DISCUSSION PAPER SERIES

DP15056

PRODUCT MARKET COMPETITION AND THE RELOCATION OF ECONOMIC ACTIVITY: EVIDENCE FROM THE SUPPLY CHAIN

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FINANCIAL ECONOMICS

ISSN 0265-8003

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Discussion Paper DP15056
Published 17 July 2020
Submitted 17 July 2020

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Abstract

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JEL Classification: G30, L1, O3

Keywords: establishment relocation, Supply Chain, Product Market Competition, knowledge spillover

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Acknowledgements
We are grateful to Stephen Brown, Liu Yang, Xiaoyun Yu, and participants at the Monash University brownbag for valuable comments.

Product Market Competition and the Relocation of Economic Activity: Evidence from the Supply Chain[◊]

First Version: February, 2020

This version: July, 2020

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Abstract

We show that increasing competition changes the location of economic activity and, in turn, affects supply chain relationships. Using establishment-level data, we find that when upstream product markets become more competitive, suppliers are more likely to relocate their establishments closer to customers. Following the supplier's relocation, its sales to the customer increase, its relationship with the customer is less likely to be terminated, and its innovation is more aligned with the customer's innovation. However, the improved relationship, by causing the supplier to engage more in innovation dedicated to the customer, adversely affects creative innovation, which is known to drive growth.

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1. Introduction

Increasing competition in a knowledge-based economy is one of the factors reshaping firm location strategies (henceforth, "firm geography") and affecting local employment and economic development. Inter-firm linkages play a crucial role in understanding this process. Over the last two decades, upstream firms (suppliers) in the U.S. opened new establishments or relocated an existing establishment closer to their downstream customers—a trend that is not explained by the simple fact that the economy is possibly getting more crowded over time (see Figure 1). We argue that a possible reason for this trend is that, due to increasing globalization during this period, supplier firms are facing more competition in the product market. Relocating closer to the customer allows the supplier to "protect" a part of the market, placing the supplier in a position from which it can benefit more from knowledge spillover, cooperation in R&D, and coordination of various aspects of the supply chain relationship.

A substantial literature—dating back to Marshall (1890)—addresses firms' location choice. While the early literature focused on the importance of transportation costs and natural advantages (e.g., resource and labor market advantages), subsequent work has emphasized particular types of externalities that create "agglomeration economies".[1] Clearly, many factors affect a firm's location choice, and the optimal locations of the firm's establishments need not be in close proximity to its principal customer(s). However, upstream competitive pressure could change the relevant tradeoffs, potentially incentivizing suppliers to relocate their existing establishments or open new establishments closer to those of their major customers to forge closer supply-chain relationships. This is the evidence we present in this paper. We show that more intense upstream competition is associated with firms creating new establishments in close proximity to their customers, and subsequent to such relocation, the relationship becomes

[1] Other than the traditional economies of scale, the literature emphasizes externalities stemming from the availability of specialized labor supply or inputs that attract firms into a location (localization economies), or those due to the overall scale or scope of economic activity in a region (urbanization economies). Kilkenny and Thisse (1999) and Duranton and Puga (2003) provide excellent reviews of this literature.

more durable and relation-specificity of the firms' R&D and innovation activities increase along several dimensions.

Specifically, using establishment location data from the National Establishment Time-Series (NETS) database, and information on the economic links between suppliers and customers from the FactSet Revere–Relationships database and Compustat Segment files for U.S. public firms, we show that upstream suppliers are more likely to relocate or open a new establishment in close proximity to the customer if: (a) the upstream industry is exposed to a major tariff cut, (b) the upstream industry experiences more import penetration during the previous five years, and (c) the upstream firm's competitors are producing products that are more similar to its own (measured using Hoberg and Phillips's (2016) product market similarity measure and Hoberg, Phillips, and Prabhala's (2014) fluidity measure).[2]

We find that, after relocation, the supplier sells more to the customer and its new patents cite more patents of the customer, and conversely. Moreover, the new patents generated by both firms have more overlap (in terms of Hall, Jaffe, and Trajtenberg's (2001) 36 patent classes). The supplier's R&D also becomes more sensitive to the customer's R&D. These results together suggest greater collaboration between the supplier and the customer after relocation. In a similar vein, we find that the supplier's relocation has a positive effect on the duration of the relationship between the customer and the supplier, consistent with the idea that relationship-specific investment creates benefits for the supplier.

Other than these "relationship-level" changes, we find that relocations are also associated with changes in some important operating characteristics of both supplier and customer firms. We find that the customer's inventory holdings decrease after relocation, consistent with just-in-time inventory management. The outstanding purchase

[2] Throughout, by "relocation," we mean either the opening of a new establishment, or the relocation of an existing establishment, within a radius of 100 miles from an existing customer. Our findings are robust to alternate distance criteria of 50 or 150 miles.

obligations of the customer also increase, suggesting that, with improved quality control and operational efficiency, the customer is willing to commit to more future purchases.

We also find that there are significant changes in the supplier's production and innovation strategies after it relocates closer to the customer. In particular, the supplier produces inputs that are more specific and cannot be easily replaced by other suppliers, as evidenced by lower product market similarity and fluidity measures after relocation. This shift in production strategy potentially ties the supplier to a particular customer and reduces its ability to produce inputs for other customers. Further, we find that the supplier engages in more "exploitative" innovation and less "explorative" innovation. Exploitative innovation refines existing products and processes, and in the context of suppliers, is likely to be related to the supplier's relationship with the customer. Explorative innovation, on the other hand, is associated with the invention of new technologies, and benefits the firm in the longer term. Exploitative innovation benefits the customer, and the shift to this style of innovation after relocation may well reflect the exercise of customer bargaining power, at the expense of a more diversified innovation portfolio and long-term benefits for the supplier. These changes represent the "costs" associated with relocating closer and dedicating its innovation and product-mix to the customer, but it offers the benefit of more protection from product market competition.

Relocation decisions are endogenous. Since we conjecture that firms relocate to deepen their relationships with customers and insulate themselves from competition, it is useful for our purposes to establish that the association between relocation and changes in relationship-level outcome variables is not spurious or driven by common factors. To do so, we examine tariff-induced relocations, i.e., relocations that occur immediately after the supplier's industry experiences a significant tariff cut. Following existing literature (e.g., Huang, Jennings, and Yu, 2017; Frésard, 2010; Frésard and Valta, 2012, 2016; Dasgupta, Li, and Wang, 2018), we maintain that these tariff cuts are plausibly exogenous and uncorrelated with firm characteristics that could affect relationship-level variables. We find that these tariff-induced relocations are associated with significant changes in our relationship-level variables.

Not all firms in industries that experience a major tariff cut relocate. Thus, there could be concerns that firms with certain characteristics self-select in choosing to relocate and these same characteristics affect the relationship-level variables. Similar to Acharya and Xu (2017), we use a treatment effect model to address self-selection. Using the exogenous tariff cuts as an instrument, we obtain the Inverse Mills Ratio (*Mills*) from a first-stage Probit model in which the decision to relocate is the outcome variable. In our second-stage regressions that include both relocating and non-relocating firms, we use the *Mills* to control for unobservable factors that might affect the decision to relocate. In all our regressions, the indicator for relocation continues to have a significant effect on the relationship-level variables, but the *Mills* is not significant, suggesting that unobserved relationship-level characteristics are not driving our results.

We also carefully check for pre-trends. If self-selection is driving our results, we would expect to see evidence of deepening relationships even prior to the tariff cut-induced relocations. We find no evidence that the relationship-level variables start to diverge from those of the control group prior to the relocation. In addition, we use the exogenous tariff cuts as an instrument in a two-stage-least squares (henceforth, 2SLS) setting, where the first stage is modelled as a linear probability model, to re-examine the above-mentioned relationship-level effects of relocation. Our conclusions remain.

For both the Heckman model and 2SLS, to achieve identification, the tariff-reduction indicator variable cannot be included in the second stage. This, however, could create an omitted variable problem if the change in tariff cuts itself directly affects the relationship-level variables. To ensure that there is no omitted variable bias in our second-stage estimates, we conduct several tests. First, we focus on a subset of supplier-customer pairs that do not experience relocations. We find that tariff reductions have insignificant effects on the relationship-level variables of these pairs, suggesting that tariff reductions are unlikely to confound the effects of tariff-induced relocations. Next, we re-define tariff-induced relocations as those that occur in the third and fourth year after a major tariff cut in the supplier's industry. A useful feature of this alternative setting is that it allows two years after tariff reduction to elapse before the supplier relocates an establishment closer to the customer. If tariff reductions have direct effects on relationship-level variables, we should observe significant pre-trends for these alternative tariff-induced relocation events. We find that there are no pre-trends, and all the effects show up only after the relocations. Collectively, these results suggest that our identification strategies are unlikely to suffer from omitted variable bias due to the exclusion of the tariff-reduction dummy in the second stages.

Our paper contributes to a long-standing literature on the determinants of corporate investment. In particular, we focus on the spatial dimension of such investment, and how this is shaped by existing supply-chain relationships and product market competition.[3] Studies by Mello and Wang (2012) and Frésard and Valta (2016), for example, find that greater competition from foreign firms reduces domestic corporate investment. However, an advantage of incumbent firms over foreign competitors trying to enter the domestic market is their existing relationships with domestic customers. We show that domestic firms indeed sustain their competitive advantage by relocating their business operations closer to their domestic customers, strengthening the supply chain relationships, and increasing the relationship survival rates as a result of increased competition. Distinct from the papers cited above, we focus not only on capital expenditures (i.e., new plant creations), but also on the scale and nature of investment in R&D and innovation. By focusing on new establishment additions or relocations of existing establishments, our study also relates to the literature on internal resource allocation within the firm (e.g., Tate and Yang, 2015; Giroud and Mueller, 2019; Giroud and Rauh, 2019).

Our study also contributes to a recent literature that tries to understand the determinants of firm geography and why that matters. Giroud and Rauh (2019), for example, find that state taxes are an important determinant of a firm's geography. Giroud (2013) finds that proximity of a firm's headquarters and establishments is a strong driver of plant-level productivity, helping to explain the geography of firms. Bernard,

[3] Product market competition has been shown to affect cash holdings and payout policy (Frésard, 2010; John, Knyazeva, and Knyazeva, 2011; Hoberg et al., 2014), investment efficiency (Stoughton, Wong, and Yi, 2017), investment-Q sensitivity (Akdoğu and MacKay, 2008), and firm profitability and capital structure (Khanna and Tice, 2000; Xu, 2012).

Moxnes, and Saito (2019) show that improvement in transportation infrastructure helps reduce the distance between a supplier and the customer, thereby improving the supply chain relationship. Firm geography also matters for knowledge spillover and innovation. Chu, Tian, and Wang (2019) find that the relocation of a firm's headquarters closer to a supplier incentivizes the latter to produce more patents that overlap with the customer's technological space. Frésard, Hoberg, and Phillips (2020) show that firms with high realized innovation are more likely to be acquired by a vertically-related buyer.

Our study utilizes a comprehensive establishment-level database to first show that more intense competition induces suppliers to relocate closer to customers. In doing so, we document and provide a possible explanation for the phenomenon that over time, economic activity along the supply chain is clustering closer to the downstream firms. In addition, we examine the effect of suppliers' competition-induced relocations on knowledge spillover along the supply chain. Importantly, in our study, while the supplier enjoys knowledge spillover from the customer, its new patents are more exploitative, rather than explorative, and the supplier produces more customized products. Explorative innovation is important for economic growth. Building on Schumpeter's (1939) idea of creative destruction, several authors have argued that firms, and indeed the entire economy, can emerge stronger from "hard times" as the return from exploitative innovation decreases relative to that from explorative innovation (Manso, Balsmeier, and Fleming, 2019). Our results suggest that while competition does stimulate more innovation and knowledge spillover, it can also reduce the incentives to engage in explorative investment, thereby possibly adversely affecting economic growth (Akcigit and Kerr, 2018; Manso et al., 2019).

2. Data and Variable Construction

We construct our sample from several databases for U.S. firms: (i) the National Establishment Time-Series (NETS) database; (ii) the economic links between suppliers and customers obtained from FactSet Revere and Compustat Segment files; (iii) the data on purchase obligations sourced from firms' 10-K filings; (iv) corporate innovation data obtained from Kogan, Papanikolaou, Seru, and Stoffman (2017), and finally (v) accounting and market data sourced from Compustat Fundamentals Annual file and Center for Research in Securities and Prices (CRSP). The definitions of all the key variables are detailed in Appendix Table A1.

2.1. Establishment Data

We collect information on subsidiaries, branches, and plants of multistate firms from the NETS database between 1991 and 2015, which is supplied by a credit rating agency, Dun and Bradstreet (D&B), and is maintained by Walls and Associates.[4] D&B collects comprehensive information on establishments as part of its credit evaluation process (Faccio and Hsu, 2017). D&B also obtains information from independent sources including phone calls to suppliers and customers, legal and bankruptcy filings, press reports, and government records (Heider and Ljungqvist, 2015; Ljungqvist, Zhang, and Zuo, 2017). In addition, business entities are required to register with D&B, if they wish to bid for government contracts (Barrot and Nanda, 2020).

A unique feature of the NETS database is that each establishment is assigned a permanent identifier, which allows us to trace an establishment's location throughout its entire life, including all relocations. Moreover, for each establishment, the NETS database provides us with annual information on historical locations (FIPS code, state, county, and longitude and latitude coordinates), relocation year, sales in dollars, the number of employees, and the first year (or opening year for new establishments) and the last year of active business. As such, the NETS database is free from survivorship bias. We match establishments in the NETS database with firms in Compustat Fundamentals Annual file and CRSP by their historical legal names, using a fuzzy matching algorithm recommended by the Wharton Research Data Service (WRDS) Research and Support. To ensure the integrity of the match, we supplement this matching procedure with careful

[4] Our sample period is constrained by the availability of the NETS database.

manual checking. As is standard in the literature, we do not consider financial firms (those with SIC codes 6000-6999) and noncommon stocks (those with CRSP share codes different from 10 or 11).

2.2.Supply Chain Data

We obtain information on customer-supplier relationships from FactSet Revere–Relationships database, which is available from 2003. FactSet Revere collects company-level relationship information from corporate filings, investor presentations, websites, and press releases (Dai, Liang, and Ng, 2020). An advantage of FactSet Revere is that it provides us with Compustat's unique firm identifiers (GVKEY), facilitating merging across databases.

We also obtain information on supply chain relationships before 2003 from the Compustat Segment file. Regulation SFAS No. 131 requires firms to disclose their customers that account for more than 10% of their total sales, although many firms also disclose customers below this threshold (Dasgupta, Zhang, and Zhu, 2015). We hand-match firms in the Compustat Segment file with those in the Compustat Fundamentals Annual file. Our final sample of raw supply chain data (before matching with firm-level characteristics) contains 80,414 customer-supplier pair-year observations.[5]

Having constructed a comprehensive dataset of supply-chain relationships, we merge it with the NETS dataset to identify the establishment locations of customers and suppliers. We construct a dummy variable, *Relocation*, which is equal to 1 if a supplier relocates business activities to be closer to a customer and 0 otherwise. A supplier firm is deemed to have relocated its business activities to be in close proximity to its customer if the following scenarios occur: (i) the supplier opens a new establishment in close proximity (within 100 miles) to the customer's establishment, and/or (ii) the supplier relocates an existing establishment to be closer to the customer's establishment (within 100 miles). Our results are robust to alternative definitions of close proximity ranging

[5] Our sample does not contain government customers.

from 50 miles to 150 miles. For ease of exposition, we refer to these suppliers as "relocated suppliers."

We construct two alternate measures of pair-level relationship strength. The first measure is *Pair Sales*, which is computed as the pair-level sales scaled by the customer's cost of goods sold. The second measure is a dummy variable, which is equal to 1 if the supplier-customer relationship terminates and 0 otherwise.

2.3. Product Market Competition Measures

We employ both industry-level and firm-level measures of a firm's product market competitiveness. First, we utilize large reductions in industry import tariff rates as a shock to a firm's product market competition (Frésard, 2010; Valta, 2012; Huang et al., 2017). Prior literature suggests that significant reductions in tariff rates will expose domestic firms to foreign competition, causing prices and profit margins to decrease. Dasgupta et al. (2018), for example, show that shocks to market competition caused by significant tariff cuts increase the likelihood of CEO turnover.

To identify large import tariff rate reductions, we collect U.S. import data on duties and custom values of imports.[6] For each three-digit SIC industry in a given year, we calculate the tariff rate as the collected duties divided by the custom value of imports. Following Huang et al. (2017), we define large tariff reduction events as (i) an industry's tariff rate in the current year is lower than that in the prior year by more than two times the median tariff rate reduction of the industry during our sample period,[7] and (ii) this reduction is a nontransitory change, i.e., it is not preceded or followed by a major tariff increase greater than 80% of the reduction. Our regression analysis uses a dummy variable, *Tariff Reduction*, which is equal to 1 for the two years after a supplier's industry has experienced a large tariff cut and 0 otherwise.

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[6] The US import data is from Peter K. Schott's website: https://faculty.som.yale.edu/peterschott/international-trade-data/

[7] The results are similar if we identify tariff reductions as three times the median (alternatively, mean) or two times the mean tariff reduction for the industry during our sample period.

Second, we use industry-level import penetration as an alternative measure of the level of competition across industries (Bertrand, 2004; Xu, 2012). We obtain the U.S. import data from Peter K. Schott's website and data on domestic production from the Bureau of Economic Analysis of the U.S. Department of Commerce. For each three-digit NAICS (Northern American Industry Classification System) industry in each year, we compute the import penetration index as the total industry import value divided by the sum of total industry import value and the industry gross domestic production. We then calculate *Import Penetration* at the three-digit NAICS level as the five-year rolling average of the industry import penetration index.

The third measure is *Product Market Fluidity*, which is developed by Hoberg et al. (2014) to capture how intensively a firm's product market is changing.[8] To construct the measure, Hoberg et al. (2014) obtain firms' product text descriptions from firms' 10-K filings and analyze the extent to which a firm's product words overlap with its rival firms' aggregate change of product vocabulary. A higher *Product Market Fluidity* value is associated with greater competition threat for a firm. Our fourth measure is *Product Market Similarity*, which captures a firm's product similarity to its peers and is developed by Hoberg and Phillips (2016) by parsing firms' 10-K business descriptions.[9] A higher *Product Market Similarity* value indicates greater competitive threats posed by peer firms.

2.4. Innovation Measures

We obtain innovation data from Kogan, Papanikolaou, Seru, and Stoffman (2017) (KPSS) for the period from 1991 to 2010.[10] Following prior research, we use the application year of each patent to match the innovation data with our supply-chain data. Since the innovation database contains patent applications that are eventually granted, it

[8] The product market fluidity measure is from the Hoberg-Phillips data library: http://hobergphillips.tuck.dartmouth.edu/

[9] Hoberg and Phillips (2016) compute the firm-by-firm pairwise similarity scores based on the words used in firms' product descriptions in their 10-K filings. *Product Market Similarity* is then the sum of the pairwise similarity scores between the firm and its peers in the same text-based network.

[10] The data are available at https://iu.app.box.com/patents.

is known to suffer from truncation issues (i.e., pending patent applications filed in the last few years of the sample period are not included in the database). We thus follow the literature (e.g., Hall et al., 2001) and adjust for this truncation bias using weight factors estimated from the empirical distribution of the application grant time gap. Citation counts also suffer from a similar truncation issue, whereby patents continue to be cited after the end of our sample period, even though we can only observe citations made up to 2010. We use the approach of Hall et al. (2001) to adjust the truncation bias in citation information based on the empirical citation-lag distribution.

Our measures of innovation similarity between supplier's patents and customer's patents are constructed based on cross-citations, the commonality in the scope of innovation activities, and the sensitivity of a supplier's R&D investment to a customer's R&D. First, we create a dummy variable, *Sup_Cross_Citations*, which is equal to 1 if a supplier's patent cites the customer's existing patent portfolio, and 0 otherwise. We also construct *Ln(Supplier Cross-Citations)*, which is the natural logarithm of 1 plus the number of citations of the customer's patents made in the supplier's patents. Similarly, we construct a dummy variable, *Cus_Cross_Citations*, which is equal to 1 if a customer's patent cites its supplier's existing patent portfolios and 0 otherwise. *Ln(Customer Cross-Citations)* is the natural logarithm of 1 plus the number of citations of the supplier's patents made in the customer's patents.

Second, we follow Jaffe (1986) and compute a measure of technological proximity of suppliers and customers. Specifically, technological proximity in a given year t is the correlation between the supplier's patent classes and the customer's patent classes.

$$Technological\ Proximity = \frac{P_s P_c'}{(P_s P_s')^{1/2} \times (P_c P_c')^{1/2}}$$

where $P_k = (P_{k1}, \dots, P_{k36})$; $k \in (s, c)$ is a vector of the innovation activity of supplier s (or customer c). Each element of P_k is the ratio of the number of patents in one of the 36 technology categories applied for (and eventually awarded) over the past three years to the total number of patents applied for over the same period. Following Hall et al. (2001), we classify patents into 36 categories based on the patent class number assigned by the USPTO.

The third measure of innovation similarity is the sensitivity of supplier's R&D expenditure to a customer's R&D expenditure. If the supplier and customer cooperate more on innovation, we expect that the supplier's R&D expenditure will become more correlated with that of the customer. We measure R&D as the ratio of a firm's R&D expenditure divided by total assets and set missing R&D values to zero (Allen and Phillips, 2000; Griffith, Redding, and Van Reenen, 2004).

2.5. Working Capital Measures

We employ two alternate measures of working capital: purchase obligations and inventory. We collect information on customers' purchase obligations and use it as a proxy for the strength of the customer's supply chain relationships with trading partners (Costello, 2013). These purchase obligations are disclosed in a footnote of a firm's 10-K filing. Due to SEC requirements related to Sarbanes-Oxley, firms are required to report these contracts in their 10-K filings since December 2003. However, because many firms voluntarily disclose these obligations prior to 2003, we are able to obtain an extended sample over the period 1993 to 2015. Following Almeida, Hankins, and Williams (2017), we employ a crawling algorithm to search for "purchase obligation" or "purchase commitments" line items in a firm's 10-K report in a given year. A customer's *Purchase Obligation* is computed as the sum of future dollar values of purchase obligations divided by total assets.

Customers can maintain a lower inventory of inputs to its production process if the suppliers can replenish inventory in a timely manner.[11] To the extent that the supplier's relocation enhances the efficiency of just-in-time logistics, we expect that a decrease in the customer's inventory level is also a reasonable indicator of improved supply chain

[11] Customers can also maintain lower inventory of finished goods if uncertainty regarding the availability of inputs is mitigated.

relationship. We thus construct *Inventory* as total inventory divided by book value of total assets.

2.6. Control Variables

Our multivariate analyses control for firm size, *Ln(Market Cap)*, defined as the natural logarithm of a firm's market capitalization (price times the number of shares outstanding). In addition, we control for *Book Leverage* computed as the sum of long-term debt and debt in current liabilities divided by total assets, since a firm' leverage can affect its relationship with trading partners (Dass, Kale, and Nanda, 2015). We also include the natural logarithm of sales, *Ln(Sale)*, because a firm's revenue can affect its willingness to make relationship-specific investments. We control for the fact that more profitable firms and firms with more cash holdings would find it easier to relocate toward a customer by including *Return on Assets*, defined as operating income before depreciation divided by the book value of total assets, and *Cash Holdings*, computed as cash and short-term investments divided by total assets.

We control for *Market-to-Book*, which is the ratio of market capitalization divided by the book value of equity, since growth firms may be more aggressive in their investments in supply chain relationships. Moreover, firms with more fixed assets may face different constraints when relocating their establishments compared to other firms with low tangible assets. We control for this with *Asset Tangibility*, which is computed as net property, plant, and equipment divided by total assets. Firms spending more on R&D and advertising tend to experience low ex-post product market competition and have stronger product differentiation (Hoberg and Phillips, 2016). We therefore include *R&D* variable, computed as R&D expenditure scaled by sales, and *Advertising* variable, calculated as advertising expenditure divided by sales. Finally, since financial constraints may affect a firm's decision to make relationship-specific investments, our regressions control for this effect using the *Kaplan-Zingales Index* (Kaplan and Zingales, 1997).

2.7. Sample and Summary Statistics

Table 1 reports the summary statistics for variables used in our regression analyses. Panels A and B present descriptive statistics for customer firms and supplier firms, respectively, while Panel C shows the summary statistics for the measures of innovation similarity between suppliers and customers. In Panel A, the average customer has a market capitalization of $3.8 billion, *Ln(Sale)* of 8.22, a *Book Leverage* ratio of 0.24, a *Market-to-Book* ratio of 3.15, a *Return on Assets* ratio of 0.12, and a ratio of cash holdings to total assets of 15%. Customers' fixed assets are, on average, worth about 31% of a firm's total assets. In addition, customers spend 5% and 1.4% of their sales revenue on R&D and advertising expenditure, respectively, and they have an average *Kaplan–Zingales Index* of 0.31. On average, purchase obligations are worth 3.5% of total assets.

We report the summary statistics for supplier firms in Panel B. Approximately 11.9% of the suppliers relocate an existing establishment or open a new establishment in close proximity to their customers. Suppliers are also much smaller than the customers, with an average market capitalization of $270 million, *Ln(Sale)* of 5.31, a *Book Leverage* ratio of 0.19, a *Market-to-Book* ratio of 3.29, a *Return on Assets* ratio of 0.06, a *Cash Holdings* ratio of 0.26, and an *Asset Tangibility* ratio of 0.26. On average, suppliers spend 21% of their revenues on R&D and 1.3% of their revenues on advertising. Compared to the customers, suppliers are slightly more financially constrained, with an average *Kaplan–Zingales Index* of 0.34. Among the measures of product market competition, the average values of *Tariff Reduction*, *Import Penetration*, *Product Market Fluidity*, and *Product Market Similarity* are 0.37, 0.25, 6.82, and 4.60, respectively.

Panel C reports the summary statistics of pair-level measures between customers and suppliers. On average, sales from suppliers to customers are worth 6.4% of customers' cost of goods sold *(Pair Sales)*, suggesting that these customers are important to suppliers. Suppliers are more likely to cite customers' patents, with 7.5% of suppliers' new patents citing the customers' existing patent portfolios, compared to 6.6% of the customers' new patents citing their suppliers' existing patent portfolios. Finally, the average value of

Technological Proximity, a measure of innovation correlation between suppliers and customers, is 11.68%.

[Insert Table 1 About Here]

3. Empirical Results

3.1. Proximity of Supplier and Customer Establishments Over Time

The intersection of two comprehensive databases on establishment locations and supply chain relationships allows us to shed initial light on the evolution of geographic proximity of suppliers and customers in the U.S. over time. Figure 1 Panel A depicts the average minimum distance between supplier establishments and customer establishments during the period from 1991 to 2015. We observe a decreasing trend in the shortest distance, from 205 miles in 1991 to 85 miles by the end of 2015. This declining proximity is somewhat surprising given that the last twenty-five years has also witnessed significant advances in information technology, which arguably help reduce the need for establishments to be located closer to each other. The fact that firms along the supply chain still chose to locate their establishments in close proximity to each other suggests that there are additional benefits that only geographic proximity can bring about. The pattern fits the narrative that globalization and increasing competition has pushed upstream firms closer to their downstream customers. While we do not attempt to explain this time series pattern in this paper, we present cross-sectional evidence consistent with this narrative.

A potential concern regarding the time trend observed in Figure 1 Panel A is that the economy gets more crowded over time, rendering the decreasing proximity to be mechanical. One may, therefore, observe the declining proximity for any random firm pairs that are not necessarily in a supply chain relationship. To test this alternative hypothesis, for each supplier in a given year, we randomly select 10 "pseudo" customers that are in the same industry as the actual customer firm, but do not have an actual supply chain relationship with the supplier. We proceed as before and compute the shortest distance between the supplier's establishment network and the pseudo customer's establishment network. We repeat this procedure 1,000 times and calculate the average shortest distance across all pseudo pairs in each year.

To the extent that the decreasing geographic proximity of firms is mechanical, we expect to a see a decreasing time trend similar to Figure 1 Panel A. On the other hand, if the proximity of pseudo pairs is random, then a reduced distance separating one pair can offset an increased distance separating another pair, causing the average distance to be relatively stable over time. Figure 1 Panel B depicts the average shortest distance between these pseudo pairs. We can see that the average minimum distance between the pseudo pairs is relatively steady over time, with some variation within a narrow range between 426 miles and 450 miles. These results suggest that the declining time trend documented for the actual supplier-customer pairs (Panel A) is unlikely to be mechanical.

[Insert Figure 1 About Here]

3.2. Product Market Competition and Supplier Relocation

Our central hypothesis is that increased market competition can induce suppliers to relocate closer to their customers, allowing them to enjoy the benefits of closer proximity and gain competitive advantage over competitors. We note that while proximity is unlikely to be costless for the supplier (otherwise the supplier would have located closer to the customer even in the absence of the competitive threat), competitive pressure could threaten survival and lower the payoff from remaining "independent", making relocation more attractive, even at the cost of greater dependence on a principal customer.

We start the first part of our main empirical analysis by examining whether the supplier's product market competition influences its decision to relocate business activities to be in closer proximity to the customer. We then examine whether the supply chain relationship improves following the supplier's relocation.

3.2.1. Tariff Rate Reductions as a Quasi-natural Experiment and Establishment Relocation

Large tariff cuts provide us with a good setting to examine the effect of product market competition on firms' relocation decisions for at least two reasons. First, these large tariff reductions are adopted by the federal government mainly due to global economic and political factors, and, therefore, these events are unlikely to be related to firm decisions or characteristics (Huang et al., 2017; Frésard, 2010; Frésard and Valta, 2012, 2016, Dasgupta et al., 2018). Second, significant tariff reductions affect firms in different years during our sample period, which allow us to implement a staggered difference-in-differences analysis to test our hypothesis.

To examine the effect of significant tariff reductions on suppliers' relocation decisions, we estimate a linear probability model at the supplier firm-year level:

$$Relocation_{i,t} = \alpha + \beta\, Tariff\ Reduction_{i,t} + \gamma'\, X_{i,t-1} + \theta_i + \varphi_y + \varepsilon_{i,t}, \tag{1}$$

where, for supplier firm i in year t, $Relocation_{i,t}$ is a dummy variable that is equal to 1 if the supplier relocates an existing establishment and/or opens a new establishment in close proximity (within 100 miles) to one of its customers' establishments and 0 otherwise; $Tariff\ Reduction_{i,t}$ is a dummy variable that is equal to 1 for the two years after a large import tariff rate cut in the supplier firm's industry and is equal to 0 for other years and for firms in industries without tariff changes; $X_{i,t-1}$ represents a vector of firm-level control variables (i.e., *Ln(Market Cap)*, *Ln(Sale)*, *Book Leverage*, *Market-to-Book*, *Return on Asset*, *Cash Holdings*, *Asset Tangibility*, *R&D*, *Advertising*, and *Kaplan–Zingales Index*), and θ_i and φ_y are vectors of firm (or industry) fixed effects and year fixed effects, respectively. Standard errors are clustered at the firm level.[12] We estimate Equation (1) using OLS but confirm that all of our findings do not qualitatively change when using a Probit specification.[13] Angrist (2001) and Angrist and Pischke (2008) show that the coefficients and corresponding t-statistics estimated using OLS are sufficiently accurate. The linear

[12] Our results are robust to double clustering standard errors at the firm and year level.

[13] Specifically, we estimate Equation (1) using the Probit model, whereby firm fixed effects are estimated by demeaning the variables in the regression at the firm level (Wooldridge, 2010; Wooldridge, 2011; Gormley and Matsa, 2014).

probability model also allows us to incorporate industry, firm, and year fixed effects, whereas having a large number of fixed effects in the Probit model may create an incidental parameters problem (Greene, 2004).

Table 2 presents the estimation results. In Column 1, we add industry and year fixed effects. Firm and year fixed effects are included in Column 2. In both specifications, the point estimates on *Tariff Reduction* are positive and statistically significant at the 1% level, indicating that, after the tariff reduction in the supplier's industry, supplier firms are more likely to relocate and/or open new establishments closer to their customers.

The coefficients are also economically significant. For example, Column 1 shows that the estimated coefficient on *Tariff Reduction* is 0.147, which implies that, in the two years after a significant tariff reduction in the supplier's industry, the firm's likelihood of relocating its business activities closer to its customer increases by 14.7% compared to other firms in industries without tariff reductions. This estimate is equivalent to 45.37% (=0.147/0.324) relative to the standard deviation of *Relocation*.[14]

[Insert Table 2 About Here]

3.2.2. Import Penetration and Establishment Relocation

In this section, we further test whether the supplier's relocation is more likely to occur in industries with greater import competition.[15] To examine whether increases in import

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[14] A possible side effect of tariff reductions is that, while firms have an incentive to relocate or open an establishment in close proximity to customers, the relocation of business activities could mean that firms may close down a different establishment elsewhere. An employment implication is that the level of employment within the relocated firm does not change. Although these questions are not the focus of our study, we attempt to examine these predictions in Appendix Table A2. We find that the probability of an establishment closure is significantly higher following relocation, especially when the relocation is motivated by a large tariff reduction. However, the firm's total employment across all establishments does not change following relocation.

[15] Other than tariff rates, import penetration reflects competitive pressure from foreign producers due to exchange rate movements, productivity shifts, and foreign subsidies. Moreover, our measure of import penetration is a five-year cumulative measure, and thus presents a somewhat different indication of competitive pressure than major tariff cuts. Prior research (e.g., Katics and Petersen, 1994; Levinsohn, 1993) shows that an increase in import penetration increases industry competition and reduces domestic firms' profitability. Using import penetration as a shock to a firm's profit margins, Xu (2012) finds that firms experiencing high import penetration industries have lower profit margins and tend to reduce their leverage ratios.

penetration affect a firm's future likelihood of relocation, we estimate the following linear probability regression specification at the supplier firm-year level:

$$Relocation_{i,t} = \alpha + \beta \; Import \; Penetration_{i,t-1} + \gamma' \, X_{i,t-1} + \theta_i + \varphi_y + \varepsilon_{i,t-1}, \qquad (2)$$

where *Import Penetration*$_{i,t-1}$ is the import penetration measure for the supplier firm's three-digit NAICS industry. Other variables are defined in Equation (1).

Table 3 reports the estimation results. Column 1 presents the regression controlling for industry and year fixed effects, while Column 2 includes both firm and year fixed effects. We find consistent results in both specifications. The positive and significant coefficient on *Import Penetration* suggests that suppliers in high import competition industries are more likely to relocate their business activities closer to their customers. The effect is also economically significant. For example, the coefficient of *Import Penetration* in Column 1 is 0.228, suggesting that an increase in *Import Penetration* by one standard deviation increases the probability of *Relocation* by 3% (=0.228×0.132×100, where 0.132 is the standard deviation of *Import Penetration*), which is equivalent to 26% of the unconditional probability of *Relocation*.

[Insert Table 3 About Here]

3.2.3. Firm-level Product Market Threats and Establishment Relocation

Our tests thus far employ industry-level shocks to a firm's product market competition to examine the effect of competition on the firm's relocation decision. In this section, we examine this question using firm-level measures of product market competition. As before, we estimate the following linear probability model to examine the effect of supplier firm-level *Product Market Threat* on the probability of *Relocation*:

$$Relocation_{i,t} = \alpha + \beta \; Product \; Market \; Threat_{i,t-1} + \gamma' \, X_{i,t-1} + \theta_i + \varphi_y + \varepsilon_{i,t-1}, \qquad (3)$$

where *Product Market Threat*$_{i,t-1}$, is either *Product Market Fluidity* or *Product Market Similarity*. Other variables are defined in Equation (1).

We report the estimation results in Table 4. Columns 1 and 2 present the results from the regressions using *Product Market Fluidity* and *Product Market Similarity* as independent variable, respectively. The coefficients for both *Product Market Fluidity* and *Product Market Similarity* are positive and statistically significant at the 1% level. Consistent with the results from industry-level competition, these findings suggest that suppliers are more likely to relocate business activities closer to their customers when they face greater product market competition from their peer firms.

County-level characteristics: Suppliers may relocate business activities to a region that is attractive to both firms, and not because proximity to the customer per se is desirable. Factors that could be relevant here include the destination region's business environment or demographics such as education levels of the local workforce, the average age of the workforce, gender diversity in the workforce, the average skill level of occupations, or ethnic diversity of the workforce. We examine whether these factors play a meaningful role by comparing the characteristics of the original county and the destination county. Appendix Table A3 reports these results. Comparing the characteristics (average number of employees, sales, and trade credit scores) of all establishments located in the original county and those located in the destination county, we find the differences to be economically small and statistically insignificant. County-level comparisons of demographics consistently show negligible differences in the levels of education, average wages, gender balance, age, ethnic diversity, and Siegel occupation prestige score (a proxy for the average skill level of the county workforce). These results suggest that the characteristics of the supplier's original county and those of its destination county are not meaningfully different from each other (except that the destination is closer to the customer). Thus, the relocations are unlikely to be driven by the pursuit of agglomeration externalities in regions where customers are located.

[Insert Table 4 About Here]

3.3. Relocation and Changes in Relationship-Level Outcomes

The previous section has shown that increased product market competition could be a reason for the supplier to relocate its establishment closer to the customer so as to take advantage of knowledge spillover and greater coordination in R&D and operations. One objective of relocation could be to make the relationship more valuable for the customer, which makes it less likely that the customer would walk away from such a relationship, and thus the supplier could be insulated to some extent from competition. While the supplier is exposed to more potential hold-up and opportunism vis-à-vis the customer, this could be a lesser cost to pay compared to the higher likelihood of exit when competition intensifies.

In this section, we explore the potential consequences brought about by relocation on several relationship-level variables that suggest a closer relationship between the supplier-customer pair. First, we examine the role of relocation in improving supplier-customer pairwise sales. Second, we explore whether the closer proximity is associated with a longer relationship duration. Last, we examine whether the supplier's relocation leads to knowledge spillover and more coordination in R&D with the customer.

Our main empirical specification for examining the effect of relocation on our relationship-specific variables is as follows. We estimate the following regression specification at the pair-year level:

$$Y_{i,j,t} = \alpha + \beta \ Post\ Relocation_{i,t} + \gamma' X_{i,t-1} + \delta' \ W_{j,t-1} + \theta_{i,j} + \varphi_y + \varepsilon_{i,j,t-1}, \tag{4}$$

where, $Y_{i,j,t}$ denotes a relationship-level variable for supplier firm i and customer firm j in year t; $Post\ Relocation_{i,t}$ is a dummy variable that is equal to 1 for the five years after the supplier relocates an existing establishment and/or opens a new establishment in close proximity (within 100 miles) to the customer, and is equal to 0 otherwise (i.e., for nonrelocated pair-years, relocated far away pair-years, pre-relocation years of relocated pairs, and post-relocation years of relocated pairs beyond five years); $X_{i,t-1}$ ($W_{j,t-1}$) represents the same set of supplier (customer) firm-level control variables as defined in Equation (1), and $\theta_{i,j}$ and φ_y are vectors of supplier-customer pair fixed effects and year fixed effects, which control for unobservable time-invariant differences across supplier-customer pairs.

Next, we estimate Equation (4) by replacing *Post Relocation*$_{i,t}$ with *Post Tariff-Induced Relocation*$_{i,t}$, which is a dummy variable equal to 1 for the five years after a tariff-induced relocation, and 0 otherwise, where a tariff-induced relocation is the relocation that happened within two years after a large import tariff rate cut in the supplier's industry. Tariff-induced relocations are more likely to be in response to competitive pressure originating from the entry of foreign products into the domestic market. A large existing has used industry-level major tariff cuts as quasi-natural experiments to study how changes in competition affect corporate policies (e.g., Feenstra, 1996; Feenstra, Romalis, and Schott, 2002; Frésard, 2010; Frésard and Valta, 2012, 2016; Dasgupta et al., 2018). These papers contain excellent discussions as to why tariff cuts are a valid quasi-natural experiment in the context of the issues they address, and we do not repeat these arguments here.

Since relocations are voluntary decisions made by firms, our results are subject to endogeneity concerns. While tariff-induced relocations are likely to capture relocation decisions that occur in response to increased competitive pressure, even within industries experiencing major tariff cuts, firms with specific characteristics could self-select into relocating, and these same characteristics could cause the relationships between relocating suppliers and their customers to deepen.

To address potential endogeneity or self-selection issues, we use exogenous tariff cuts as an instrument in a Heckman treatment effect model. From a first-stage Probit regression for the relocation decision, where *Tariff Reduction* is used as an instrument, we extract the Inverse Mills Ratio (*Mills*), for both the relocating pairs as well as the non-relocating pairs (Acharya and Xu, 2017; Field, Souther, and Yore, 2020). Specifically, we estimate the pair-level Probit regression of *Tariff-Induced Relocation* on *Tariff Reduction*, the set of standard control variables, and pair and year fixed effects. Since each pair in a given year either relocates or does not, the *Mills* is estimated every year and is time-varying. However, since our interest is in how the relationship-level variables are affected by the relocation decision in the first five years after relocation, we fix the *Mills* at the value as of the relocation year for the first-five years after relocation. In the second stage, we estimate Equation (4), where we replace *Post Relocation* by the *Post Tariff-Induced Relocation* dummy variable and include the *Mills* variable as an additional control.

We also check for the trends in pair-level relationships before the supplier's relocation. The absence of pre-trends makes the inference more plausible that it is the relocation, and not persistent pair-specific factors that affect the costs and benefits from relocation, that drive our results. In Appendix Table A4, we test for the presence of pre-relocation trends in our relationship-level dependent variables. To do so, we add to the regression specification indicator variables for each of the four years prior to the tariff-induced relocation (year *t*). The pre-trend indicator variables are insignificant in all regressions of relationship-level variables, suggesting that there are no discernible pre-trends.

Finally, we estimate all the relationship-level results in a two-stage least squares (2SLS) setting, where the first stage relocation decision is modelled as linear probability model (LPM), using exogenous tariff cuts as an instrument.

3.3.1. Supplier-Customer Pairwise Sales After Relocation

To test whether suppliers make more sales to their customers after the relocation of business activities, we replace the left-hand side variable of Equation (4) with pairwise sales and report the estimation results in Table 5. Panel A reports OLS results, while Panel B reports the results from the Heckman model. In Column 1 of Panel A, we report the results for general relocations, while Column 2 presents the results for tariff-induced relocations. The dependent variable is *Pair Sales*, which is the ratio of sales from the supplier to the customer divided by the customer's cost of goods sold. In Column 1, the coefficient on *Post Relocation* is positive and statistically significant at the 1% level. The coefficient estimate is also economically meaningful. For example, the estimated coefficient on *Post Relocation* in Column 1 indicates that the pair-level sales increase by 4.7% $(=\frac{0.003}{0.064})$ relative to the mean of *Pair Sales* following the supplier's relocation.

Column 2 reports the estimation results for the regression of pair-level sales on *Post Tariff-Induced Relocation* and controls. The coefficient on *Post Tariff-Induced Relocation* is positive and significant. These results suggest that, after the supplier's relocation, which is actuated by more intense industry competition, the supplier makes more sales to the customer.

Panel B shows that *Post Tariff-Induced Relocation* remains significant in the Heckman treatment model discussed above, while Appendix A4 shows that there are no pre-trends in *Pair Sales*. The last two conclusions hold for all subsequent relationship-level results, and are not discussed further. Moreover, the *Mills* itself remains insignificant in this and all subsequent regressions for the Heckman treatment model, suggesting that self-selection does not drive the relationship-level results.

[Insert Table 5 About Here]

3.3.2. Supply Chain Relationship Survival After Relocation

If the supplier's closer proximity to the customer can strengthen the supply chain relationship, we expect that the relationship duration will be longer and less likely to be terminated following the relocation. To test this prediction, we estimate the following Cox proportional hazard model:

$$h_{i,j}(t) = \exp\big(\alpha + \beta\ Post\ Relocation_{i,t} + \gamma' X_{i,t-1} + \delta'\ W_{j,t-1} + \theta_{i,j} + \varphi_y\big), \qquad (5)$$

where the dependent variable is a dummy variable that is equal to 1 if the supply chain relationship terminates in year t, and 0 otherwise. Other variables are defined in Equation (4). Following prior research, if a supply chain relationship lasts until the end date of our sample (2015), we assume that the relationship continues to exist, i.e., right censored. As an alternative specification, we also model the likelihood of relationship termination using a linear probability model. Table 6 reports the estimation results. As before, we examine the effect of all relocations that reduce the proximity of suppliers and customers (Columns 1 and 2), as well as the effect of tariff-induced relocations (Columns 3 and 4), and the Heckman model (Columns 5 and 6). Columns 1, 3 and 5 present the estimation results for the Cox proportional hazard model, while Columns 2, 4 and 6 report the estimation results for the LPM.

In Column 1 (Columns 3 and 5), the coefficients on *Post Relocation* (*Post Tariff-Induced Relocation*) in the Cox proportional hazard model are negative and significant at the 1% level. For example, in Column 3, the hazard ratio for *Post Tariff-Induced Relocation* is 0.42, indicating that the relationship between the relocated suppliers and the customers is 58% less likely to be terminated than those relationships without relocated suppliers. Consistently, Columns 2, 4 and 6 show that the likelihood of relationship termination is significantly reduced following the supplier's relocation of an establishment to be in close proximity to the customer.

[Insert Table 6 About Here]

3.3.3. Technology Spillover After Relocation

In a knowledge-based economy, close proximity allows trading partners to gain a competitive edge and benefit from knowledge spillovers (Jaffe, 1986; Chu et al., 2019). As such, we expect that, following the supplier's relocation of a business activity close to the customer, both the supplier and the customer could produce innovations that are more aligned with each other. They would be more likely to cite each other's existing patents when developing new patents. Their innovation similarity, measured by *Technological Proximity*, is also expected to increase following the relocation. We test these predictions by replacing the dependent variable of Equation (4) with one of the alternate measures of supplier-customer cross-citations and *Technological Proximity*.

Table 7 reports the estimation results. Panel A reports the results for the tests of the supplier's new patents citing the customer's existing patent portfolio, and conversely, Panel B shows the results for the tests of the customer' new patents citing the supplier's existing patent portfolio. In both panels, Columns 1, 3 and 5 report the estimation results for the LPM in which the dependent variable is equal to 1 if at least one firm's new patent cites the partner's existing patents, and 0 otherwise. Columns 2, 4 and 6 present the regression of the natural logarithm of a firm's cross-citations of the partner's existing patent portfolio.

In all models, the coefficient on *Post Relocation* (*Post Tariff-Induced Relocation*) is positive and statistically significant, suggesting that both the supplier and the customer are more likely to cite each other's existing patents after the supplier's relocation. For example, the coefficient on *Post Relocation* in Column 2 of Panel A is 0.18, suggesting that the supplier's citations of the customer's existing patents increase by 18% following the relocation. Columns 3-6 consistently show that the coefficient on *Post Tariff-Induced Relocation* is positive and statistically significant at the 1% level, suggesting that closer geographic proximity is associated with innovation similarities.

[Insert Table 7 About Here]

If geographic proximity can facilitate knowledge spillover, we expect that technological proximity of the supplier and the customer would be stronger following the supplier's relocation. To test this prediction, we replace the dependent variable of Equation (4) with *Technological Proximity*, which is the correlation between the scope of innovation activities of a supplier and that of the customer. Table 8 Panel A reports the estimation results. We find that the coefficients on *Post Relocation* and *Post Tariff-Induced Relocation* are positive and statistically significant at the 1% level. For example, the estimated coefficient on *Post Tariff-Induced Relocation* in Column 2 suggests that *Technological Proximity* of a supplier and the customer increases by 3.9% following the supplier's tariff-induced relocation.

3.3.4. Supplier R&D

R&D expenditure, which captures a firm's innovation input, is also relevant to a firm's future innovation output (Griffith et al., 2004). Greater sensitivity of the supplier's R&D expenditure to the customer's R&D expenditure reflects a greater degree of customization in the supplier's products provided to this customer. Therefore, we expect that, after a supplier moves closer to the customer, its R&D expenditure could exhibit a stronger co-movement with the customer's R&D expenditure. We empirically test this conjecture using the following supplier-customer pair-year level regression:

$$Sup\ R\&D_{i,t} = \alpha + \beta_1\ Post\ Relocation_{i,t} \times Cus\ R\&D_{j,t-1} + \beta_2\ Post\ Relocation_{i,j,t} + \gamma' X_{i,t-1} + \delta'\ W_{j,t-1} + \theta_{i,j} + \varphi_y + \varepsilon_{i,j,t-1}, \tag{6}$$

where $Sup\ R\&D_{i,t}$ and $Cus\ R\&D_{j,t-1}$ are the supplier's R&D expenditure and the customer's R&D expenditure, respectively. Other variables are defined in Equation (4).

Table 8 Panel B reports the estimation results. Column 1 shows that the coefficient on *Post Relocation* × *Cus R&D* is positive and significant at the 1% level, suggesting that the supplier's R&D expenses become more sensitive to the customer's R&D expenses following the supplier's relocation. In Column 2, we replace *Post Relocation* with *Post Tariff-Induced Relocation,* while Column 3 presents the results for the Heckman selection model. We find similar results. Overall, these findings are consistent with the notion that the supplier's relocation is associated with greater collaboration with the customer in innovation activities.

[Insert Table 8 About Here]

3.3.5. Two-Stage Least Squares Estimates

We next use tariff cuts as an instrument in 2SLS setting, modelling the first-stage relocation decision as an ordinary least squares (OLS) linear probability model. As Table 2 shows the coefficient on the tariff-reduction dummy variable is highly significant, and thus the instrument is strong. To the extent that tariff cuts are plausibly exogenous, we can also assume that the tariff-reduction dummy variable is uncorrelated with the errors of the relationship-level regressions, so that the exclusion restriction would also be satisfied. However, both the Heckman treatment model and especially the 2SLS require that the instrument cannot be included in the second-stage regression. If tariff cuts directly affect the relationship-level variables, this could create an omitted variable bias.

We now present evidence in support of the claim that our results are unlikely to be affected by omitted variable bias. To do so, we first consider an alternative sample of relocations. Specifically, these are tariff-induced relocations that occurred between year 3 and year 4 after a tariff cut. We exclude all other relocations. We construct *Post Alt Tariff-Induced Relocation*, which is an indicator variable equal to 1 for the five years after the alternative tariff-induced relocation, and zero otherwise. The advantage of this setting is that we can directly examine whether, in the two years prior to relocation, the tariff cut affected the relationship-level variables. If the effect of tariff reductions is insignificant and the relationship-level changes show up only after the relocation, then we can argue that the tariff cut does not directly affect the relationship level changes, but only does so through the induced relocation.

Appendix Table A5 reports the estimation results. In Column 1, we show that tariff reductions have strong predictive power for the supplier's future relocation. Subsequent columns of Appendix Table A5 report regressions similar to those in Tables 5-8. We include in all regressions four pre-trend variables, *Pre1-Pre4*, which take the values of 1 for relocating firms over the past one year, two years, three years, and four years before relocation, respectively, and zero otherwise. *Pre1* and *Pre2*, in particular, examine whether there is any effect on the relationship-level variables for relocating firms after the tariff cut but before the relocation. In all regressions, these variables are insignificant. In particular, the insignificant coefficients on *Pre1* and *Pre2* imply that the tariff cut itself does not directly affect the relationship-level variables. In contrast, the coefficient on *Post Alt Tariff-Induced Relocation* remains significant in all regressions.

Next, if tariff cuts have a direct impact on relationship-level variables, we expect that the effect of tariff cuts would be significant among non-relocating firms. In tests reported in Panel A of Appendix Table A6, we remove all pair-years over the period [-5, +5] years around tariff-induced relocations. We then examine the effect of *Tariff Reduction*, which is an indicator variable equal to 1 for the five years after a major tariff reduction in the supplier's industry and zero otherwise, on the relationship-level variables of the remaining pairs. In Panel B of Table A6, we examine a subset of firms that have had establishments within 100 miles of their customers in the five years before the tariff cut. For both samples, we find that the coefficient on *Tariff Reduction* is insignificant in all regressions, indicating that its exclusion from the second stage of the 2SLS or the Heckman treatment model creates no omitted variable bias.

Having shown that tariff reductions could be a valid instrument, we formally conduct a 2SLS analysis in which we use *Tariff Reduction* to predict *Post Relocation* in the first stage.[16] In the second stage, we estimate the regressions of relationship-level variables on *Fit_Post Relocation*, controls, pair fixed effects, and year fixed effects. Table 9 reports the estimation results. In all regressions, the coefficients on *Fit_Post Relocation* are consistent with our OLS results in Tables 5-8. The coefficient estimates in some cases are somewhat larger compared to OLS, which is not uncommon in 2SLS since *local* average treatment effects can differ from average treatment effects.

[Insert Table 9 About Here]

3.4. Relocation and Changes in Firm-Level Outcomes

The previous section shows that relocated suppliers make more sales to their customers after they relocate business activities closer to the customers. In this section, we show that some operational and innovation characteristics of suppliers and customers also change as the supplier relocates closer to the customer. However, since the outcome variables are only observed at the customer-firm level or supplier-firm level (as opposed to the relationship level or pair level), it is more difficult to claim that the changes are causally related to more proximate location of a supplier to a particular customer. Moreover, given that the regressions are estimated at the firm level, our empirical specifications for these tests are slightly different from Equation (4), as discussed below.

[16] Specifically, *Tariff Reduction*, used to instrument *Post Relocation*, is defined as follows. For relocating firms that experienced a tariff reduction, *Tariff Reduction* is a dummy variable equal to 1 starting from the year after the tariff cut to year 5 after the relocation year, and is zero otherwise. For non-relocating firms in an industry experiencing the tariff cut, *Tariff Reduction* is equal to 1 for seven years after a tariff cut and zero otherwise. For all non-relocating firms from an industry that does not experience a tariff cut, *Tariff Reduction* is zero.

3.4.1. Customer Firms' Purchase Obligations and Inventories After Relocation

First, as discussed before, since the supplier makes relationship-specific investment (relocation itself is a relationship-specific investment), it is likely to be concerned about customer bargaining power and potential hold-up. Hold-up is more problematic when contracts are implicit. Consequently, as a way to commit to future purchases and mitigate opportunism, customers are more likely to use purchase obligations (Klein, Crawford, and Alchian, 1978).[17]

Second, relocating closer to the customer is likely to enable just-in-time inventory management, allowing the customer to maintain lower inventory of inputs as well as finished products. Consequently, we expect the customer's inventory holdings to decrease after the supplier relocates. To test this prediction, we estimate the following regression at the customer firm-year level:

$$Cust_{j,t} = \alpha + \beta\ Post\ Relocation_{j,t} + \delta'\ W_{j,t-1} + \theta_j + \varphi_y + \varepsilon_{j,t-1}, \quad (7)$$

where, for customer firm j in year t, $Cust_{j,t}$ is either the customer's *Purchase Obligation*$_{j,t}$, which is measured as the total dollar amount of the customer's purchase obligations for the future five years scaled by its total assets, or *Inventory*$_{j,t}$, which is calculated as the customer's total inventory over total assets. For each customer, $Post\ Relocation_{j,t}$ is a dummy variable equal to 1 for the two years after one of its suppliers relocates an existing establishment or opens a new establishment in close proximity to the firm and zero otherwise. $W_{j,t-1}$ represents the same set of customer firm-level control variables as in Equation (1); θ_j and φ_y are vectors of customer firm and year fixed effects.

As before, we also estimate Equation (7) using *Post Tariff-Induced Relocation*, which is equal to one for the five years after a supplier's tariff-induced relocation. In addition, we estimate the Heckman selection model in which the first stage is the regression of *Tariff-*

[17] Purchase obligations are enforceable and legally binding agreements to purchase goods or services that specifies significant terms regarding quantities, price and the approximate timing of transaction. The SEC mandates their disclosure on 10-K filings. While firms disclose their purchase obligations in SEC filings, they do not disclose the counter party of the contract (i.e., the supplier). As such, we are unable to estimate the pair-level regressions of purchase obligations.

Induced Relocation on *Tariff Reduction*, controls, firm fixed effects, and year fixed effects. *Tariff Reduction* is a dummy variable equal to 1 for the two years after a major tariff reduction in one of the suppliers' industries and zero otherwise. We obtain the inverse Mills ratio, *Mills*, from the first-stage estimation and use it as an additional control variable in the second-stage regression.[18]

Table 10 reports the estimation results. In Columns 1, 3, and 5, which present the results for the regressions of *Purchase Obligation*, the coefficients on *Post Relocation* and *Post Tariff-Induced Relocation* are positive and significant at the 1% level, indicating that the customer makes more purchase commitments after the supplier relocates an establishment in close proximity. In Columns 2, 4, and 6, in which the dependent variable is *Inventory*, the coefficients on *Post Relocation* and *Post Tariff-Induced Relocation* are negative and significant, suggesting that the customer's inventory levels are lower following the supplier's relocation. The coefficients on *Mills* are insignificant. These results are also consistent with the findings in the logistics literature, which suggests that, when the supply-chain relationship is strengthened, customers maintain a low level of inventory because suppliers can replenish inventory in a timely manner (Copacino, 1993; Hung, Fun, and Li, 1995).[19]

[Insert Table 10 About Here]

3.4.2. Input Specificity, Explorative Innovation, and Exploitation Innovations: A Possible Manifestation of Customer Bargaining Power

While locating closer to a customer allows the supplier to benefit from knowledge spillover and steer its innovation activity towards the customer, the very fact that competitive pressure is required to induce such relocation suggests that relocation is not costless for the supplier. Upstream firms making investments that are specific to the downstream firm are vulnerable to downstream opportunism and bargaining power.

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[18] The 2SLS results are presented in Appendix A7.

[19] The logistics literature also suggests that the improved relationship means that the customer would make more purchases from the supplier (Dong and Xu, 2002).

Competitive pressure could be driving supplier firms towards a degree of product and innovation specificity they would not otherwise find optimal. [20]

To test whether suppliers' products become more specialized and insulate the suppliers from competition, we return to the two firm-level measures of product market threat considered in Section 3.2.3, namely, *Product Market Fluidity* or *Product Market Similarity*. We expect similarity and fluidity scores for relocating suppliers to decrease after relocation. For a given relocating supplier, we construct a dummy variable, *Post Relocation*, which is equal to 1 for the five years after it relocates an existing establishment or opens a new establishment in close proximity to a customer and zero otherwise. As before, we also examine *Post Tariff-Induced Relocation*, which is equal to 1 for the five years after the supplier's tariff-induced relocation in close proximity to a customer and zero otherwise. We then estimate the regression of the product market threat variable on *Post Relocation* (or *Post Tariff-Induced Relocation*), control variables, and firm and year fixed effects. Table 11 presents the estimation results. The coefficients on *Post Relocation* and *Post Tariff-Induced Relocation* are negative and significant, suggesting that the supplier's products become more specific and the competitive threat in its product market is lower after relocation.

[Insert Table 11 About Here]

Our previous results at the relationship level show that there is greater overlap between the innovation and R&D activities of the customer and supplier. These results suggest that the type of innovation activity pursued by the supplier possibly changes after relocation. In particular, the supplier may emphasize exploitative innovation more than explorative innovation. Exploitative innovation involves extensions or refinements of existing knowledge or processes, while explorative innovation steers the firm's activities in new directions. While exploitative innovation is safer and profitable in the

[20] Dasgupta and Tao (2000) provide a model in which customer bargaining power can push the supplier towards less valuable general investment, and propose alternative solutions to the hold-up problem.

short run, explorative innovation is seen as the main driver of longer-term survival and growth (Balsmeier, Fleming and Manso, 2017; Manso et al., 2019).

Accordingly, we next examine whether the supplier generates more explorative or exploitative innovations after relocation. To do so, we construct a measure of exploitative innovation, *Exploit*, which is the ratio of the number of exploitative patents divided by total number of patents filed in a given year, where exploitative patents cite at least 60% of patents that are either the firm's own patents or patents that have been cited by the firm in the past five years. Similarly, our measure of explorative innovation is *Explore*, which is the ratio of explorative innovations divided by the total number of patents filed in a given year. Explorative innovations cite at least 60% of patents that are neither the firm's own patents nor patents that have been cited by the firm over the past five years.[21]

We regress these innovation measures on *Post Relocation* (or *Post Tariff-Induced Relocation*), control variables, and firm and year fixed effects. Table 12 reports the estimation results. In the regressions of exploitative innovation, the coefficients on *Post Relocation* and *Post Tariff-Induced Relocation* are positive and statistically significant at the 1% level, suggesting that the supplier disproportionately conducts more exploitative innovations after it relocates an establishment toward the customer. In contrast, in the regressions of explorative innovations, the coefficients on *Post Relocation* and *Post Tariff-Induced Relocation* are negative and statistically significant at the 1% level, indicating that the relocated supplier engages in less explorative innovation.

Taken together, these results are consistent with the notion that suppliers produce more specific products after relocation. The shift in innovation focus potentially diminishes the supplier's ability to enter new product markets in the future and affects its long-term growth (Manso et al., 2019).

[Insert Table 12 About Here]

[21] We obtain very similar results if we require the citations to be above the 80% threshold.

To complete our empirical investigation, we conduct 2SLS analysis for these firm-level variables, in which we use major tariff reductions in the suppliers' industries as instrument for *Post Relocation*. Appendix Table A7 reports the estimation results. Across all firm-level outcome variables, the coefficient on instrumented *Post Relocation* are significant and consistent with the OLS results.

4. Conclusion

In this paper, we examine the role of product market competition in driving a supplier to relocate one or more of its existing establishments (or open a new establishment) in close proximity to its customer, and we explore the potential benefits brought about by such close proximity. Using both industry-level competition shocks to a supplier firm's product market and firm-level product market threat measures, we find that increased product market competition induces the supplier to relocate closer to the customer. We further find that after the relocation, the supplier sells more to the customer, the duration of the supplier-customer relationship becomes longer, and innovations produced by the supplier and the customer have more overlaps. While the supplier's relocation can strengthen the supply chain relationship and facilitate knowledge spillover, the potential cost of such relocation is that the supplier conducts more exploitative innovation and less explorative innovation. Overall, our findings suggest that competition in the upstream product market influences the supplier's geography, increases relationship-specific investment, and facilitates knowledge spillover.

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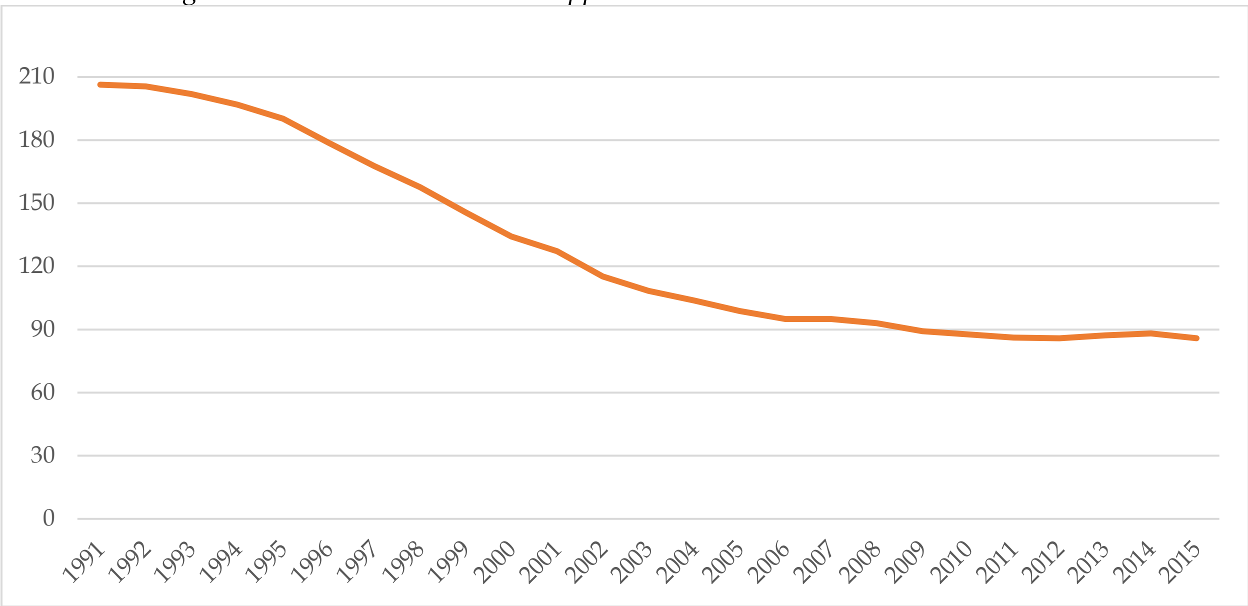
Figure 1: Average Shortest Distance between Supplier and Customer

Panel A plots the average shortest distance between suppliers' establishment networks and customers' establishment networks in the U.S. between 1991 and 2015. Panel B shows the average shortest distance between random pairs of establishments that do not have an actual supply chain relationship. To construct a placebo sample, for each supplier firm we randomly choose 10 "pseudo" customer firms in a given year that are in the same two-digit SIC industry. We then calculate the shortest distance between the establishments of the two firms. We repeat this procedure 1000 times and calculate the average shortest distance across simulated samples.

Panel A: Average Shortest Distance between Suppliers and Customers



Panel B: Pseudo Pairs Based on Customers with the Same SIC

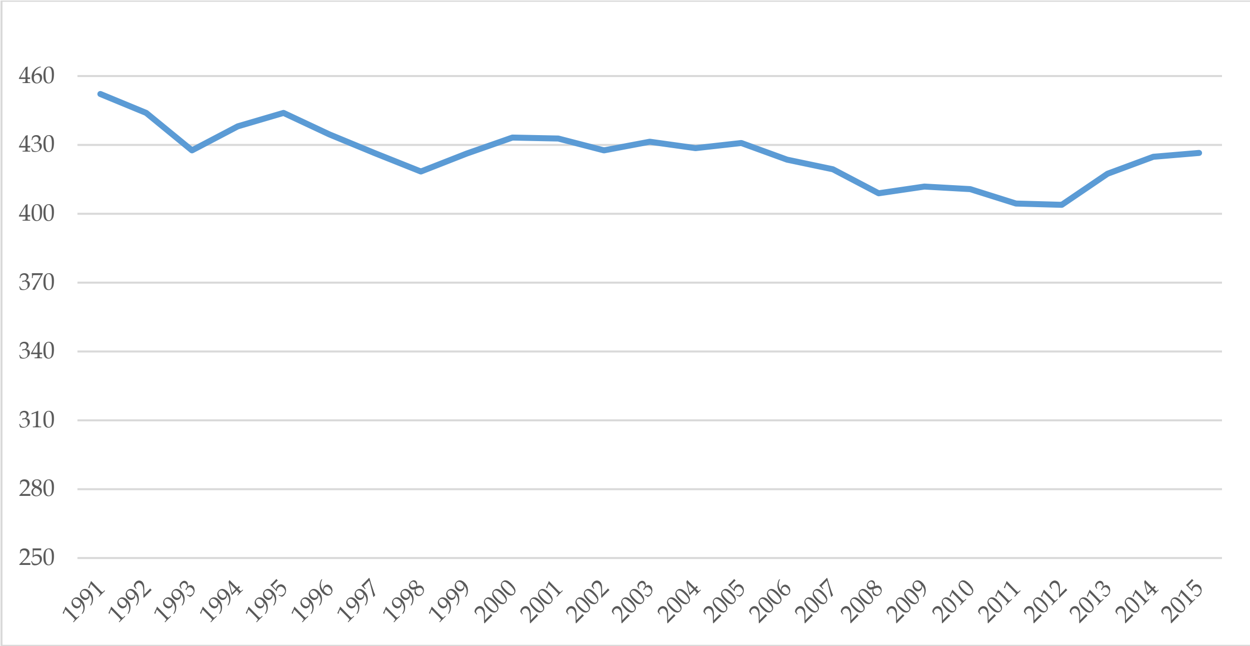


Table 1: Summary Statistics

Panel A reports summary statistics for customer firms. Panel B reports summary statistics for supplier firms. Panel C reports summary statistics for supplier-customer pairs. The summary statistics include the sample mean, minimum, median, maximum, and standard deviation of the key variables used in this study. These variables are defined in Appendix Table A1. The sample period is between 1991 and 2015.

Panel A: Customer Firms

Variable	N	Mean	25th	Median	75th	Std. Dev.
Ln(Market Cap)	10,199	8.240	6.874	8.411	9.776	2.106
Ln(Sale)	10,199	8.217	7.004	8.463	9.640	2.006
Book Leverage	10,199	0.237	0.110	0.229	0.347	0.161
Market-to-Book	10,199	3.147	1.482	2.327	3.875	2.447
Return on Asset	10,199	0.123	0.085	0.129	0.180	0.127
Cash Holdings	10,199	0.149	0.028	0.084	0.205	0.173
Asset Tangibility	10,199	0.312	0.126	0.247	0.471	0.229
R&D	10,199	0.051	0.000	0.002	0.057	0.103
Advertising	10,199	0.014	0.000	0.000	0.014	0.116
Kaplan–Zingales Index	10,199	0.305	-0.166	0.374	0.912	0.949
Purchase Obligation	6,172	0.035	0.000	0.000	0.000	0.116
Inventory	10,130	0.140	0.027	0.096	0.201	0.146

Panel B: Supplier Firms

Variable	N	Mean	25th	Median	75th	Std. Dev.
Relocation	19,000	0.119	0.000	0.000	0.000	0.324
Ln(Market Cap)	19,000	5.601	4.083	5.518	7.000	2.073
Ln(Sale)	19,000	5.312	3.890	5.233	6.702	2.127
Book Leverage	19,000	0.189	0.008	0.149	0.317	0.184
Market-to-Book	19,000	3.290	1.253	2.044	3.541	4.181
Return on Asset	19,000	0.059	0.024	0.104	0.163	0.214
Cash Holdings	19,000	0.260	0.037	0.147	0.369	0.321
Asset Tangibility	19,000	0.256	0.078	0.175	0.356	0.235
R&D	19,000	0.213	0.000	0.016	0.130	0.739
Advertising	19,000	0.013	0.000	0.000	0.003	0.091
Kaplan–Zingales Index	19,000	0.338	-0.157	0.400	1.032	1.181
Tariff Reduction	19,000	0.372	0.000	0.000	1.000	0.483
Import Penetration	12,847	0.253	0.152	0.262	0.358	0.132
Product Market Fluidity	13,970	6.821	4.122	6.133	8.828	3.595
Product Market Similarity	14,926	4.600	1.122	1.770	4.820	6.488

Table 1: Continued

Panel C: Customer-Supplier Pairs

Variable	N	Mean	25th	Median	75th	Std. Dev.
Pair Sales	32,758	0.064	0.000	0.002	0.009	1.726
Sup_Cross_Citations	26,195	0.075	0.000	0.000	0.000	0.263
Ln(Supplier Cross-Citations)	26,195	0.144	0.000	0.000	0.000	0.613
Cus_Cross_Citations	23,735	0.066	0.000	0.000	0.000	0.249
Ln(Customer Cross-Citations)	23,735	0.105	0.000	0.000	0.000	0.477
Technological Proximity	26,195	11.684	0.000	0.130	26.236	11.684

Table 2: Tariff Reduction and Supplier Relocation

This table presents results from linear probability regressions at the supplier firm-year level predicting the probability of supplier relocation within two years of a large import tariff rate reduction in the supplier's industry. *Relocation* is a dummy variable equal to 1 if the supplier relocates an existing establishment or opens a new establishment in close proximity to the customer establishment, and 0 otherwise. *Tariff Reduction* is a dummy variable, which is equal to 1 if there is a large import tariff rate reduction in the supplier's industry (at the three-digit SIC level) in previous two years and 0 otherwise. In Column 1, industry and year fixed effects are included. In Column 2, firm and year fixed effects are included. Standard errors are clustered at the firm level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

	Dependent Variable: Future *Relocation*	
Variable	(1)	(2)
Tariff Reduction	0.147***	0.130***
	(6.602)	(4.876)
Ln(Market Cap)	0.015***	0.004
	(4.339)	(0.970)
Ln(Sale)	0.029***	0.017***
	(7.093)	(2.915)
Book Leverage	0.021	-0.030
	(0.961)	(-1.186)
Market-to-Book	-0.000*	-0.000
	(-1.828)	(-1.074)
Return on Asset	-0.045***	-0.029
	(-3.167)	(-1.534)
Cash Holdings	-0.004	0.044***
	(-0.349)	(3.330)
Asset Tangibility	-0.099***	-0.007
	(-3.964)	(-0.176)
R&D	0.014***	0.007
	(3.806)	(1.309)
Advertising	0.329**	0.220
	(2.210)	(1.239)
Kaplan–Zingales Index	0.001	0.009***
	(0.210)	(2.885)
Industry fixed effects	Yes	No
Firm fixed effects	No	Yes
Year fixed effects	Yes	Yes
Number of Obs	19,000	19,000
Adj. R-squared	0.061	0.008

Table 3: Import Penetration and Supplier Relocation

This table presents results from linear probability regressions at the supplier firm-year level predicting the probability of supplier relocation using the supplier's industry import penetration measure. *Import Penetration*, calculated at the three-digit NAICS industry level, is the five-year rolling average of the industry import penetration index computed as the import divided by the sum of import and domestic production. Column 1 includes industry and year fixed effects. Column 2 includes firm and year fixed effects. Standard errors are clustered at the firm level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

	Dependent Variable: Future *Relocation*	
Variable	(1)	(2)
Import Penetration	0.228***	0.208**
	(3.543)	(2.278)
Ln(Market Cap)	0.020***	0.012**
	(7.139)	(2.572)
Ln(Sale)	0.023***	0.019***
	(7.454)	(2.636)
Book Leverage	0.012	-0.026
	(0.647)	(-0.935)
Market-to-Book	-0.001	-0.003***
	(-0.886)	(-2.924)
Return on Asset	-0.105***	-0.062***
	(-7.428)	(-2.779)
Cash Holdings	-0.019*	0.038***
	(-1.922)	(3.049)
Asset Tangibility	-0.136***	-0.054
	(-8.169)	(-1.565)
R&D	0.004**	0.004
	(2.015)	(1.180)
Advertising	0.503***	0.242
	(4.324)	(1.265)
Kaplan–Zingales Index	-0.004	0.012***
	(-1.471)	(3.152)
Industry fixed effects	Yes	No
Firm fixed effects	No	Yes
Year fixed effects	Yes	Yes
Number of Obs	12,847	12,847
Adj. R-squared	0.219	0.014

Table 4: Product Market Competition and Supplier Relocation

This table presents results from linear probability regressions at the supplier firm-year level predicting the probability of supplier's relocation using the supplier's product market threat measures. Column 1 presents the regression results with *Product Market Fluidity* as the product market threat measure. Column 2 presents the regression results with *Product Market Similarity* as the product market threat measure. Firm and year fixed effects are included in all regressions. Standard errors are clustered at the firm level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

	Dependent Variable: Future *Relocation*	
Variable	(1)	(2)
Product Market Fluidity	0.004**	
	(2.530)	
Product Market Similarity		0.003***
		(2.751)
Ln(Market Cap)	-0.003	0.002
	(-0.637)	(0.359)
Ln(Sale)	0.004	0.021***
	(0.561)	(3.108)
Book Leverage	-0.127***	-0.114***
	(-4.761)	(-4.455)
Market-to-Book	-0.001	-0.001
	(-1.248)	(-1.537)
Return on Asset	0.008	-0.020
	(0.534)	(-1.449)
Cash Holdings	0.057***	0.048***
	(4.149)	(3.720)
Asset Tangibility	0.079*	0.030
	(1.940)	(0.790)
R&D	-0.007*	-0.003
	(-1.709)	(-0.607)
Advertising	0.127***	0.133***
	(5.567)	(5.495)
Kaplan–Zingales Index	0.013***	0.011***
	(4.206)	(3.553)
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Number of Obs	13,970	14,926
Adj. R-squared	0.034	0.051

Table 5: Supplier Relocation and Customer-Supplier Pair Sales

This table reports regression results at the customer-supplier pair-year level. *Pair Sales*, is a supplier's sales to the customer scaled by the customer's cost of goods sold. In Panel A, Column 1 presents the results for the regression of the customer-supplier pair sales on the supplier's relocation. *Post Relocation* is a dummy variable equal to 1 for the five years after the supplier relocates an existing establishment and/or opens a new establishment in close proximity to the customer, and 0 otherwise. Column 2 presents the results for the regression of *Pair Sales* on the supplier's relocation induced by the large tariff rate reduction in the supplier's industry. *Post Tariff-Induced Relocation* is a dummy variable equal to 1 for the five years after a tariff-induced relocation, and 0 otherwise. Panel B presents the results from a Heckman two-stage selection model. Column 1 reports the results from the first stage, where we estimate the Probit model of *Tariff-Induced Relocation* on *Tariff Reduction*, the set of pair-level control variables, pair fixed effects, and year fixed effects. In Column 2, we repeat the regression of Column 3 of Panel A but additionally control for the inverse Mills ratio, *Mills,* obtained from the first-stage Probit regression. Customer-supplier pair and year fixed effects are included in all regressions. Standard errors are clustered at the pair level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Panel A: Effects of Relocation and Tariff-Induced Relocation

	Dependent Variable: *Pair Sales*	
Variable	(1)	(2)
Post Relocation	0.003***	
	(4.137)	
Post Tariff-Induced Relocation		0.003**
		(2.478)
Cus Ln(Market Cap)	0.000	0.000
	(0.570)	(0.163)
Cus Ln(Sale)	-0.009***	-0.008***
	(-16.684)	(-8.879)
Cus Book Leverage	-0.001	0.001
	(-0.350)	(0.519)
Cus Market-to-Book	-0.000***	-0.000
	(-2.860)	(-1.247)
Cus Return on Asset	0.017**	0.013***
	(2.569)	(3.001)
Cus Cash Holdings	0.007***	0.006**
	(3.571)	(2.405)
Cus Asset Tangibility	0.004	0.005*
	(1.323)	(1.647)
Cus R&D	0.051***	0.031**
	(2.787)	(2.435)
Cus Advertising	-0.011	-0.023
	(-0.498)	(-0.895)
Cus Kaplan–Zingales Index	-0.000	-0.000
	(-0.055)	(-0.830)
Sup Ln(Market Cap)	0.000	0.000

	(1.536)	(1.450)
Sup Ln(Sale)	0.006***	0.005***
	(17.356)	(12.006)
Sup Book Leverage	0.001	0.001
	(0.594)	(0.810)
Sup Market-to-Book	-0.000	0.000
	(-0.019)	(0.267)
Sup Return on Asset	0.001	0.001
	(0.878)	(1.029)
Sup Cash Holdings	0.000	0.000
	(0.749)	(0.012)
Sup Asset Tangibility	0.003**	0.001
	(2.068)	(0.585)
Sup R&D	0.000	0.000
	(1.348)	(0.653)
Sup Advertising	0.003***	0.002***
	(11.016)	(4.325)
Sup Kaplan–Zingales Index	-0.000***	-0.000*
	(-3.176)	(-1.919)
Pair fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Number of Obs	25,526	23,209
Adj. R-squared	0.090	0.106

Panel B: Heckman Model

	First Stage	Second Stage
	Tariff-Induced Relocation	*Pair Sales*
Variable	(1)	(2)
Post Tariff-Induced Relocation		0.003**
		(2.503)
Mills		-0.000
		(-0.353)
Tariff Reduction	0.887**	
	(2.111)	
Supplier control variables	Yes	Yes
Customer control variables	Yes	Yes
Pair fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Number of Obs	23,209	23,209
Adj. R-squared	0.008	0.105

Table 6: Supplier Relocation and Supply Chain Relationship Duration

This table presents the regression results at the customer-supplier pair-year level examining the effect of the supplier's relocation on the duration of the supply chain relationship. The dependent variable is a dummy variable which equals 1 if the supply chain relationship terminates in the year and 0 otherwise. Columns 1 and 2 present the results for the regression with *Post Relocation* as the primary independent variable. Columns 3 and 4 present the results for the regression with *Post Tariff-Induced Relocation* as the primary independent variable. Columns 5 and 6 present the estimation results from the second-stage regressions of the Heckman-selection model. We obtain the inverse Mills ratio, *Mills*, from the first stage estimation and use it as an additional control variable in the second-stage regression. Columns 1, 3, and 5 report the regression results for the Cox proportional hazard model, where the number of failures indicates the number of terminated relationships. Columns 2, 4, and 6 use the linear probability model. Standard errors are clustered at the pair level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Variable	Cox Model (1)	Linear Probability (2)	Cox Model (3)	Linear Probability (4)	Cox Model (5)	Linear Probability (6)
Post Relocation	-0.705***	-0.113***				
	(-13.257)	(-2.643)				
Post Tariff-Induced Relocation			-0.875***	-0.246***	-0.877***	-0.248***
			(-10.436)	(-6.047)	(-10.412)	(-5.150)
Mills					-0.029	-0.036
					(-0.193)	(-1.079)
Supplier control variables	Yes	Yes	Yes	Yes	Yes	Yes
Customer control variables	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Hazard Ratio for *Post Relocation*	0.494	--	0.417	--	0.416	--
Number of failures	5,460	--	5,019	--	5,019	--
Number of Obs	31,892	31,892	29,408	29,408	29,408	29,408
Chi-squared	3512.73	--	3050.57	--	3052.96	--
Log Likelihood	-52354.73	--	-47727.02	--	-47727.17	--
Adj. R-squared	--	0.182	--	0.206	--	0.225

Table 7: Supplier Relocation and Customer-Supplier Cross Citations

This table reports the regression results at the customer-supplier pair-year level examining the effect of the supplier's relocation on the cross citations of patents between the customer and the supplier. In Panel A, the dependent variables are *Sup_Cross_Citations* (a dummy variable) and *Ln(Supplier Cross-Citations)*, representing the citations made by the supplier's patents toward the customer's patents. In Panel B, the dependent variables are *Cus_Cross_Citations* (a dummy variable) and *Ln(Customer Cross-Citations)*, representing the citations made by the customer's patents toward the supplier's patents. Columns 1 and 2 present the results for the regression with *Post Relocation* as the primary independent variable. Columns 3 and 4 present the results for the regression with *Post Tariff-Induced Relocation* as the primary independent variable. Columns 5 and 6 present the estimation results from the second-stage regressions of the Heckman-selection model. We obtain the inverse Mills ratio, *Mills*, from the first stage estimation and use it as an additional control variable in the second-stage regression. Columns 1, 3, and 5 report results for linear probability regressions. Customer-supplier pair and year fixed effects are included in all regressions. Standard errors are clustered at the pair level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Panel A: Supplier's Patents Cite Customer's Patents

Variable	*Sup_Cross_ Citations* (1)	*Ln(Supplier Cross-Citations)* (2)	*Sup_Cross_ Citations* (3)	*Ln(Supplier Cross-Citations)* (4)	*Sup_Cross_ Citations* (5)	*Ln(Supplier Cross-Citations)* (6)
Post Relocation	0.093***	0.181***				
	(8.427)	(6.977)				
Post Tariff-Induced Relocation			0.114***	0.198***	0.114***	0.199***
			(10.185)	(10.156)	(10.041)	(10.031)
Mills					-0.000	0.001
					(-0.202)	(0.624)
Supplier control variables	Yes	Yes	Yes	Yes	Yes	Yes
Customer control variables	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	23,853	23,853	22,422	22,422	22,422	22,422
Adj. R-squared	0.023	0.037	0.025	0.037	0.025	0.037

Table 7: Continued

Panel B: Customer's Patents Cite Supplier's Patents

Variable	*Cus_Cross_ Citations* (1)	*Ln(Customer Cross-Citations)* (2)	*Cus_Cross_ Citations* (3)	*Ln(Customer Cross-Citations)* (4)	*Cus_Cross_ Citations* (5)	*Ln(Customer Cross-Citations)* (6)
Post Relocation	0.041***	0.100***				
	(2.886)	(4.128)				
Post Tariff-Induced Relocation			0.058***	0.141***	0.057***	0.140***
			(3.341)	(4.428)	(3.214)	(4.378)
Mills					0.003	0.001
					(1.441)	(0.449)
Supplier control variables	Yes	Yes	Yes	Yes	Yes	Yes
Customer control variables	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	19,267	19,267	17,857	17,857	17,857	17,857
Adj. R-squared	0.015	0.027	0.016	0.030	0.016	0.030

Table 8: Supplier Relocation, Technological Proximity, and R&D Sensitivity

Panel A reports the regression results at the customer-supplier pair-year level examining the effect of the supplier's relocation on the technological proximity of the customer and the supplier. The dependent variable, *Technological Proximity*, is a measure of similarity in innovation activities between the supplier and customer. Panel B reports the regression results examining the effect of the supplier's relocation on the sensitivity of the supplier's R&D to the customer's R&D. The dependent variable, *Sup R&D*, is the supplier's R&D expenses divided by its total sales. In both panels, Column 1 presents the results for the regression with *Post Relocation* as the primary independent variable. Column 2 presents the results for the regression with *Post Tariff-Induced Relocation* as the primary independent variable. Column 3 presents the estimation results from the second-stage regression of the Heckman-selection model. We obtain the inverse Mills ratio, *Mills*, from the first stage estimation and use it as an additional control variable in the second-stage regression. Customer-supplier pair and year fixed effects are included in all regressions. Standard errors are clustered at the pair level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Panel A: Technological Proximity

	Dependent Variable: *Technological Proximity*		
Variable	(1)	(2)	(3)
Post Relocation	3.515***		
	(4.764)		
Post Tariff-Induced Relocation		3.542***	3.372***
		(4.118)	(3.829)
Mills			-0.139
			(-1.146)
Supplier control variables	Yes	Yes	Yes
Customer control variables	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Number of Obs	23,853	22,405	22,405
Adj. R-squared	0.015	0.014	0.014

Table 8 continued.

Panel B: R&D Sensitivity

	Dependent Variable: *Sup R&D*		
Variable	(1)	(2)	(3)
Post Relocation × Cus R&D	5.157**		
	(2.125)		
Post Relocation	0.343**		
	(2.252)		
Post Tariff-Induced Relocation × Cus R&D		15.268**	14.750**
		(2.445)	(2.372)
Post Tariff-Induced Relocation		0.079	0.133
		(0.357)	(0.597)
Mills × Cus R&D			6.253
			(1.621)
Mills			0.101
			(0.790)
Cus R&D	-0.002	-20.200	-31.156
	(-0.580)	(-1.548)	(-1.350)
Supplier control variables	Yes	Yes	Yes
Customer control variables	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Number of Obs	31,892	29,408	29,408
Adj. R-squared	0.104	0.123	0.123

Table 9: Two-Stage Least Square (2SLS) Regressions

This table presents the results of two-stage least squared regressions using major tariff reductions as instrument. In the first stage, we estimate the pair-level linear probability regression of the *Post Relocation* dummy on the tariff reduction dummy, the set of standard control variables, and pair and year fixed effects. Column 1 reports the results for the first stage linear probability regression. For non-relocating firms, *Tariff Reduction* is a dummy variable equal to 1 for the seven years after a major tariff cut in the supplier's industry. For relocating firms, *Tariff Reduction* is a dummy variable equal to 1 for the years after a major tariff cut and within five years after relocation. The remainder of the table reports the estimation results of second-stage regressions, which use the instrumented *Post Relocation* obtained from the first-stage regression, denoted as *Fit_Post Relocation*. The dependent variable in Column 2 is *Pair Sales*. Column 3 uses the linear probability model to model the likelihood of relationship termination, *Relationship Termination,* which is equal to 1 if the supply-customer relationship ends in a given year. The dependent variables in Columns 4, 5, and 6 are *Ln(Supplier Cross-Citations)*, *Ln(Customer Cross-Citations)*, and *Technological Proximity*, respectively, which measure the innovation similarity between the supplier and the customer. The dependent variable in Column 7 is supplier's R&D. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

	First Stage	Second Stage					
	Post Relocation	*Pair Sales*	*Relationship Termination*	*Ln(Supplier Cross-Citations)*	*Ln(Customer Cross-Citations)*	*Technological Proximity*	*Sup R&D*
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tariff Reduction	0.151***						
	(10.627)						
Fit_Post Relocation		0.017***	-0.114***	0.135***	0.195***	3.508***	0.065
		(3.164)	(-3.100)	(9.172)	(3.245)	(4.784)	(0.477)
Fit_Post Relocation × Cus R&D							10.203***
							(2.684)
Supplier control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Customer control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	31,892	25,526	22,387	23,853	19,267	23,853	31,892
Adjusted/Pseudo R^2	0.072	0.099	0.182	0.032	0.020	0.015	0.113

Table 10: Supplier Relocation, Customers' Purchase Obligations, and Inventory

This table presents regression results at the customer firm-year level examining the effect of the supplier's relocation on the customer's purchases. Columns 1 and 2 present the results for the regression with *Post Relocation* as the primary independent variable. *Post Relocation* is a dummy variable equal to 1 for the five years after a supplier relocates closer to the customer and zero otherwise. Columns 3 and 4 present the results for the regression with *Post Tariff-Induced Relocation* as the primary independent variable. *Post Tariff-Induced Relocation* is a dummy variable equal to 1 for the five years after a supplier's tariff-induced relocation in close proximity to the customer and zero otherwise. Columns 5 and 6 present the results for the second-stage regressions of the Heckman-selection model. We obtain the inverse Mills ratio, *Mills*, from the first stage estimation and use it as an additional control variable in the second-stage regression. In Columns 1, 3, and 5, the dependent variable is *Purchase Obligation*. In Columns 2, 4, and 6, the dependent variable is *Inventory.* Firm and year fixed effects are included in all regressions. Standard errors are clustered at the firm level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Variable	*Purchase Obligation* (1)	*Inventory* (2)	*Purchase Obligation* (3)	*Inventory* (4)	*Purchase Obligation* (5)	*Inventory* (6)
Post Relocation	0.047***	-0.013***				
	(5.286)	(-3.257)				
Post Tariff-Induced Relocation			0.062***	-0.020***	0.064***	-0.019***
			(4.136)	(-3.218)	(4.165)	(-2.919)
Mills					0.003	0.002
					(0.894)	(0.641)
Ln(Market Cap)	-0.002	0.005*	-0.002	0.006**	-0.002	0.006**
	(-0.959)	(1.676)	(-0.817)	(1.966)	(-0.804)	(1.991)
Ln(Sale)	0.003	-0.003	-0.001	-0.003	-0.000	-0.003
	(0.751)	(-0.724)	(-0.370)	(-0.751)	(-0.138)	(-0.761)
Book Leverage	-0.013	0.025	-0.020	0.027*	-0.022	0.029*
	(-0.868)	(1.597)	(-1.326)	(1.714)	(-1.467)	(1.795)
Market-to-Book	0.000*	0.001***	0.000*	0.001***	0.000*	0.001***
	(1.870)	(2.772)	(1.790)	(2.975)	(1.794)	(2.812)
Return on Asset	0.020	0.065***	0.021*	0.083***	0.019	0.085***
	(1.582)	(4.228)	(1.745)	(4.964)	(1.499)	(5.059)
Cash Holdings	0.005	-0.024**	0.006	-0.028**	0.006	-0.028**
	(0.690)	(-1.977)	(0.993)	(-2.389)	(1.006)	(-2.370)

Asset Tangibility	-0.011	-0.080***	-0.003	-0.072***	-0.003	-0.072***
	(-0.538)	(-3.887)	(-0.152)	(-3.605)	(-0.129)	(-3.609)
R&D	0.000	-0.000	0.000	-0.000	0.000	-0.000
	(0.980)	(-0.182)	(0.995)	(-0.113)	(0.987)	(-0.146)
Advertising	-0.078	-0.075	-0.033	-0.053	-0.038	-0.045
	(-1.054)	(-1.029)	(-0.453)	(-0.713)	(-0.529)	(-0.612)
Kaplan–Zingales Index	0.000	-0.002*	0.002	-0.002*	0.002	-0.002**
	(0.261)	(-1.799)	(0.774)	(-1.923)	(0.783)	(-1.969)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	6,172	10,130	5,385	9,048	5,385	9,048
Adj. R-squared	0.168	0.144	0.170	0.138	0.173	0.140

Table 11: Product Market Similarity After Supplier Relocation
This table presents regression results at the customer firm-year level examining the effect of the supplier's relocation on the supplier's product market threat measures. Columns 1, 3, and 5 present the regression results with *Product Market Similarity*, which measures the degree of similarity between the firm's products and those of peer firms. Columns 2, 4, and 6 present the regression results with *Product Market Fluidity* as the product market threat measure. Columns 5 and 6 presents the estimation results from the second-stage regression of the Heckman-selection model. We obtain the inverse Mills ratio, *Mills*, from the first-stage estimation and use it as an additional control variable in the second-stage regression. Firm and year fixed effects are included in all regressions. Standard errors are clustered at the firm level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Variable	*Product Market Similarity* (1)	*Product Market Fluidity* (2)	*Product Market Similarity* (3)	*Product Market Fluidity* (4)	*Product Market Similarity* (5)	*Product Market Fluidity* (6)
Post Relocation	-1.521***	-0.341***				
	(-10.988)	(-4.254)				
Post Tariff-Induced Relocation			-0.435***	-0.396***	-0.519**	-0.378***
			(-3.312)	(-4.303)	(-2.088)	(-4.026)
Mills					-0.045	-0.021
					(-1.351)	(-1.081)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	13,970	14,926	12,262	13,268	12,262	13,268
Adj. R-squared	0.072	0.156	0.079	0.185	0.078	0.185

Table 12: Supplier Relocation and Exploitative/Explorative Innovation

This table presents the regression results at the supplier-year level examining the effect of the supplier's relocation on its exploitative or explorative innovations. The dependent variable in Columns 1, 3, and 5 is exploitative innovation measure, i.e., *Exploit*. The dependent variable in Columns 2, 4, and 6 is explorative innovation measure, i.e., *Explore*. Columns 1 and 2 present the results for the regression with *Post Relocation* as the primary independent variable. *Post Relocation* is a dummy variable equal to 1 for the five years after the supplier relocates closer to a customer and zero otherwise. Columns 3 and 4 present the results for the regression with *Post Tariff-Induced Relocation* as the primary independent variable. *Post Tariff-Induced Relocation* is a dummy variable equal to 1 for the five years after the supplier's tariff-induced relocation in close proximity to a customer and zero otherwise. Columns 5 and 6 present the estimation results from the second-stage regressions of the Heckman-selection model. We obtain the inverse Mills ratio, *Mills*, from the first stage estimation and use it as an additional control variable in the second-stage regression. Standard errors are clustered at the pair level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Variable	*Exploit* (1)	*Explore* (2)	*Exploit* (3)	*Explore* (4)	*Exploit* (5)	*Explore* (6)
Post Relocation	0.080***	-0.118***				
	(3.130)	(-3.864)				
Post Tariff-Induced Relocation			0.102***	-0.134***	0.094***	-0.115***
			(3.606)	(-3.868)	(3.007)	(-3.008)
Mills					0.004	-0.016
					(0.831)	(-1.444)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	5,195	5,195	4,804	4,804	4,804	4,804
Adj. R-squared	0.041	0.041	0.047	0.047	0.047	0.047

Appendix

Table A1: Variable Definitions

Variable	Definition	Source
Relocation	A dummy variable, which is equal to 1 if the supplier relocates an existing establishment or opens a new establishment in close proximity to the customer establishment and 0 otherwise.	NETS, FactSet Relationship–Revere, Compustat
Post Relocation	A dummy variable, which is equal to 1 for the five years after the supplier relocates an existing establishment and/or opens a new establishment in close proximity (within 100 miles) to the customer, and 0 for nonrelocated pair-years, relocated far away pair-years, the pre-relocation years of relocated pairs, and post-relocation years of relocated pairs beyond five years.	NETS, FactSet Relationship–Revere, Compustat
Tariff Reduction	A dummy variable, which is equal to 1 for the two years after a major tariff reduction in the supplier's industry (at the three-digit SIC level) and is equal to 0 for other years and for firms in industries without tariff changes. We follow Huang, Jennings, and Yu (2017) to identify large import tariff rate reduction events if the tariff rate declines relative to the prior year by more than three times the median tariff rate reduction of the industry and the reduction is not preceded or followed by a tariff increase greater than 80% of the reduction.	Peter Schott's website (http://faculty.som.yale.edu/peterschott/)
Import Penetration	Calculated at the three-digit NAICS level as the five-year rolling average of the industry import penetration index. The import penetration index for each three-digit NAICS in each year is calculated as the total import value divided by the sum of total import value and the gross domestic production.	Peter Schott's website and the Bureau of Economic Analysis of the U.S. Department of Commerce
Product Market Fluidity	Constructed by Hoberg, Phillips, and Prabhala (2014), which is a measure of how intensively a firm's product market is changing each year.	Hoberg-Phillips Data Library
Product Market Similarity	Constructed by Hoberg and Phillips (2016), which measures product similarity between a firm's products and those of peer firms.	Hoberg-Phillips Data Library
Post Tariff-Induced Relocation	A dummy variable, which is equal 1 for the five years after a tariff-induced relocation, and 0 otherwise, where *Tariff-Induced Relocation* is the relocation happened within two years after a large import tariff rate cut in the supplier's industry.	NETS, FactSet Relationship – Revere, Compustat, and Peter

		Schott's website
Ln(Market Cap)	Natural logarithm of market capitalization. Market capitalization is calculated as stock price (*PRCC_F*) multiplied by the number of shares outstanding (*CSHO*).	Compustat
Ln(Sale)	Natural logarithm of sales (*SALE*).	Compustat
Book Leverage	The sum of long-term debt (*DLTT*) and debt in current liabilities (*DLC*) divided by total assets (*AT*).	Compustat
Market-to-Book	Market capitalization divided by book value of equity (*CEQ*).	Compustat
Return on Asset	Operating income before depreciation (*OIBDP*) divided by book value of total assets (*AT*).	Compustat
Cash Holdings	Cash and short-term investments (*CHE*) divided by total assets (*AT*).	Compustat
Asset Tangibility	Net property, plant and equipment (*PPENT*) divided by total assets (*AT*).	Compustat
R&D	Research and development expense (*XRD*) divided by sales (*SALE*).	Compustat
Advertising	Advertising (*XAD*) divided by sales (*SALE*).	Compustat
Kaplan–Zingales Index	Calculated following Baker, Stein, and Wurgler (2003) as 3.139×*Book Leverage*+0.283×*Tobin's Q*-1.002×(*Cash Flow/Lagged Assets*) -39.368×Dividends-1.315×*Cash Holdings*. *Tobin's Q* is calculated as the sum of market capitalization, long-term debt (*DLTT*), and debt in current liabilities (*DLC*) divided by total assets (*AT*).	Compustat
Pair Sales	The ratio of pair sales from suppliers to customers scaled by customer's cost of goods sold.	FactSet Relationship – Revere, Compustat, and 10-K filings
Sup_Cross_Citations	A dummy variable equal to 1 if a supplier's patent cites its customer's existing patent portfolios and 0 otherwise.	Kogan, Papanikolaou, Seru, and Stoffman (KPSS, 2017)
Ln(Supplier Cross-Citations)	The natural logarithm of 1 plus the number of citations made by a supplier's patents toward the customer's existing patent portfolio.	(KPSS, 2017)
Cus_Cross_Citations	A dummy variable which is equal to 1 if a customer's patent cites its supplier's existing patent portfolio and 0 otherwise	(KPSS, 2017)
Ln(Customer Cross-Citations)	The natural logarithm of 1 plus the number of citations made by the customer's patents toward the supplier's existing patents.	(KPSS, 2017)

Technological Proximity	We follow Jaffe (1986) and compute the measure of technological proximity in a given year as the correlation between supplier s and customer c as: $Technological\ Proximity = \frac{P_s P_c'}{(P_s P_s')^{1/2} \times (P_c P_c')^{1/2}}$ where $P_k = (P_{k1}, \ldots, P_{k36})$; $k \in (s, c)$ is a vector of the scope of innovation activities of supplier s (or customer c), with each element of the vector being the ratio of the number of patents in a subclass applied (and eventually granted) over a three-year period to the total number of patents applied over the same period. We match the 426 technology classes assigned by USPTO to 36 subcategories as defined by Hall, Jaffe, and Trajtenberg (2001).	(KPSS, 2017)
Purchase Obligation	Purchase obligation is calculated as the sum of purchase obligations for the future five years divided by total assets (*AT*). The purchase obligation information is disclosed in a firm's 10-K filings.	SEC 10-K filings
Inventory	Total inventory (*INVT*) divided by book value of total assets (*AT*).	Compustat
Exploit	A ratio of the number of exploitative patents to the total number of patents filed (and eventually granted) in a given year, where exploitative patents cite at least 60% of patents that are either the firm's own patents or patents that are cited by the firm in the past five years.	(KPSS, 2017)
Explore	A ratio of the number of explorative patents divided by total number of patents filed (and eventually granted) in a given year, where explorative patents cite at least 60% of patents that are neither firm's own patents nor the patents that are cited by the firm in the past five years.	(KPSS, 2017)

Table A2: Supplier Relocation, Establishment Closures, and Employment

Panel A presents the estimation results for the Probit regression predicting the probability of closing establishments. In a given year *t*, *Establishment Closure* is a dummy variable equal to 1 if the supplier closes at least one establishment over the next two years, and 0 otherwise. To avoid survivorship bias, the *Establishment Closure* measure does not include those relocated establishments because these establishments are still active. Panel B presents the results for the regression of the change in the total number of the supplier firm's employees on *Post Relocation*. *ΔEmployee* is the difference between the natural logarithm of the firm's total number of employees (across all establishments) in year *t*+2 and the natural logarithm of the firm's total employees in year *t*. Firm and year fixed effects are included in all regressions. Standard errors are clustered at the firm level. t-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Interpretation: Panel A shows that the probability of a supplier's establishment closure is significantly higher after the supplier's relocation, especially when the relocation is motivated by a large tariff reduction. However, Panel B shows that the firm's aggregate employment across all plants does not change after relocation.

Panel A: Establishment Closure

	Dependent Variable: *Establishment Closure*	
Variable	(1)	(2)
Post Relocation	0.106***	0.084**
	(2.708)	(2.092)
Post Relocation × Tariff Reduction		0.395**
		(2.334)
Tariff Reduction		-0.014
		(-0.317)
Supplier control variables	Yes	Yes
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Number of Obs	11,123	11,123
Pseudo R-squared	0.102	0.104

Panel B: Change in the Total Number of Employees at the Firm Level

	Dependent Variable: *ΔEmployee*
Post Relocation	-0.032
	(-1.122)
Supplier control variables	Yes
Firm fixed effects	Yes
Year fixed effects	Yes
Number of Obs	12,246
Adj. R-squared	0.132

Table A3: Differences in County-level Business Environment

Panel A compares characteristics of the business environment of the relocated establishment's original county and the destination county. Panel B compares the characteristics of the business environment of the county of the closest customer establishment (to which the supplier relocated its establishment) and the counties of the customer's other establishments. In Panel A, "Original" reports descriptive statistics for firms operating in the original county (excluding the relocated establishment) in the year prior to a supplier establishment's relocation. If a supplier opens a new establishment (rather than relocating an existing one), then "Original" counties refer to the average characteristics of all counties where the firm's establishments are located. "Destination" shows descriptive statistics for firms operating in the destination county (excluding the relocated establishment) one year after the supplier establishment's relocation. If the firm opens a new establishment, then "Destination" county refers to the average characteristics of the county where the new establishment is located. *Emp* is the average number of employees across all establishments in a county excluding the relocated establishment. *Sales* is the average sales revenue across all establishments in a county excluding the relocated establishment. *PayDex* is the average Dun and Bradstreet trade credit score across all establishments in a county excluding the relocated establishment. Among the county-level variables, *Education* is the average number of years of education in a county obtained from the University of Minnesota's Integrated Public Use Microdata Series project (IPUMS-USA), which in turn sources data from the American Community Survey (ACS). *Wages* is the average wage in a county provided by IPUMS. *Gender* is the proportion of female workers in a county obtained from IPUMS. *Age* is the average worker's age in a county. *Occ_Prestige* is the Siegel occupation prestige score across all occupations in a county. The prestige score is based on the series of surveys conducted at National Opinion Research Center and is provided by IPUMS (https://usa.ipums.org/usa-action/variables/PRESGL#description_section). $HHI_{ETHNICITY}$ is the Herfindahl concentration index for employee ethnicity as follows:

$$HHI_{ETHNICITY_j} = \left[CaucasianPct_{i,t}\right]^2 + \left[AfricanPct_{i,t}\right]^2 + \left[HispanicPct_{i,t}\right]^2 + \left[AsianPct_{i,t}\right]^2 + \left[OthersPct_{i,t}\right]^2$$

where each component is the proportion of each ethnic group in a county (Caucasian, African, Hispanic, Asian, or others) obtained from IPUMS. "Difference" is the difference in characteristics of the original county prior to the supplier relocation and the destination county after the supplier relocation. *t*-statistics are computed using standard errors clustered by county. Note that the county-level characteristics in Panel A Column (2) are slightly different from those in Panel B Column (1) because the destination county may not be the same as the county of the closest customer establishment (for example, the supplier may relocate its establishment within 100 miles of the closest customer establishment, but not necessarily in the same county).

Interpretation: The results suggest that the characteristics of the supplier's original county and those of its destination county are not meaningfully different from each other (except that the destination is closer to the customer).

Table A3: Continued

Panel A: Comparison between Supplier's Original County and Destination County

Variable	Original (1)	Destination (2)	Difference (1)-(2)	*t*-statistic
Establishment-Level Variables				
Emp	56.23	55.98	0.25	0.65
Sales	$8,723,764.96	$8,764,344.42	-$40,579.46	-0.41
Paydex	66.76	66.98	-0.22	-1.09
County-Level Variables				
Education	7.33	7.37	-0.05	-1.17
Wages	$41,219.69	$42,164.41	-$944.72	-0.87
Gender	1.43	1.40	0.03	0.80
Age	42.87	43.22	-0.35	-0.95
Occ_Prestige	38.18	37.70	0.48	0.33
$HHI_{ETHNICITY}$	0.91	0.91	0.00	0.12

Panel B: Comparison between the County of the Closest Customer Establishment to the Supplier's Establishment and Other Counties of the Customer Establishments

Variable	Closest establishment (1)	All other customer establishments (2)	Difference (1)-(2)	*t*-statistic
Establishment-Level Variables				
Emp	55.97	55.24	0.72	0.15
Sales	$8,769,561.29	$8,490,521.74	$279,039.55	2.09
Paydex	67.34	67.02	0.33	0.53
County-Level Variables				
Education	7.75	7.52	0.22	1.74
Wages	$44,201.53	$46,641.39	-$2,439.86	-0.66
Gender	1.50	1.37	0.13	2.44
Age	43.20	41.26	1.94	1.73
Occ_Prestige	39.32	35.28	4.04	1.70
$HHI_{ETHNICITY}$	0.87	0.88	-0.01	-0.53

Table A4: Supply-Chain Relationships Prior to Tariff-Induced Relocation
This table presents the regression results at the pair-year level examining the supply chain relationship prior to the tariff-induced relocation event. *Pre1-Pre4* are dummy variables equal to one for one year to four years before a supplier's tariff-induced relocation event, respectively. The dependent variable in Column 1 is *Pair Sales*. Column 2 uses Cox proportional hazard model to estimate the likelihood of relationship termination. The dependent variables in columns 3, 4, and 5 are *Ln(Supplier Cross-Citations)*, *Ln(Customer Cross-Citations)*, and *Technological Proximity*, which measure the innovation similarity between the supplier and the customer. The dependent variable in Column 6 is supplier's R&D. Standard errors are clustered at the pair level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Interpretation: The coefficients on *Pre1-Pre4* are insignificant, suggesting that there are no discernible trends in the supply chain relationship before the supplier's tariff-induced relocation.

Variable	*Pair Sales* (1)	*Cox Model* (2)	*Ln(Supplier Cross-Citations)* (3)	*Ln(Customer Cross-Citations)* (4)	*Technological Proximity* (5)	*Sup R&D* (6)
Pre1	-0.000	-0.141	0.006	0.007	1.038	-0.139
	(-0.150)	(-1.370)	(0.540)	(0.283)	(1.110)	(-0.550)
Pre2	0.000	-0.277	-0.004	0.020	0.564	0.262
	(1.063)	(-1.300)	(-0.301)	(0.964)	(0.545)	(0.708)
Pre3	0.000	-0.115	-0.014	-0.004	-0.236	-0.795
	(0.528)	(-0.529)	(-1.020)	(-0.171)	(-0.184)	(-1.434)
Pre4	-0.000	-0.056	0.015	-0.047	0.381	0.215
	(-0.722)	(-0.278)	(0.700)	(-1.260)	(0.284)	(0.406)
Post Tariff-Induced Relocation	0.003**	-1.084***	0.192***	0.134***	4.305***	0.176
	(2.297)	(-12.165)	(9.448)	(3.834)	(4.613)	(0.735)
Post Tariff-Induced Relocation × Cus R&D						13.989**
						(2.368)
Supplier control variables	Yes	Yes	Yes	Yes	Yes	Yes
Customer control variables	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	23,209	29,408	22,422	17,857	22,405	29,408
Adjusted/Pseudo R^2	0.105	0.022	0.038	0.031	0.016	0.123

Table A5: Alternative Definition of Tariff-Induced Relocations

This table reports the results from the analysis using an alternative definition of tariff-induced relocations. In these tests, suppliers' tariff-induced relocations are those that occurred in year 3 or year 4 after a major tariff reduction in the supplier's industry. Tariff-induced relocations that occurred in the two years after a major tariff cut and non-tariff-induced relocations are removed from the sample. Column 1 repeats the regression in Column 1 of Table 2 but uses a new definition of *Tariff Reduction* dummy variable, denoted as *Alt Tariff Reduction*. *Alt Tariff Reduction* is equal to 1 for year 3 and year 4 after a major tariff reduction in the supplier's industry and 0 otherwise. The remainder of the table examines the pair-level relationship after tariff-induced relocations by repeating the regressions in Tables 5-8 but uses the alternative definition of tariff-induced relocations. *Post Alt Tariff-Induced Relocation* is equal to 1 for the five years after the alternative tariff-induced relocation and 0 otherwise. *Pre1-Pre4* are dummy variables equal to 1 for one year to four years before the supplier's alternative tariff-induced relocation event, respectively. In particular, *Pre1* and *Pre2* are effectively two years before the alternative tariff-induced relocation and after the tariff reduction. The dependent variable in Columns 2 is *Pair Sales*. Column 3 uses Cox proportional hazard model to model the likelihood of relationship termination. The dependent variables in columns 4, 5, 6, and 7 are *Ln(Supplier Cross-Citations)*, *Ln(Customer Cross-Citations)*, *Technological Proximity*, and Supplier R&D, respectively. Standard errors are clustered at the pair level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

	Relocation	*Pair Sales*	*Cox Model*	*Ln(Supplier Cross-Citations)*	*Ln(Customer Cross-Citations)*	*Technological Proximity*	*Sup R&D*
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pre1		0.000	-0.129	0.021	0.010	0.396	0.172
		(0.529)	(-0.668)	(0.845)	(0.388)	(0.554)	(1.046)
Pre2		0.001	-0.245	0.022	0.026	-0.017	0.211
		(0.974)	(-1.631)	(0.777)	(1.112)	(-0.021)	(0.820)
Pre3		0.000	-0.105	-0.038	-0.007	-1.497	0.134
		(0.595)	(-0.779)	(-1.227)	(-0.216)	(-1.394)	(0.358)
Pre4		-0.000	0.198	0.025	-0.078	0.732	0.350
		(-0.289)	(0.999)	(0.654)	(-0.792)	(0.491)	(0.804)
Post Alt Tariff-Induced Relocation		0.003***	-1.160***	0.228***	0.151***	1.700**	0.230
		(2.620)	(-11.987)	(7.459)	(4.132)	(1.965)	(0.908)
Post Alt Tariff-Induced Relocation× Cus R&D							12.145**
							(2.170)
Alt Tariff Reduction	0.127***						

	(5.497)						
Supplier controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Customer controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	No	No	No	No	No	No
Number of Obs	18,819	23,155	29,304	22,348	17,797	22,355	29,304
Adjusted/Pseudo R^2	0.010	0.105	0.022	0.043	0.030	0.015	0.124

Table A6: Subsample Analysis: Non-Relocating Pairs

The table reports the estimation results using two subsamples of non-relocating pairs. In Panel A, the sample contains non-relocating pair-years (i.e., the pairs whose suppliers did not relocate and pair-years that are outside the window of [-5, 5] years around the relocation). Panel B shows the results for the subsample of non-relocating pairs that were already in close proximity (and did not change their proximity) in the five years before the tariff reduction. *Tariff Reduction* is a dummy variable equal to 1 for the five years after a major tariff reduction in the supplier's industry and zero otherwise. The dependent variable in Column 1 is *Pair Sales*. Column 2 uses Cox proportional hazard model to estimate the likelihood of relationship termination. The dependent variables in columns 3, 4, and 5 are *Ln(Supplier Cross-Citations)*, *Ln(Customer Cross-Citations)*, and *Technological Proximity*, which measure the innovation similarity between the supplier and the customer. The dependent variable in Column 6 is supplier's R&D. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Interpretation: The table shows that the effects of tariff reductions on supply chain relationships are insignificant when suppliers do not relocate an establishment to be in close proximity to the customers.

Panel A: Non-Relocating Pair-Years

	Pair Sales	*Cox Model*	*Ln(Supplier Cross-Citations)*	*Ln(Customer Cross-Citations)*	*Technological Proximity*	*Sup R&D*
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Tariff Reduction	-0.008	-0.001	0.018	0.036	-0.658	0.001
	(-1.021)	(-0.015)	(0.634)	(1.600)	(-0.566)	(0.044)
Tariff Reduction × Cus R&D						0.026
						(0.192)
Supplier control variables	Yes	Yes	Yes	Yes	Yes	Yes
Customer control variables	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	19,220	25,547	18,727	14,719	18,727	25,547
Adjusted/Pseudo R^2	0.006	0.018	0.032	0.022	0.021	0.245

Table A6: Continued

Panel B: Non-Relocating Pairs that Were Already in Close Proximity before Tariff Reductions

Variable	*Pair Sales* (1)	*Cox Model* (2)	*Ln(Supplier Cross-Citations)* (3)	*Ln(Customer Cross-Citations)* (4)	*Technological Proximity* (5)	*Sup R&D* (6)
Tariff Reduction	-0.014	-0.182	0.017	0.000	-2.572	-0.033
	(-1.117)	(-1.144)	(0.640)	(0.014)	(-0.931)	(-0.096)
Tariff Reduction × *Cus R&D*						-2.056
						(-1.525)
Supplier control variables	Yes	Yes	Yes	Yes	Yes	Yes
Customer control variables	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	6,584	7,844	6,092	6,005	6,092	7,844
Adjusted/Pseudo R^2	0.003	0.025	0.042	0.038	0.028	0.028

Table A7: 2SLS for Firm-Level Outcomes

This table presents the results of two-stage least squared regressions using major tariff reductions as instrument. In the first stage, we estimate the firm-level linear probability regression of the *Post Relocation* dummy on the tariff reduction dummy, the set of standard control variables, and firm and year fixed effects. The definitions of *Post Relocation* and tariff reduction dummy variable depend on whether the first-stage regression is estimated at the supplier level or at the customer level. When the dependent variable is measured at the supplier level (Columns 1-4), the first stage is the regression of *Post Relocation*, which is a dummy variable equal to 1 for the five years after the supplier relocates closer to a customer and zero otherwise. The tariff reduction dummy variable is equal to 1 for the seven years after the supplier's industry experienced a major tariff cut. When the dependent variable is measured at the customer level (Columns 5 and 6), *Post Relocation* is equal to 1 for the five years after any supplier relocates closer to the customer and zero otherwise. The tariff reduction dummy is equal to 1 for the seven years after any supplier's industry experienced a tariff cut and zero otherwise. In Columns 1 and 2, the dependent variables are alternate measures of product market threat, i.e., *Product Market Similarity* and *Product Market Fluidity*. In Column 3, the dependent variable is *Exploit*, which is the ratio of the number of exploitative patents to the total number of patents filed (and eventually granted) in a given year. In Column 4, the dependent variable is *Explore*, which is the ratio of the number of explorative patents divided by total number of patents filed (and eventually granted) in a given year. In Column 5, the dependent variable is *Purchase obligation*, which is calculated as the sum of purchase obligations for the future five years divided by total assets. In Column 6, the dependent variable is *Inventory*, which is total inventory divided by book value of total assets. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The variables are defined in Appendix Table A1.

Interpretation: The coefficient on instrumented *Post Relocation* is significant and consistent with the OLS results reported in Tables 10-12.

	Supplier Firm				Customer Firm	
	Product Market Similarity	*Product Market Fluidity*	*Exploit*	*Explore*	*Purchase Obligation*	*Inventory*
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Fit_Post Relocation	-2.261***	-3.789***	0.283**	-0.338**	0.216***	-0.182***
	(-2.998)	(-6.174)	(2.009)	(-1.980)	(3.493)	(-9.086)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Obs	13,970	14,926	5,195	5,195	6,172	10,130
Adj. R-squared	0.072	0.158	0.040	0.042	0.082	0.127