellers	Median nb of sellers
2005	3,586,090	4.89	2
2010	4,463,168	5.47	3

B. Restricted TSR Sample (Only buyers and sellers that exist in both 2005 and 2010; headquarter-subsidiary pairs excluded)

	Nb Obs	Mean nb of sellers	Median nb of sellers
2005	361,777	7.06	3
2010	458,984	8.07	4

C. Restricted Sample Merged with the Basic Survey

	Nb Obs	% of pair in TSR merged	Mean nb of sellers	Median nb of sellers
2005	149,645	41.36	17.88	8
2010	187,676	40.89	21.86	10

Samples decribed in Panel B and C include buyers and sellers that have at least 10 employees, respectively.

Figure 2: Distribution of Buyers with Different Nb of Suppliers

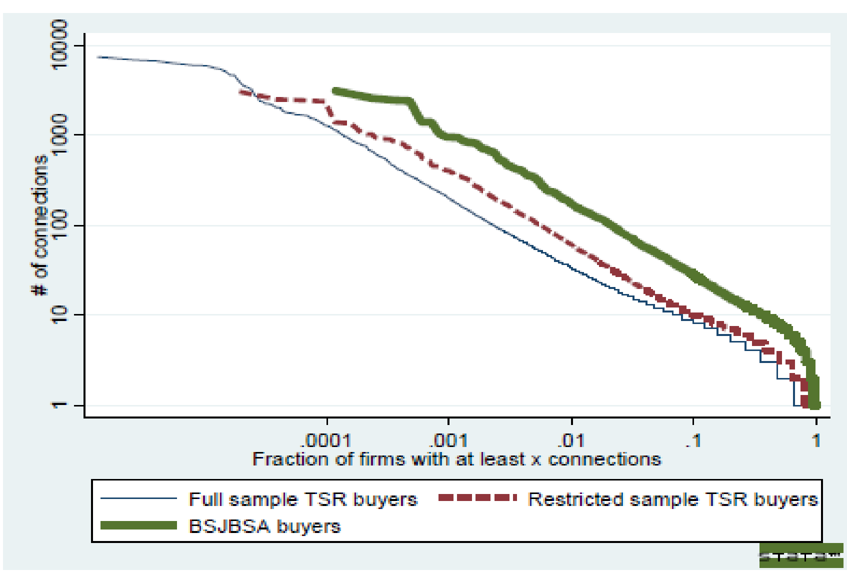


Table 2: Characteristics of Downstream Firms (Buyers) in the Basic Survey

All industries	2005	2010
No. of firms in the BSJBSA	22,939	24,892
Nb. of importers	5,344	5,659
Nb. of importers from Asia	4,315	4,786
Fraction of firms that import	0.233	0.227
Fraction of firms that import from Asia	0.188	0.192
Average importer's import intensity		
(imports/ total purchases)	0.183	0.212
Aveage firms' shares of imports from Asia		
(imports from Asia / total imports)	0.795	0.821
Manufacturing industries		
Nb. of firms in the BSJBSA	11,021	11,361
Nb. of importers	3,270	3,494
Nb. of importers from Asia	2,747	3,082
Fraction of firms that import	0.297	0.308
Fraction of firms that import from Asia	0.249	0.271
Average importer's import intensity	0.163	0.192
(imports/ total purchases)		
Aveage firms' shares of imports from Asia		
(imports from Asia / total imports)	0.824	0.846

Sample: BSJBSA (2005, 2010)

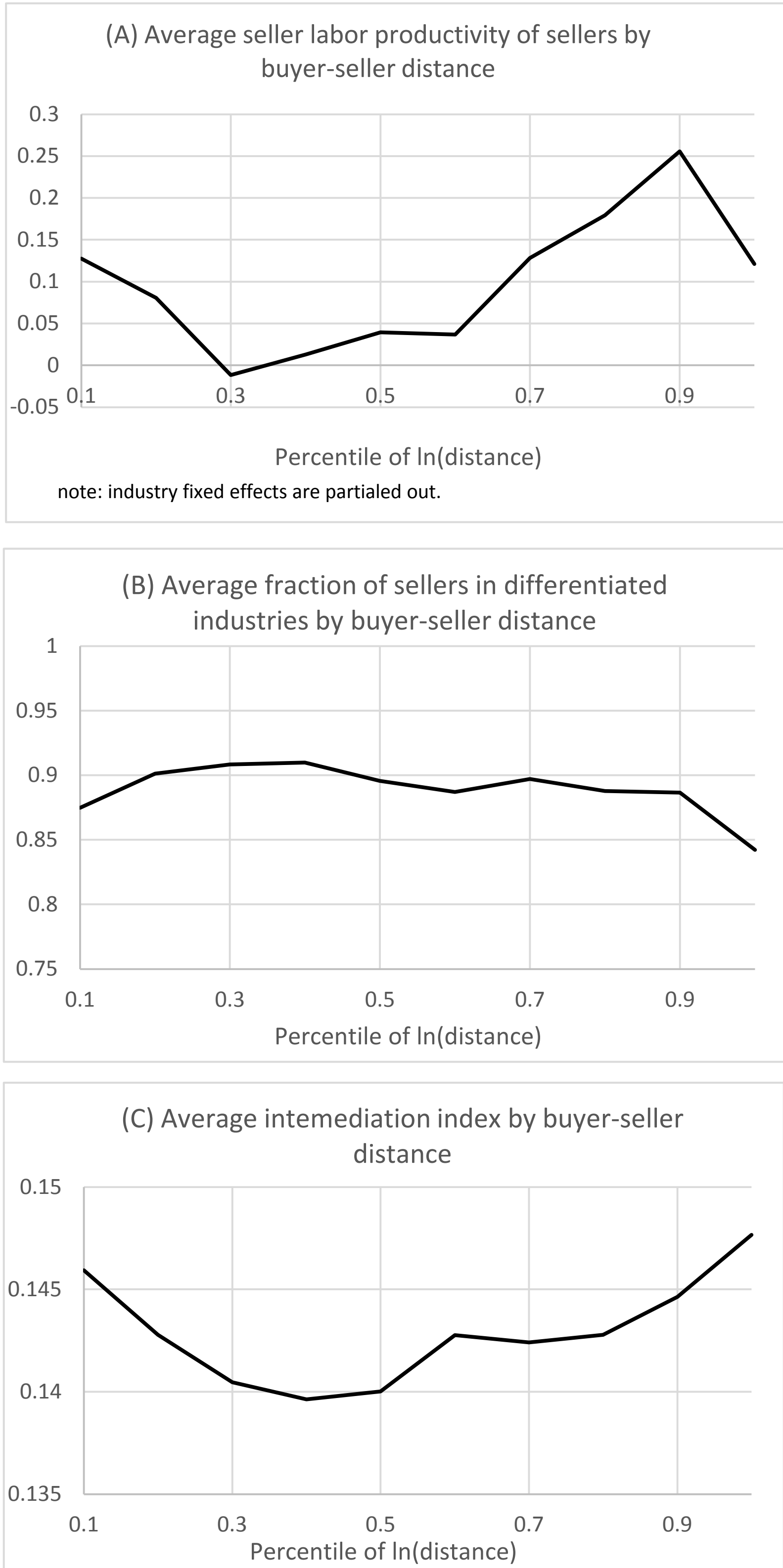
Table 3: Summary Statistics (Number of Buyers and Sellers)

Sample:	All mfg. buyers in 2005	Existing Importers in 2005	Non-importers in 2003-2005	Import starters between 2005-2010	Non-importers 2005-2010	Continuous importers 2005-2010
Panel A: Number of buyers (2005)						
	8,404	2,117	5,611	341	4,179	1,436
Panel B: Number of sellers per buyer (2005)						
Mean	19.33	34.78	13.40	20.67	13.53	38.34
Median	8	11	7	9	7	12
Min.	1	1	1	1	1	1
Max.	3,552	3,004	3,552	1,056	3,552	3,004
Panel C: Number of sellers' prefectures per buyer (2005)						
Mean	4.84	6.79	4.01	5.25	3.99	7.00
Median	4	5	3	4	3	5
Min.	1	1	1	1	1	1
Max.	47	47	46	38	46	47

Sample:	All mfg. buyers in 2010	Existing Importers in 2010	Non-importers in 2008-2010	Import starters between 2005-2010	Non-importers 2005-2010	Continuous importers 2005-2010
Panel D: Number of buyers (2010)						
	8,605	2,021	4,674	346	4,320	1,444
Panel E: Number of sellers per buyer (2010)						
Mean	24.04	41.68	17.55	27.92	16.85	47.09
Median	10	15	10	12	9	16
Min.	1	1	1	1	1	1
Max.	3,629	2,795	3,629	1,353	3,629	2,795
Panel F: Number of sellers' prefectures per buyer (2010)						
Mean	5.75	7.89	4.91	6.53	4.75	8.30
Median	4	6	4	5	4	6
Min.	1	1	1	1	1	1
Max.	46	46	46	40	46	46

Note: Sellers whose employment size is less than 10 persons are excluded. Sellers who have a capital relationship (parents, affiliates, or mutually owned) with their buyers are excluded. Only manufacturing buyers are included.

Figure 3. The Relationship between Distance and Supplier Characteristics



Note: The 2010 network sample is used.

Table 4: Buyer's Productivity and the Number of Domestic Sourcing Prefectures

Dep Var: ln(# sellers' prefectures)$_{buyer}$								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	2005				2010			
Measure of Buyer's TFP	OP	Index	Sales/Emp	VA/Emp	OP	Index	Sales/Emp	VA/Emp
ln(TFP)$_{buyer}$	0.447***	0.532***	0.394***	0.322***	0.149***	0.356***	0.365***	0.283***
	(0.056)	(0.062)	(0.021)	(0.017)	(0.033)	(0.047)	(0.022)	(0.020)
Buyer's Ind FE	yes	yes	yes	yes	yes	yes	yes	yes
Buyer's Prefecture FE	yes	yes	yes	yes	yes	yes	yes	yes
R_sq	.14	.144	.23	.183	.148	.151	.246	.198
Nb of Obs	8159	7631	8186	8167	7059	7022	7089	7047

Note: The regression sample includes manufacturing buyers only and domestic suppliers that are either manufacturing or non-manufacturing. The unit of observation is at the buyer level. All regressions include buyer's industry and buyer's prefecture fixed effects. Columns (1) through (4) use the 2005 cross-section sample, while columns (5) through (8) use the one from 2010. Standard errors, clustered at the buyer's industry level, are reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 5: Relationship between Distance and the Number of Sellers Across Domestic Regions

Dependent Variable: ln(# sellers)$_{buyer, seller's pref}$				
	(1)	(2)	(3)	(4)
Sample	2005		2010	
ln(dist)$_{buyer,seller's pref}$	-0.0904***	-0.150***	-0.0999***	-0.157***
	(0.001)	(0.001)	(0.001)	(0.001)
Buyers' Industry FE	yes		yes	
Buyers' Prefecture FE	yes		yes	
Sellers' Prefecture FE	yes	yes	yes	yes
Buyer's FE		yes		yes
R_sq	.164	.555	.181	.548
Nb of Obs	121476	121476	149588	149588

Note: The regression sample includes manufacturing buyers only and domestic suppliers that are either manufacturing or non-manufacturing. The unit of observation is at the buyer-(seller's)prefecture level. All regressions include sellers' prefecture fixed effects. Standard errors, clustered at the buyer level, are reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 6: Distance, Nb of Sellers, and Relationship-Specificity of Inputs

Dependent Variable: ln(# sellers)$_{buyer, seller's pref, sector}$				
	(1)	(2)	(3)	(4)
Sample	2005		2010	
Measure of RS	BJRS	Rauch	BJRS	Rauch
ln(dist)$_{buyer,seller's pref}$	-0.0285***	-0.0187***	-0.0305***	-0.0207***
	(0.002)	(0.001)	(0.002)	(0.001)
ln(dist)$_{buyer,seller's pref}$ x RS$_{seller's ind}$	0.0424***	-0.005***	0.0641***	-0.00146
	(0.006)	(0.002)	(0.006)	(0.001)
Buyer's FE	yes	yes	yes	yes
Sellers' Prefecture FE	yes	yes	yes	yes
Sellers' Industry FE	yes	yes	yes	yes
R_sq	.275	.275	.24	.257
Nb of Obs	102874	103115	164373	133610

Note: The regression sample includes manufacturing buyers only and domestic suppliers that are either manufacturing or non-manufacturing. The unit of observation is at the buyer-(seller's)prefecture-sector level. All regressions include sellers' industry, sellers' prefecture, and buyer fixed effects. Standard errors, clustered at the buyer level, are reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 7: Distance and Seller's Productivity

Dependent Var: $\ln(\text{Sales/ Emp})_{\text{buyer, seller}}$		
Sample	2005	2010
$\ln(\text{dist})_{\text{buyer,seller}}$	0.0504***	0.0517***
	(0.001)	(0.001)
Sellers' Industry FE	yes	yes
Sellers' Prefecture FE	yes	yes
Buyer's FE	yes	yes
R_sq	.682	.67
Nb of Obs	341494	433077

Note: The regression sample includes manufacturing buyers only and domestic suppliers that are either manufacturing or non-manufacturing. The unit of observation is at the buyer-seller level. All regressions include sellers' industry, sellers' prefecture, and buyer fixed effects. Standard errors, clustered at the buyer level, are reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 8: Buyer's Productivity and the Likelihood of Offshoring

Dep Var: Dummy for Buyer's Starting to Offshore between 2005 and 2010				
	(1)	(2)	(3)	(4)
Sample		2010		
Measure of Buyer's TFP	OP	Index	Sales/Emp	VA/Emp
$\ln(TFP)_{buyer,2005}$	0.00856	0.0567***	0.0343***	0.0255***
	(0.021)	(0.021)	(0.008)	(0.009)
Buyer's Ind FE	yes	yes	yes	yes
Buyer's Prefecture FE	yes	yes	yes	yes
R_sq	.0794	.0873	.0854	.0822
Nb of Obs	4506	4172	4522	4509

Note: The regression sample includes manufacturing buyers only and domestic suppliers that are either manufacturing or non-manufacturing. The unit of observation is at the buyer level. All regressions include buyer's industry and buyer's prefecture fixed effects. Standard errors, clustered at the buyer's industry level, are reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 9: Relationship-specificity of Inputs and Likelihood of Offshoring

Dep Var: import dummy$_{buyer, sector}$		
Measure of RS	BJRS Intermediation Index	Rauch Index
$RS_{seller's\ ind}$	0.264***	-0.0550***
	(0.018)	(0.008)
Buyer's FE	yes	yes
R_sq	.43	.441
Nb of Obs	75786	75786

Note: The regression sample includes manufacturing buyers only and domestic suppliers that are either manufacturing or non-manufacturing. The unit of observation is at the buyer-(seller's)sector level. Import data are only available at the 2-digit level. All regressions include buyer fixed effects. Standard errors, clustered at the buyer level, are reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 10: Buyer's Offshoring and Changes in the Pattern of Domestic Outsourcing

Dep Var	$\Delta\ln(\text{sales})_{\text{buyer, 2005-2010}}$		$\Delta\ln(\text{TFP})_{\text{buyer, 2005-2010}}$		$\Delta\ln(\#\text{ pref})_{\text{buyer, 2005-10}}$		$\Delta\text{Avg }\ln(\text{dist})_{\text{buyer, 2005-}}$	
	(1)	(2)			(3)	(4)	(5)	(6)
Offshore Dummy	0.0636***	0.0685***	0.0354*	0.0328*	0.0286	0.0202	-0.0120	-0.0108
	(0.022)	(0.022)	(0.019)	(0.018)	(0.024)	(0.024)	(0.034)	(0.034)
$\Delta\ln(\text{sales})_{\text{buyer, 2005-2010}}$						0.117***		-0.0173
						(0.016)		(0.039)
Buyer's Ind FE	yes	yes	yes	yes	yes	yes	yes	yes
Buyer's Prefecture FE		yes		yes	yes	yes	yes	yes
R_sq	.0992	.112	0.168	0.179	0.098	0.12	0.077	0.077
Nb of Obs	4522	4522	4506	4506	4386	4386	4386	4386

Note: The regression sample includes manufacturing buyers only and domestic suppliers that are either manufacturing or non-manufacturing. The unit of observation is at the buyer level. All regressions include buyer's industry and buyer's prefecture fixed effects. Standard errors, clustered at the buyer's industry level, are reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 11: Offshoring and Supplier Churning

Dep Var:	Drop Dummy		Add Dummy	
	(1)	(2)	(3)	(4)
$d(\text{Imp Dummy})_{buyer}$	0.0131	0.0150*	0.0284**	0.0229**
	(0.008)	(0.009)	(0.013)	(0.012)
$\ln(\text{sales})_{buyer,t-1}$	0.000567		-0.0125***	
	(0.002)		(0.002)	
$d\ln(\text{sales})_{buyer,t}$	-0.0277***		0.0801***	
	(0.010)		(0.010)	
$\ln(\text{sales})_{seller,t-1}$	0.0124***		0.00907***	
	(0.001)		(0.002)	
$d\ln(\text{sales})_{seller,t}$	-0.0279***		0.0580***	
	(0.005)		(0.005)	
$\ln(\text{distance})_{buyer-seller}$	0.00801***	0.00818***	0.0187***	0.0193***
	(0.001)	(0.001)	(0.002)	(0.002)
$\ln(\text{emp})_{buyer,t-1}$		0.000329		-0.0168***
		(0.002)		(0.002)
$d\ln(\text{emp})_{buyer,t}$		-0.0338***		0.0978***
		(0.011)		(0.013)
$\ln(\text{emp})_{seller,t}$		0.0155***		0.0105***
		(0.002)		(0.002)
$d\ln(\text{emp})_{seller,t}$		-0.0327***		0.0538***
		(0.005)		(0.005)
Buyers' Industry FE	yes	yes	yes	yes
Buyers' Prefecture FE	yes	yes	yes	yes
Sellers' Industry FE	yes	yes	yes	yes
Sellers' Prefecture FE	yes	yes	yes	yes
R_sq	.0462	.0459	.0661	.0647
Nb of Obs	53869	53869	62060	62060

The sample includes only manufacturing firms that did not import in 2003-2005. The unit of observation is at the buyer-seller level. Standard errors (clustered at the buyer level) in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Appendix

Table A1: Summary Statistics of the Original TSR Data and the Merged Sample

	Full TSR sample (A in Table 1)					
	2005			2010		
	Nb Obs	Nb of Sellers		Nb Obs	Nb of Sellers	
		mean	median		mean	median
Agriculture and forestry	8,888	2.77	2	13,476	2.85	2
Fishing	2,668	3.68	2	2,708	3.48	2
Mining	5,762	5.21	3	6,176	5.72	3
Construction	1,013,087	5.27	3	1,242,916	5.46	3
Manufacturing	842,034	7.24	3	1,002,775	7.57	3
Electricity, gas, and water supply	13,349	32.48	4	14,548	27.87	4
Information services	56,181	5.10	2	91,822	6.03	2
Transportation	106,034	4.65	3	152,774	5.53	3
Wholesale and retail trade	959,720	5.11	3	1,159,663	5.33	3
Finance and insutrance	29,675	7.48	2	30,492	6.12	2
Housing and real estate	50,687	3.86	2	117,443	4.83	2
Research	49,521	3.61	2	91,459	4.46	2
Hotels and accomodation	37,103	3.86	2	53,122	4.10	2
Living service	48,824	4.24	2	60,287	4.41	2
Education	9,068	3.87	2	18,530	5.59	2
Medical services	19,660	3.07	2	45,096	3.88	3
Miscellaneous services	25,967	6.20	3	34,252	7.31	3
Services, not elsewhere classified	95,950	3.61	2	117,521	3.70	2
Public servies	34	8.50	5.5	6	3.00	3
Not available	211,878	2.00	1	208,102	3.41	2

Table A2: Summary Statistics of the Original TSR Data and the Merged Sample

	Restricted TSR sample (B in Table 1)			Sample Merged the Basic Survey (C in Table 1)			
	Nb Obs	Nb of Sellers		Nb Obs	% pair merged	Nb of Sellers	
		mean	median			mean	median
2005							
Food products and beverages	41,204	5.84	4	14,916	36.20	14.43	8
Textiles	12,038	4.49	3	2,357	19.58	7.06	5.5
Lumber and wood products	10,464	4.84	3	2,700	25.80	15.00	8
Pulp, paper and paper products	12,235	6.58	4	4,740	38.74	18.23	8
Printing	13,905	4.88	3	5,276	37.94	13.99	6
Chemical products	22,501	10.39	5	10,402	46.23	18.00	9
Petroleum and coal products	1,440	9.86	5	1,105	76.74	32.50	9.5
Plastic products	15,326	5.62	3	5,013	32.71	11.24	7
Rubber products	4,994	7.80	3	1,231	24.65	12.43	8
Ceramic, stone and clay products	15,997	5.69	3	3,729	23.31	12.03	7
Iron and steel	12,418	9.82	4	5,926	47.72	21.24	9
Non-ferrous metals	7,755	8.93	4	3,436	44.31	17.53	7
Fabricated metal products	30,666	4.70	3	7,085	23.10	10.75	7
Machinery	61,551	7.33	4	27,234	44.25	20.62	8
Electrical machinery and appliances	33,674	11.71	4	10,091	29.97	19.11	7
Computer and electronic equipment	12,785	18.75	5	12,964	101.40	44.70	9
Electronic parts and devices	11,124	7.67	4	5,952	53.51	14.10	7
Transportation equipment	31,735	14.56	4	21,913	69.05	27.81	10
Miscellaneous mfg. industries	9,965	5.27	3	3,575	35.88	15.15	7
2010		mean	median			mean	median
Food products and beverages	50,378	6.65	4	17,874	35.48	16.86	10
Textiles	15,435	5.00	3	2,999	19.43	8.69	7
Lumber and wood products	12,985	5.49	3	3,336	25.69	18.33	10
Pulp, paper and paper products	15,824	7.71	4	5,808	36.70	22.17	9.5
Printing	18,241	5.49	3	6,857	37.59	17.06	8
Chemical products	28,583	12.23	6	13,331	46.64	22.91	11
Petroleum and coal products	1,813	11.12	5	1,332	73.47	39.18	14
Plastic products	19,919	6.53	4	6,709	33.68	14.55	8
Rubber products	6,255	8.76	4	1,671	26.71	16.38	8
Ceramic, stone and clay products	20,265	6.54	4	5,187	25.60	16.52	9
Iron and steel	15,482	11.16	5	7,472	48.26	25.94	11
Non-ferrous metals	9,972	10.23	4	4,397	44.09	21.99	10
Fabricated metal products	40,307	5.48	4	8,973	22.26	13.37	9
Machinery	81,401	8.68	4	34,769	42.71	25.93	11
Electrical machinery and appliances	40,385	12.62	5	12,844	31.80	23.79	10
Computer and electronic equipment	14,546	19.82	5	13,775	94.70	45.61	11
Electronic parts and devices	14,375	9.02	4	7,637	53.13	17.28	9
Transportation equipment	40,361	16.99	5	28,106	69.64	34.61	12
Miscellaneous mfg. industries	12,457	5.85	3	4,599	36.92	18.70	8.5