Vertical integration with two-sided heterogeneity and a firm-to-firm network structure of production *

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Abstract

We study the overlap of the production and ownership relationships between firms in Japan. We leverage data of unprecedented coverage to document the economy-wide incidence of vertical integration and to study the importance of customer and supplier networks for the organization of production relationships. We develop a property-rights-theory model of organizational choice within a production network that features two-sided heterogeneity and a market for corporate control, in which firms compete for the ownership of common suppliers and customers. In line with the predictions of our model, we find that firms that are large, but have fewer and smaller customers and suppliers are more likely to be vertically integrated. Moreover, these targets are likely to be integrated by the largest customer/supplier within their network. Long-standing relationships to other firms reduce the probability to be vertically integrated.

JEL Classification Codes: L22, L23, L24, L60

Keywords: Vertical Integration, Production network, Network structure

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1 Introduction

The boundary of the firm takes center stage in microeconomics. How firms organize production within and across firm boundaries is crucial for aggregate productivity, and observed organizational choices shed light on the type and relevancy of frictions facing firms. In this paper, we study the overlap of production and ownership relationships between firms in Japan. We leverage data of unprecedented scope to document for the first time how common vertical integration (VI) is for an economy as a whole and across its industries, and to study the determinants of firms' decisions to vertically integrate a supplier or customer or to transact at arms-length.

We aim to contribute to the theoretical and empirical literature on the organizational choice of production relationships. In contrast to the existing empirical literature, we are able to study VI decisions at the firm-pair level among the almost complete population of domestic firms. This is possible thanks to the detail and scope of our dataset on firm-to-firm linkages, which spans two overlapping networks; i.e., we observe both supplier-customer relationships and ownership relationships for the domestic firms in Japan. This data allows us to document the incidence of VI among nearly all domestic firms in the economy, distinguishing between integration of suppliers (backward vertical integration, BVI) and integration of customers (forward vertical integration, FVI), and to explore new determinants of the choice between different the organizational modes.[1]

While existing theoretical models of VI typically study a firm pair's choice in isolation, we show theoretically and verify empirically that the VI decision depends on the characteristics of more firms than just the acquirer and the target, namely, the characteristics of firms to which the potential target is linked through the production network and which are potential competitors of the acquirer in the market for corporate control. Our key finding is that a firm's connections in the production network predict organizational choices: Firms integrate suppliers that have a weak customer network and they integrate customers that have a weak supplier network. To explain this pattern, we build a model of organizational choice where heterogeneous firms are linked through a production network and also interact with each other in a market for corporate control.

In the first part of the paper, we document salient patterns in our overlapping networks that complement or corroborate stylized facts documented in the literature. Our first empirical finding is the

[1] In contrast, existing empirical evidence on the incidence and determinants of forward and backward integration are based on samples of cross-border firm-to-firm ownership relationships (Liu, 2021; Egger et al., 2023; Del Prete and Rungi, 2017) or samples of domestic parent-plant linkages (Lileeva and Van Biesebroeck, 2013) and, (with the exception of Liu, 2021), *imputed* production relationships.

tantamount importance of FVI and BVI. Even though both types of VI can equally well be rationalized by the dominant theories of organizational choice (that is, the property-rights theory (PRT) of Grossman and Hart (1986) and the theory of transaction cost economies (TCE) put forward by Klein et al. (1978); Williamson (1985)), empirical research has almost exclusively focused on BVI.[2] Our data covering the Japanese economy during the years 2008 to 2023 shows that FVI is just as important as BVI. Across manufacturing sectors, the share of production relationships that are integrated ranges between 1 and 6%. Notably, we find that within sectors the propensity to integrate a customer is very similar to the propensity to integrate a supplier and the likelihood to be integrated by a supplier is similar to the likelihood of being integrated by a customer. In other words, neither the sector of the integrating firm nor the sector of the integrated firm appear to be strong predictors of the direction of integration.

Our second stylized fact documents a relationship between VI and capital intensity at the sector level and at the sector-pair level. We show that vertical integration is more common in more capital intensive industries. This is true for both FVI and BVI and both for the capital intensity of the supplier industry as well as the customer industry. Hence, absolute capital intensity of the supplier or the customer alone also does not help predicting the direction of integration either. However, when turning to the sector-pair level, we find that relative capital intensity is a strong predictor of the *direction* of VI. We find BVI to be more prevalent when the customer's capital intensity is high relative to the supplier's capital intensity and vice versa for FVI.[3] Both patterns are consistent with the PRT of VI.[4]

In the second part of the paper, we turn to firm-level determinants of BVI and FVI and study the role of customer and supplier networks for the organizational choice. We build a PRT model of organizational choice into a network of customer-supplier relationship between heterogeneous firms.

[2] A plausible explanation for this bias is limited data availability. The bulk of large-scale empirical evidence on the determinants of VI is based on data distinguishing related-party imports from arms-length import transactions, where the headquarter firm is the customer purchasing goods under the two different forms of organization; see, e.g., Antras (2003); Nunn and Trefler (2008); Corcos et al. (2013); Berlingieri et al. (2020). Lileeva and Van Biesebroeck (2013); Del Prete and Rungi (2017); Liu (2021); Egger et al. (2023) are exceptions in that they consider VI in both directions.

[3] Our finding of a positive association between BVI and absolute capital intensity complements the empirical evidence that, among others, Antras (2003); Corcos et al. (2013); Berlingieri et al. (2020) have provided for the case of BVI. The relationship between relative capital intensity the direction of integration corroborates the results in Liu (2021) and Egger et al. (2023).

[4] The seminal PRT model of VI developed by Antras (2003) is built on the assumption that the capital intensity of production determines the scope for cost-sharing between the customer and supplier and the relative importance of the contribution by the headquarter, which provides capital. In Antras (2003) it is assumed that the downstream firm is the headquarter which provides capital services to supplier, which hires labor. Thus, the input of the downstream firm is relatively more important in capital-intensive industries, and hence, in line with the prediction of Grossman and Hart (1986), its incentive to backward integrate the supplier rises. Acemoglu et al. (2010) and Liu (2021) develop generalized PRT models where either the downstream firm or the upstream firm provide more of the essential (capital) input, predicting a higher incentive for FVI when the upstream firm's input is more important and vice versa for BVI.

In this setting, the productivity and capital intensity of both parties determine the net surpluses from choosing BVI or FVI over arms-length relationships, similar to the framework of Liu (2021) and Egger et al. (2023). However, a positive net surplus from VI is not sufficient for VI to actually materialize, because there may be several firms that would gain from integrating a certain target. Potential acquirers compete for the majority share of the target in a market for corporate control. To capture this additional layer of interaction, we build a market for corporate control into our model. In our production network the only motive for acquisition is vertical integration. Hence, the set of competitors in the market for corporate control for a given target comprises the target's customers and suppliers. We model this market as an auction where the firm that could generate the largest surplus from integrating a given target submits the winning bid. Hence, conditional on a pairs' surplus from VI, integration is more likely if the other customers and suppliers of the target do not have strong integration incentives. In terms of our model, the latter means that the target's production network is weak in the sense of the target being connected to fewer, less productive and less capital-intensive firms.

The market for corporate control is a well established concept (Jensen and Ruback, 1983) and it has frequently been applied to study acquisition; see., e.g., Nocke and Yeaple (2007) and Head and Ries (2008). Nevertheless, most existing models of the choice of the organizational form of a production relation describe the integration decision as a choice made by a given firm pair in isolation. Accordingly, most of the existing empirical literature has focused on characteristics of the owner and the integrated firm to explain the allocation of ownership rights in a customer-supplier relationship; see the literature review below. However, in a network of production linkages, several potential acquirers may be competing for the same target. Hence, a given pairs' decision to integrate cannot be viewed independently of the organizational choices of other firms.

In the empirical part, we take the predicted relationship between production network strength and the likelihood to be integrated forward or backward to the data. To circumvent the problem of reverse causality between organizational choices and firm outcomes, we focus on changes in the organizational form of production relationships, that is, forward and backward acquisitions, and measure firm characteristics prior to the change. Besides network strength, we also analyze the role of target and acquirer productivity and additional pair-specific characteristics: geographic distance, product similarity, and relationship age.

Consistent with the model's prediction, we find that suppliers that become backward integrated

have weaker customer networks compared to the acquirer's other suppliers that continue to supply inputs in arms-length relationships. Likewise, customers that become forward integrated have weaker supplier networks compared to the other customers of their acquirers. A "weaker" network here refers to a smaller number of connections, and a smaller size and lower capital intensity of the connected firms. The model's prediction of a positive relationship between the probability to become a target or an acquirer and firm productivity (which we proxy with size) is also confirmed.

Lastly, we find that the likelihood of vertical integration is higher the shorter the distance between acquirer and potential target, and the greater the distance to the potential competitors in the market for corporate control. Similarly, the likelihood of vertical integration increases when a customer-supplier relationship has existed for a longer period of time and when the relationships with other potential acquirers are less established. Finally, vertical integration is more likely when the two firms produce more similar products and when the other potential acquirers produce less similar products.

Our paper builds on a small literature studying how production network links between potential acquirers and potential targets and connections to other firms determine vertical integration; see, e.g., Harford et al. (2019), Dong et al. (2021), Cheng et al. (2022). Due to the lack of comprehensive data on both production networks and ownership networks, existing studies rely on selected samples, such as the firms in the Compustat or Factsheet databases.

Our paper also contributes to the literature studying VI through the lens of PRT models building on Antras (2003), in particular the strand exploring the *direction* of VI (Acemoglu et al., 2010; Lileeva and Van Biesebroeck, 2013; Del Prete and Rungi, 2017; Liu, 2021; Egger et al., 2023). Our finding of the importance of relative capital intensity strongly support the property-right based theory of BVI and FVI.

Other motives for vertical integration studied in the literature comprise transaction cost economies (Klein et al., 1978; Williamson, 1985; Berlingieri et al., 2020), intangible assets complementarity (Nocke and Yeaple, 2007), vertical foreclosure (Ordover et al., 1990; Boehm and Sonntag, 2023), and managerial overload (Aghion and Tirole, 1997). Neither of these theories, however, gives systematic guidance on the direction of VI and, hence, per se they cannot explain the observed patterns in relative capital intensity of BVI and FVI relationships. One alternative mechanism that could explain this pattern are credit constraints (Aghion and Tirole, 1994). However, our other dominant finding that targets tend to be large speaks against this mechanism.

Our paper proceeds as follows. Section 2 summarizes our data and Section 3 presents descriptive

evidence. Section 4 presents the model and Section 5 the empirical results. Section 6 concludes.

2 Data

This study utilizes two datasets, the dataset provided by Tokyo Shoko Research (TSR) and the dataset from the Basic Survey of Japanese Business Structure and Activities (BSJBSA or "KIKATSU"). The TSR dataset includes information on firm-to-firm production and ownership relationship, which enables us to examine the overlap of the relationships. It also includes firm characteristics, which can be merged to firm-to-firm network to consider two-sided heterogeneity. In addition, we create industry-level characteristics of capital intensity from BSJBSA.

2.1 TSR data

Tokyo Shoko Research (TSR) is a credit reporting company, collecting firm information, such as firm location, industry code, product code, sales, # of employment, and the information on transaction relation and ownership relation. Each firm reports its suppliers, customers, and owners up to 24. Using own reported and other reported information, we can identify firms with more than 24 transactions (Bernard et al. (2019)).

We use data from 2008 to 2023. Around 1 million firms are included each year. In 2010, 30% of firms are for construction, 14% for manufacturer, 12% for wholesaler, and 11% for retailers. There are 4 million transaction relations and 160 thousands ownership relations, where # of the overlap of these relations is 76 thousands. Of 4 million transaction relations, 15% are between construction, 15% are between manufacturers, and 16% are between manufacturer and wholesaler. Of 160 thousands ownership relations, 11% are between manufacturers, 9% are between manufacturer and wholesaler, and 4% are between constructions. Summing up by target's industry, 25% relations are owned by manufacturers, 18% are owned by financial sector, and 15% are owned by wholesalers. Our focus is relationship between manufacturers. Detailed summaries of overlap of the relations are shown in the next section.

2.2 BSJBSA

Basic Survey of Japanese Business Structure and Activities (BSJBSA or "KIKATSU") is a yearly survey by Ministry of Economy, Trade and Industry (METI). Target are firms with more than 50

Table 1: Capital intensity by broad manufacturing sector

Sector name	Sector	$\frac{\text{fixed assets}}{\text{employees}}$
PetroleumCoalprod..	17	47.92
BeverageTobaccoFeed	10	18.36
Steel	22	16.87
Chemical	16	15.81
CeramicStoneprodu..	21	15.77
PulpPaperproducts	14	13.70
Nonferrousmetal	23	12.90
WoodProducts	12	11.00
LeatherFurs	20	10.42
Metalproducts	24	9.64
Plasticproducts	18	9.54
Transportmachinery	31	9.43
Textile	11	9.39
Furniture	13	8.87
Printing	15	8.72
Food	9	8.50
ProductionMachinery	26	8.26
ElectronicCompone..	28	7.86
GeneralMachinery	25	7.82
BusinessMachines	27	7.59
Othermanu	32	7.56
Rubberproducts	19	7.29
Electricalmachinery	29	6.75
Telecomequip	30	6.39

Notes: fixed assets / employees is average across firms. Time period: 2016

employees and 30 million capital. In addition to firm activities such as exporting and importing, balance sheet information is included. Around 30 thousands firms for all sectors and 13 thousands firms for manufacturing sectors are included in 2010. We create industry level index instead of firm level variable by merging to TSR dataset, since only large firms are included in BSJBSA dataset and more than 90% firms are dropped through merging process. Our focus is capital intensity for manufacturing sectors. Here we define capital intensity as the value of fixed asset divided by # of employees. Table 1 shows the list of 2 digit industries with high capital intensity.

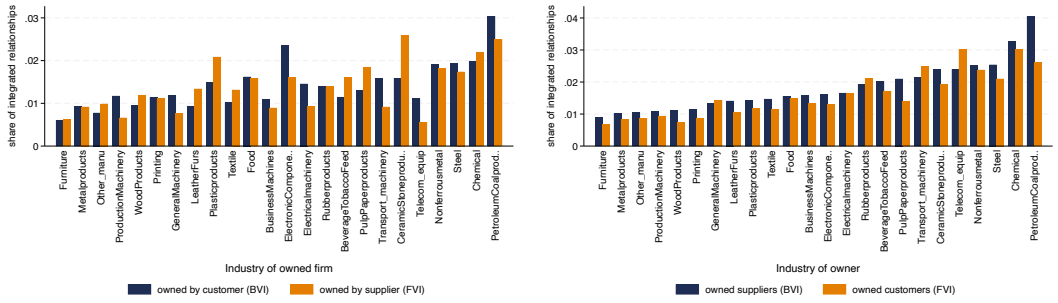
3 Descriptives

In this section, we describe the incidence of vertical integration, both forward and backward, across industries and for the Japanese economy as a whole. The unique coverage of our data permits us to draw – for the first time – a nearly complete picture of vertical integration among the population of domestic firms.

Incidence of FVI and BVI. The first stylized fact that we highlights is the similar prevalence of forward and backward VI across all industries. In Figure 1 panel a), the blue bars show the share of customer-supplier relationships in which the customer owns the supplier (BVI) in the total number of supplier-relationships, by sector of the owned firm. The orange bar shows the share of customer-supplier relationships in which the supplier owns the customer (FVI), by sector of the owned firm. The shares show that the probability to integrate ranges between .5% and 3%, depending on the sector. Moreover, in most sectors the probability to be forward integrated is about the same as the probability to be backward integrated. Only in a few sectors (Electronic Components, Telecom Equipment, Petroleum and Coal Production, Transport Machinery) is backward integration significantly more common. In a few sectors (Plastic Products, Ceramic and Stone Products), forward integration is much more likely.

Panel b of Figure 1 computes similar shares of integrated relationships, but from the perspective of the acquiring firm. The blue (orange) bars show how likely it is for a firm in a given industry to acquire a supplier (customer). Here, the similarity between BVI and FVI is even more pronounced. Except for firms in Petroleum and Coal Production there are very small differences between the likelihood to integrate forward or backward.

Figure 1: FVI and BVI

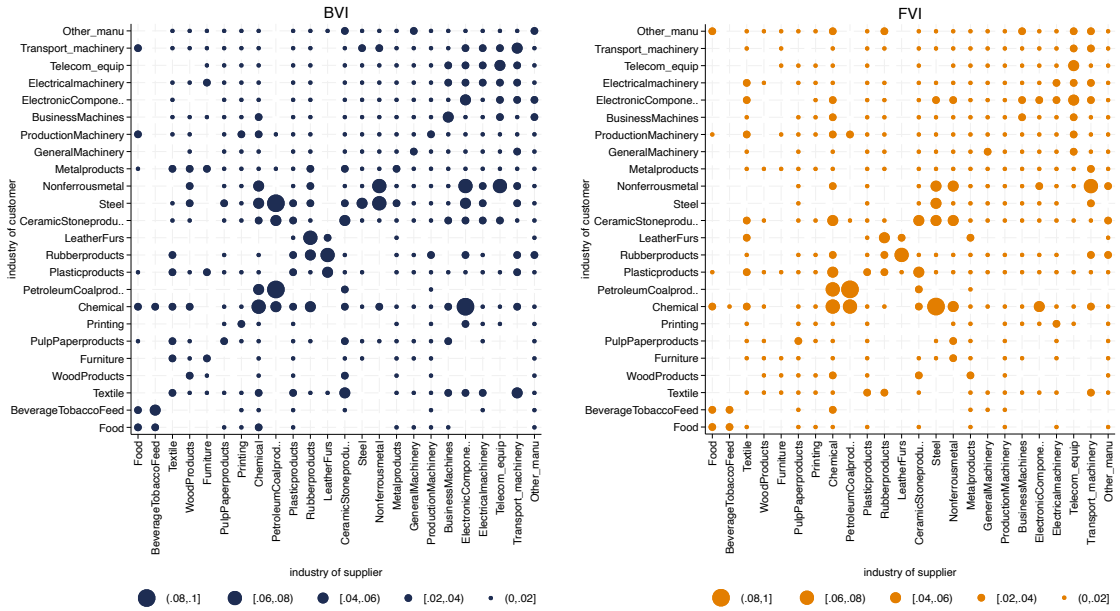


(a) by sector of owned firm

(b) by sector of owner

Note: The figure shows the share of integrated customer-supplier relationships in the total number of customer-supplier relationships by industry of the owned firm (a) and industry of the owner (b). Time period: 2010-2016.

Figure 2: Probability of VI



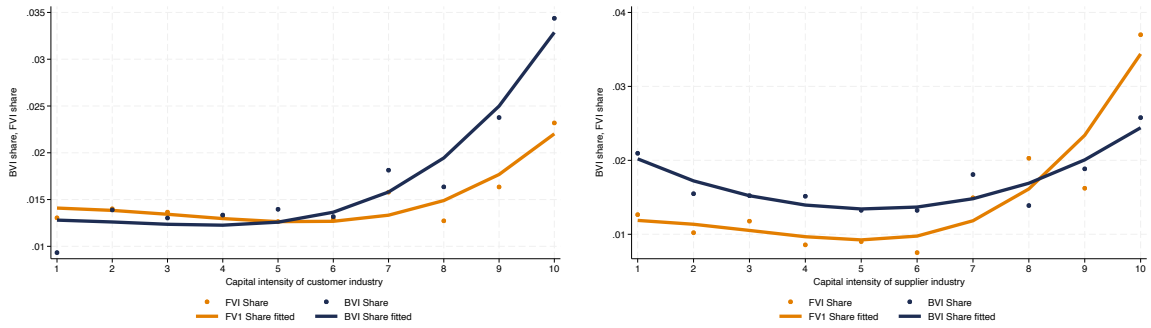
Note: The figure shows the share of integrated customer-supplier relationships (BVI left panel, FVI right panel) in total number of customer-supplier relationships by sector pair. Time period: 2010-2016.

Figure 2 shows backward and forward integration shares at the sector-pair level.[5] The left (right) panel shows the share of BVI (FVI) relationships in total customer-supplier relationships. At the sector-pair level, starker differences between the likelihood of FVI and BVI emerge. For example, Steel producers are very likely to backward integrate their suppliers from the Petroleum and Coal industry, but the reverse is unlikely. For producers in the Transport Machinery sector it is common to forward integrate customers in Nonferrous Metal Production, but not vice versa. This suggests that sector-pair characteristics, possibly reflecting technological relationships between specific inputs and outputs play a role in determining the direction of integration.

Absolute and relative capital intensity predict BVI and FVI. To explain the direction of vertical integration, we first look at industry characteristics. As stipulated by the PRT, the gains from integrating a transaction partner depend on the relative importance of the two parties' investment into the success of the relationship. Antras (2003) proposed that in more capital intensive production processes, vertical integration is more likely because if the headquarter contributes to joint production,

[5]Figure 6 in the appendix shows the number of transaction relationships and the number of ownership relationships separately.

Figure 3: Absolute capital intensity



Note: The figure shows the average share of integrated customer-supplier relationships across industries in 10 bins, defined by the 10 deciles of the distribution of capital intensity of the customer industry (left panel) and supplier industry (right panel). Capital intensity is measures as $ln(fixed\ assets/\#employees)$, and averaged across firms in an industry. Time period: 2016.

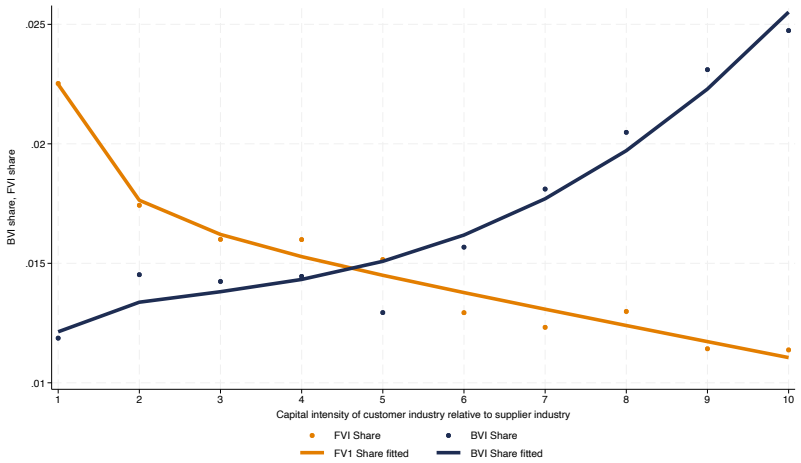
this is more likely to happen in the form of capital rather than labor. Hence, the higher the capital intensity, the more important the headquarter input for the output of the joint investment and the stronger the headquarters incentive to integrate. Antras (2003) and several papers thereafter have documented a positive relationship between the capital intensity of the headquarter (i.e. downstream) firm's industry and the likelihood of vertical integration.

We document several new aspects of this relationship. Figure 3 shows the relationship between the probability of BVI (blue) and FVI (orange) and the capital intensity of the customer's industry (left panel) and the capital intensity of the supplier's industry (right panel).[6] Both panels show increasing probabilities for both modes of vertical integration. That is, in line with the existing evidence, we find that downstream firms in more capital intensive industries are more likely to integrate their suppliers. However, we *also* find that that downstream firms in more capital intensive industries are more likely to be vertically integrated. A similar but sofar undocumented pattern emerges with regard to the capital intensity of the upstream firm. Upstream firms in more capital intensive sector have a higher likelihood to integrate their customers, but are also more likely to be integrated by a customer.

Both figures show that the likelihood to integrate increases relatively more in capital intensity than the likelihood to be integrated. This gives rise to the stark pattern displayed in Figure 4. While absolute capital intensity increases the propensity of VI integration in general, relative capital intensity predicts the direction of integration. The higher the capital intensity of the supplier is relative to the customer, the higher probability of FVI. Vice versa, the higher the capital intensity of the customer relative to the supplier, the higher the probability of BVI. This pattern is consistent with the results of

[6]Table 1 ranks sectors according to their capital intensity. In line with Figure 3, the most capital intensive sectors with the highest probabilities of vertical integration are Petroleum and Coal, Steel, and Chemicals.

Figure 4: Relative capital intensity



Note: The figure shows the average share of integrated customer-supplier relationships across industry pairs in 10 bins, defined by the 10 deciles of the distribution of relative capital intensity. Relative capital intensity is measured as $ln(fixed\ assets/\#employees)_{customer\ industry} - ln(fixed\ assets/\#employees)_{supplier\ industry}$. Time period: 2016.

Lileeva and Van Biesebroeck (2013), Liu (2021) and Egger et al. (2023), adding to a body of empirical evidence for the relevancy of the PRT of VI. We take the PRT as our starting point for the ensuing theoretical and empirical analysis of firm-level determinants of BVI and FVI.

4 Theory

To study how the network of production relationships influences the organization of production between customers and suppliers, we build a PRT model of organizational choice. We start by laying out the assumptions about the technology and the contracting environment that guide the surplus from any individual customer-supplier relationship under different organizational modes, i.e., ownership allocations. These assumptions do not deviate in any substantial way from existing models of the choice between BVI, FVI, and arms-length transactions (Acemoglu et al., 2010; Liu, 2021; Egger et al., 2023). The key mechanism at work follows Grossman and Hart (1986): Vertical integration mitigates the hold-up problem that arises when suppliers and customers make relationship-specific, non-contractible investments. The detrimental effects of contracting frictions are minimized when ownership rights are given to the firm that makes the larger contribution to the joint output. The key novel element in our setting is the market for corporate control. In this market, multiple customers and suppliers of a firm compete for its ownership.

4.1 Production

The downstream firm ("customer") c combines a set of inputs $cs \in S_c$ according to the production function

$$Y_c = \sum_{cs}^{S_c} y(cs) \qquad \text{with} \qquad y(cs) = q_c(cs)^{\eta(cs)} q_s(cs)^{1-\eta(cs)},$$

where $q_c(cs)$ measures the quality of the downstream firm's own relationship-specific component for the input cs, $q_s(cs)$ measures the quality of the relationship-specific component produced by the supplier of input cs, $\eta(cs)$ measures the relative importance of the customer's component.[7] The production function assumes that the components produced by c and s are complements. The inputs are substitutes in c's final good production. This setup ensures that the surplus of the relationship between c and any individual s is independent of the total output of c. For simplicity, we drop the relationship index cs. It will be reintroduced below when outcomes will be compared across different relationships.

[7] Instead of modeling factor intensity directly, we take a modeling shortcut and posit that η is higher for more capital-intensive components in more capital-intensive production processes. Several microfoundations deliver such a relationship, albeit at the cost of some tractability.

The customer and supplier produce their components at a cost

$$\Gamma_c = \frac{1}{2z_c} q_c^2 \qquad \text{and} \qquad \Gamma_s = \frac{1}{2z_s} q_s^2, \tag{1}$$

respectively. z_c and z_s measure productivity. The convex cost imply that all inputs will be produced.

4.2 Contracting environment

The quality of the components produced by c and s is assumed to be non-contractible, so the parties Nash-bargain ex-post about how the production surplus from the relationship is split. To reduce contracting frictions, c and s can choose an organizational form $o \in \{BVI, FVI, NI\}$ for their production relationship ex-ante. The three organizational forms are backward vertical integration (BVI, customer owns supplier), forward vertical integration (FVI, supplier owns customer), and non-integration (NI). Ex-ante transfers are also possible, hence both parties will find it optimal to choose the organizational form that maximizes the joint surplus in the subgame-perfect equilibrium.

4.3 Second-stage equilibrium conditional on o

4.3.1 Bargaining and outside options

Under either organizational form, symmetric Nash-bargaining yields the following split of the production surplus to party $i \in c, s$

$$y_i^o = O_i^o + \frac{1}{2}\left(y - O_c^o - O_s^o\right) \tag{2}$$

where O_i^o denotes the outside option for party i under organizational form o.

BVI. Under BVI, the customer owns both inputs. Hence, in case of a non-agreement, the supplier would be left with nothing:

$$O_s^{BVI} = 0.$$

For the customer we assume that the lack of cooperation by the supplier in case of disagreement reduces the relationship-specific output by a fraction $(1-\gamma)$. Hence,

$$O_c^{BVI} = \gamma y_{cs}$$

FVI. Under FVI, the outcome is the mirror image of BVI. The supplier owns the input. Hence, in case of a non-agreement in the bargaining process, the supplier is left with a fraction γ of the output

$$O_s^{FVI} = \gamma y_{cs}$$

and the customer is left with nothing.

$$O_c^{FVI} = 0.$$

NI. Under non-integration, both parties own their respective components. We assume that the components are worthless outside of the relationship, hence both firms' outside options are zero[8]

$$O_c^{NI} = 0 \qquad \text{and} \qquad O_s^{NI} = 0. \tag{3}$$

4.3.2 Quality choices and output

Conditional on the organizational form, c and s choose optimal quality investments for their components in anticipation of the bargaining outcome, taking the other parties choice as given. For $o = \{BVI, FVI, NI\}$, optimal quality of the supplier's and the customer's component is determined by

$$q_s^{*o} = \text{argmax} \quad y_s^o - \Gamma_s \qquad \text{and} \qquad q_c^* = \text{argmax} \quad y_c^o - \Gamma_c,$$

respectively. The resulting quality investments are

$$q_s^{*BVI} = \frac{1}{2}\left(z_c(1+\gamma)\eta\right)^{\frac{\eta}{2}}\left(z_s(1-\gamma)(1-\eta)\right)^{1-\frac{\eta}{2}} \qquad \text{and} \qquad q_c^{*BVI} = \frac{1}{2}\left(z_c(1+\gamma)\eta\right)^{\frac{1+\eta}{2}}\left(z_s(1-\gamma)(1-\eta)\right)^{\frac{1-\eta}{2}}.$$

[8] We could also assume some constant value, that might also be different between the two parties. This outside option has no bearing on the quality choice unless the outside options depend on the quality of the input.

$$q_s^{*FVI} = \frac{1}{2}\left(z_c(1-\gamma)\eta\right)^{\frac{\eta}{2}}\left(z_s(1+\gamma)(1-\eta)\right)^{1-\frac{\eta}{2}} \qquad \text{and} \qquad q_c^{*FVI} = \frac{1}{2}\left(z_c(1-\gamma)\eta\right)^{\frac{1+\eta}{2}}\left(z_s(1+\gamma)(1-\eta)\right)^{\frac{1-\eta}{2}},$$

and

$$q_s^{*NI} = \frac{1}{2}\left(z_h\eta\right)^{\frac{\eta}{2}}\left(z_s(1-\eta)\right)^{1-\frac{\eta}{2}} \qquad \text{and} \qquad q_c^{*NI} = \frac{1}{2}\left(z_c\eta\right)^{\frac{1+\eta}{2}}\left(z_s(1-\eta)\right)^{\frac{1-\eta}{2}}.$$

The corresponding production surpluses are

$$y^{BVI} = \frac{1}{2}\left(z_c(1+\gamma)\eta\right)^{\eta}\left(z_s(1-\gamma)(1-\eta)\right)^{1-\eta}, \tag{4}$$

$$y^{FVI} = \frac{1}{2}\left(z_c(1-\gamma)\eta\right)^{\eta}\left(z_s(1+\gamma)(1-\eta)\right)^{1-\eta} \tag{5}$$

and

$$y^{NI} = \frac{1}{2}\left(z_c\eta\right)^{\eta}\left(z_s(1-\eta)\right)^{1-\eta}. \tag{6}$$

4.4 Full equilibrium

In the first stage, potential acquirers bid for the shares of potential targets. We abstract from modeling the details of the auction and simply assume that the outcome of the bidding process is that the target accepts the offer from the bidder that *could* make the best possible offer. We start by describing the backward acquisition decision of a customer.

The maximum offer c is willing to make is given by

$$S_c^{BVI} - S_c^{NI} + V_s - S_s^{NI},$$

where $S_c^{BVI} = y_c^{BVI} - \Gamma(q_c^{BVI})$ is c's surplus under BVI, and $S_s^{NI} = y_s^{NI} - \Gamma(q_s^{*NI})$ and $S_c^{NI} = y_c^{NI} - \Gamma(q_c^{*NI})$ are the net surpluses for both firms under NI. V_s is the current value of firm s, equal to sum over the surpluses s generates in all its existing production relationships under their current organizational form.

If c was the only bidder, then the minimum offer needed to pursuade s's shareholders to agree to

BVI is

$$V_s - S_s^{BVI}.$$

Hence, the maximum premium that c can offer is

$$S_c^{BVI} - S_c^{NI} + V_s - S_s^{NI} - (V_s - S_s^{BVI}) = S_{cs}^{BVI} - S_{cs}^{NI},$$

where $S_{cs}^{BVI} = S_c^{BVI} + S_s^{BVI}$ and $S_{cs}^{NI} = S_s^{NI} + S_c^{NI}$ are the joint surpluses of both parties under BVI and NI, respectively.

If there are other bidders, c will win the auction if offers the highest premium among all bidders. That is, c will integrate s if

$$S_{cs}^{BVI} - S_{cs}^{NI} \geq \max\left\{0, S_{c's}^{BVI} - S_{c's}^{NI}, S_{s's}^{FVI} - S_{s's}^{NI} | c' \in N_s^{CUS}, s' \in N_s^{SUP}\right\} \tag{7}$$

In (7), we have taken into account that c competes not only with other customers of s that consider BVI, but also with suppliers of s that consider FVI (indexed by s'). By complete analogy, the maximum premium that suppliers of s could offer is $S_{s's}^{FVI} - S_{s's}^{NI}$.

Invoking analogy again, we can describe the forward acquisition decision of a supplier by an auction for the majority share of a customer. s will integrate c if

$$S_{cs}^{FVI} - S_{cs}^{NI} \geq \max\left\{0, S_{cs'}^{FVI} - S_{cs'}^{NI}, S_{c'c}^{BVI} - S_{c'c}^{NI} | s' \in N_c^{SUP}, c' \in N_c^{CUS}\right\}. \tag{8}$$

Which firm wins the auction, depends on the determinants of net surpluses from BVI and FVI in a given relationship. One key factor is η the relative importance of the two parties' components. Across the parameter space, it holds that

$$\frac{\partial(S^{BVI} - S^{NI})}{\partial \eta} > 0 \qquad \text{and} \qquad \frac{\partial(S^{FVI} - S^{NI})}{\partial \eta} < 0. \tag{9}$$

That is, the more important the input of the customer is (the higher η), the higher the net surplus from BVI. Likewise, the more important the input of the supplier is (lower η), the higher is the net surplus from FVI. This is a straightforward example of the PRT by Grossman and Hart (1986).

Moreover, there exists a threshold level $\underline{\eta} \in (0, \overline{\eta})$ at which $S^{FVI} - S^{NI}$ turns negative and a

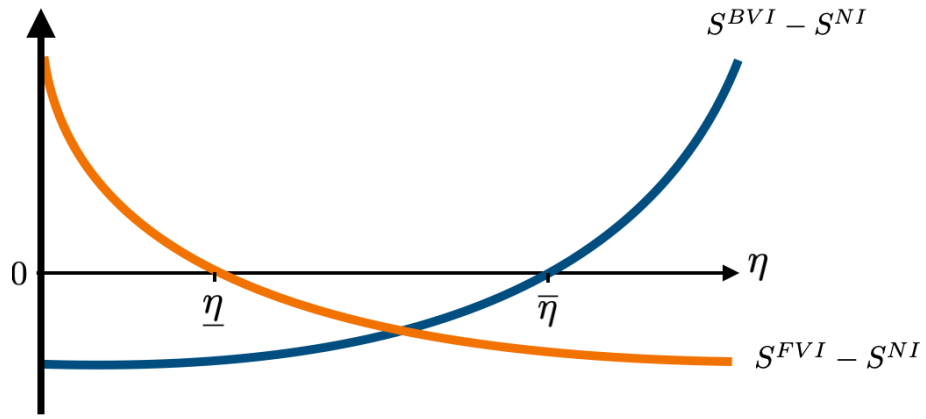


Figure 5: Net surplus of BVI and FVI

threshold level $\overline{\eta} \in (\underline{\eta}, 1)$ at which $S^{BVI} - S^{NI}$ turns positive. For any values of η observing $\underline{\eta} \leq \eta \leq \overline{\eta}$, the net surpluses from either form of integration are negative and non-integration is preferred independent of the presence of competitors in the market for corporate control. Figure 5 depicts the relationship between the net surpluses and η for a certain value of γ. Figure 10 in the appendix shows the same relationship across the full parameter space spanned by η and γ.

Moreover, the net surpluses from both types of integration are increasing in the productivity of the customer and supplier:

$$\frac{\partial(S^{BVI} - S^{NI})}{\partial z_i} > 0 \quad \text{for } i \in c, s \quad \text{and} \quad \frac{\partial(S^{FVI} - S^{NI})}{\partial z_i} > 0 \quad \text{for } i \in c, s \tag{10}$$

Proposition 1 Suppose the net surplus from BVI and FVI are given by $\tilde{S}_{cs}^{BVI} = S_{cs}^{BVI} - S_{cs}^{NI} + \varepsilon_{cs}$ and $\tilde{S}_{cs}^{FVI} = S_{cs}^{FVI} - S_{cs}^{NI} + \epsilon_{cs}$, where ε and ϵ are i.i.d. disturbances. Then,

a) the probability that $o_{cs} = BVI$ is increasing in $\eta(cs)$ and the probability that $o_{cs} = FVI$ is decreasing in $\eta(cs)$.

b) the probability that $o_{cs} = \{BVI, FVI\}$ is increasing in both parties' productivity.

c) the probability that $o_{cs} = BVI$ is decreasing in the number of customers and suppliers of s, decreasing in $\eta(c's)$ for $c' \in N_s^{CUS,-c}$ and increasing in $\eta(ss')$ for $s' \in N_s^{SUP}$ and the probability that $o_{cs} = BVI$ is decreasing in the number of customers and suppliers of c, decreasing in $\eta(c'c)$ for $c' \in N_c^{CUS}$ and increasing in $\eta(cs')$ for $s' \in N_c^{SUP,-s}$.

Part a) of proposition states that BVI is more likely if the customer's input is relatively more important and FVI is more likely if the supplier's input is relatively more important. This result is well established and has been empirically confirmed by Lileeva and Van Biesebroeck (2013); Liu (2021) and Egger et al. (2023). Our descriptive evidence in Section 3 is strongly consistent with this theoretical results.

Part b) means that the probability of VI increases in the productivity of both the potential acquirer and the potential target. Part c) means that BVI is more likely if the supplier is connected to fewer firms and to firms that have weaker incentives to integrate the supplier. FVI is more likely if the customer is connected to fewer firms and to firms that have weaker incentives to integrate the customer. In the next section, we bring the predictions from part b) and c) to the data.

5 Empirical analysis

We use our firm-pair data to study the empirical relationship between customer and supplier networks and the probability of BVI and FVI, as well as the role of target and acquirer productivity. To circumvent the problem of endogeneity, we focus on changes in the organizational form of production relationships, that is, forward and backward acquisitions, and measure firm characteristics prior to the change. We use firm size measured by sales as a proxy for firm productivity.

In line with the model predictions, we use sales and capital intensity of the target's customers and suppliers to measure their gains from vertical integration. In addition, we examine whether the following pair-specific characteristics predict vertical integration: The geodetic distance between customer and supplier (*Distance*), the number of years since the customer-supplier relationship was formed (or since the start of the sample, *Duration*), and the similarity of products produced by the customer and the supplier (*Similarity*). To calculate *Similarity*, we use the natural language processing algorithm BERT to determine the similarity between products according to the product description in the TSR data and then take the average similarity between the sets of products produced by both firms.

Our estimation sample consists of all vertical acquisition events, covering targets and acquirers and their full network of suppliers and customers. For most parts of our empirical analysis, we restrict the set of control firms to the non-integrated suppliers and customers of acquirers and targets. Table 2 (3) summarizes our sample of BVI (FVI) events.

Table 2: Summary statistics: BVI sample

	controls				acquirers & targets			
	# relationships	mean	median	s.d.	# relationships	mean	median	s.d.
Distance	374216	243.70	132.27	271.68	4247	220.42	84.31	277.34
Duration	374216	4.84	3.00	4.53	4247	5.29	4.00	4.72
Similarity	374216	0.34	0.33	0.06	4247	0.36	0.35	0.10
	# customers	mean	median	s.d.	# customers	mean	median	s.d.
N^{CUS}	18263	18	7	73	1602	104	20	372
N^{SUP}	18263	18	8	59	1602	121	25	328
Sales	18256	10	1	89	1600	100	8	420
	# suppliers	mean	median	s.d.	# suppliers	mean	median	s.d.
N^{CUS}	62917	12	6	68	1953	20	7	74
N^{SUP}	62917	11	5	55	1953	26	7	130
Sales	62914	5	0	79	1943	18	1	144

Notes: Columns titled "acquirers & targets" include firms that are involved in an acquisition during the sample period. Columns titled "controls" include customers and suppliers that have relationships with acquirers & targets but are not themselves involved in any acquisitions.

5.1 Acquirer characteristics

We begin by studying how acquirers differ from customers and suppliers with whom the targets continue to transact at arms-length. For BVI, we run the following regression:

$$\Delta BVI_{cs,t+1} = \alpha_1 \ln Sales_{c,t} + \alpha_2 \ln Dist_{cs} + \alpha_3 Similarity_{cs,t} + \alpha_4 Duration_{cs,t} + \delta_{s,t} + \delta_{Ind_c,t} + \varepsilon_{cs,t} \tag{11}$$

The dependent variable $\Delta BVI_{cs,t+1}$ is one if c integrates s in $t+1$. The regression includes supplier-time fixed effects. Hence, identification is solely based on the comparison of the acquiring customer to the target's other customers. In addition, we include customer-industry-time fixed effects to account for unobserved heterogeneity between acquirers and non-acquirers at the sector level.

For FVI, we run the analogous regression

$$\Delta FVI_{cs,t+1} = \alpha_1 \ln Sales_{s,t} + \alpha_2 \ln Dist_{cs} + \alpha_3 Similarity_{cs,t} + \alpha_4 Duration_{cs,t} + \delta_{c,t} + \delta_{Ind_s,t} + \varepsilon_{cs,t} \tag{12}$$

comparing the acquiring supplier with other suppliers of the target.

Table 3: Summary statistics: FVI sample

	controls				acquirers & targets			
	# relationships	mean	median	s.d.	# relationships	mean	median	s.d.
Distance	209008	284.72	191.08	299.28	3551	251.09	107.10	304.07
Duration	209008	4.77	4.00	4.43	3551	5.42	4.00	4.72
Similarity	209008	0.34	0.34	0.07	3551	0.37	0.35	0.10
	# customers	mean	median	s.d.	# customers	mean	median	s.d.
N^{CUS}	32547	15	7	84	1385	95	20	267
N^{SUP}	32547	12	5	43	1385	111	19	329
Sales	32544	6	0	56	1383	98	6	481
	# suppliers	mean	median	s.d.	# suppliers	mean	median	s.d.
N^{CUS}	40823	16	6	89	1590	28	9	83
N^{SUP}	40823	16	6	76	1590	30	9	107
Sales	40808	8	1	85	1587	25	2	277

Notes: Columns titled "acquirers & targets" include firms that are involved in an acquisition during the sample period. Columns titled "controls" include customers and suppliers that have relationships with acquirers & targets but are not themselves involved in any acquisitions.

Table 4 presents the results. Consistent with the model, we find that acquirers are larger than non-acquirers. More specifically, the coefficient estimates from our within-supplier analysis imply that suppliers are more likely to be backward integrated by a customer that is large compared to the supplier's other customers. Customers are more likely to be forward integrated by the supplier that is large compared to the other suppliers of the customer. Acquirers are also closer to their targets, produce more similar products, and have been transacting with their targets for longer periods of time. These findings hold true for both BVI (columns 1-3) and FVI (columns 4-6) and are robust to including acquirer-region time fixed effects. Our main specifications (columns 1,2,4,5) include targets and control firms only in the year of the acquisition. The results do not change qualitatively when we include all years (columns 3,6).

Table 4: Determinants of VI: Acquirer characteristics

	BVI			FVI		
Dep. variable:	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}
$\ln Sales$	0.0095***	0.0072***	0.0004***	0.0105***	0.0105***	0.0007***
	(0.0008)	(0.0008)	(0.0000)	(0.0007)	(0.0008)	(0.0000)
$\ln Distance$	-0.0037***	-0.0022*	-0.0001***	-0.0021***	-0.0016**	-0.0001***
	(0.0009)	(0.0012)	(0.0000)	(0.0005)	(0.0007)	(0.0000)
$Similarity$	0.1047***	0.1163***	0.0045***	0.0353***	0.0616***	0.0039***
	(0.0235)	(0.0275)	(0.0008)	(0.0130)	(0.0140)	(0.0008)
$Duration$	0.0024***	0.0025***	0.0000***	0.0012***	0.0008***	0.0001***
	(0.0006)	(0.0007)	(0.0000)	(0.0003)	(0.0003)	(0.0000)
Fixed effects	$s \times t, ind_c \times t$	$s \times t, reg_c \times t$	$s \times t, ind_c \times t$	$c \times t, ind_s \times t$	$c \times t, reg_s \times t$	$c \times t, ind_s \times t$
N	33,690	30,163	1,774,937	59,447	55,717	1,236,933

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Standard errors clustered by target (supplier in columns 1-3 and customer in columns 4-6). Columns 1,2 (4,5) are based on subsample including only customers (suppliers) that acquire a supplier (customer) and all of their suppliers (customers).

5.2 Target characteristics

Next, we zoom in on the targets. For BVI, we estimate the following regression:

$$\begin{aligned}\Delta BVI_{cs,t+1} =& \alpha \ln Sales_{s,t} + \alpha_2 \ln Dist_{cs} + \alpha_3 Similarity_{cs,t} + \alpha_4 Duration_{cs,t} \\ &+ \underbrace{\beta_1 \ln N_{s,t}^{CUS} + \beta_2 \overline{\ln X}_{s,t}^{CUS}}_{\text{target's other customers}} + \underbrace{\beta_4 \ln N_{s,t}^{SUP} + \beta_5 \overline{\ln X}_{s,t}^{SUP}}_{\text{target's suppliers}} + \delta_{c,t} + \delta_{Ind_s,t} + \varepsilon_{cs,t}\end{aligned} \tag{13}$$

This regression isolates firm characteristics that differentiate suppliers that become integrated from suppliers that remain independent. Heterogeneity on the customer side is fully absorbed by fixed effects $\delta_{c,t}$. Besides sales and the pair-specific characteristics $\ln Distance, Similarity, Duration$, we include measures of the size of the target's production network and a vector of network characteristics $\overline{\ln X}_{s,t}^{CUS}$ and $\overline{\ln X}_{s,t}^{SUP}$, which measure the economic weight of the target's connections and proxy their propensity to gain from the integration of the target as well. That is, $\overline{\ln X}_{s,t}^{CUS}$ and $\overline{\ln X}_{s,t}^{SUP}$ respectively measure the average strength of the integration incentives of the target's other customers and suppliers with whom the acquirer c competes in the market for corporate control. $\overline{\ln X}_{s,t}^{CUS}$ contains the average sales and capital intensity of the target's other customer, $\overline{\ln Sales}_{s,t}^{CUS}$ and $\overline{\ln Assets}_{s,t}^{CUS}$. Moreover, we also include the target's average geographical distance ($\overline{\ln Dist}_{s,t}^{CUS}$) and product similarity ($\overline{Similarity}_{s,t}^{CUS}$) to the competitors, as well as the average age of these relationships ($\overline{Duration}_{s,t}^{CUS}$).[9] According to the predictions of the model, we expect that larger sales and greater capital intensity

[9] We exclude the acquiring customer c from all these averages.

of the competitors in the market for corporate control reduce the likelihood of vertical integration. Moreover, given that a shorter distance between customer and supplier is associated with a higher propensity to vertically integrate (see Table 4), we expect that integration is more likely if the potential competitors in the market for corporate control are further away from the target. Similarly, we expect that integration is more likely, if the competitors produce less similar products and if their relationship with the target is less established.

We also include the same variables for the supplier's own supplier network:

$$\overline{\ln X}_{s,t}^{SUP} = \left\{ \overline{\ln Sales}_{s,t}^{SUP}, \overline{\ln Assets}_{s,t}^{SUP}, \overline{\ln Dist}_{s,t}^{SUP}, \overline{Similarity}_{s,t}^{SUP}, \overline{Duration}_{s,t}^{SUP} \right\}$$

Tables 5 and 6 present the results for BVI and FVI, respectively. In the first column of Table 5 we include only the (potential) target's sales, the pair-specific variables $\ln Distance, Similarity$ and $Duration$, and the log number of customers and suppliers of the (potential) target. In column (2) we add the full set of variables that capture the integration incentives of the target's other customers. In column (3) we also include observations for acquirers and their suppliers from years other than the year of the acquisition (hence the increase in the number of observations). In column (4) we include time-varying fixed effects for the region of the target instead of its industry. In column (5) we add the variables that capture the integration incentives of the target's suppliers. In column (6) we drop acquirers with less than 20 suppliers. Table 6 has the same structure.

Across specifications, we find a positive relationship between (pre-acquisition) sales of suppliers and their probability to be backward integrated or forward integrated, consistent with part b) of Proposition 1. More precisely, our estimates from the models with acquirer-time fixed effects imply that a supplier which is backward integrated by a customer tends to be larger than the other suppliers of this customer, and that a customer which is forward integrated by a supplier tends to be larger than the other customers of that supplier. Our findings on target (and also acquirer) productivity are different from existing evidence on the relationship between VI and productivity because we study customer productivity relative to other customers of the same supplier and supplier productivity relative to the other suppliers of a customer.[10] In this specification we can rule the possibility that the estimated effect of productivity is confounded by assortative matching between customers and suppliers. Figures

[10] A large body of empirical evidence documents a positive relationship between the absolute productivity of headquarters and their propensity to source inputs from related parties; see, e.g. the evidence and literature overview in Kohler and Smolka (2014). This implies that our results are not driven by assortative matching of customers and suppliers. As regards the absolute productivity of acquired firms, Guadalupe et al. (2012) provide evidence that foreign acquirers select the most productive firms.

8 and 9 show that this pattern is also present in the raw data, without conditioning on other firm variables. The results further confirm the negative effect of *Distance* and the positive effect of product similarity and relationship age across specification and for both BVI and FVI.

Moreover, we find strong support for the hypothesis that production network links to other potential acquirers reduce the probability of vertical integration (part c of Proposition 1). Focusing on BVI first (Table 5), we find that connections to more customers and to customers with stronger integration incentives (measured by their averages sales, their distance and product similarity to the target, and the age of their relationship with the target) reduce the probability of vertical integration. Interestingly, we do not find a similar result for the target-supplier's own supplier network: The number of suppliers is (weakly) positively related to the probability of integration, and, except for the average distance to the suppliers, the supplier characteristics are not significant or unstable across specifications.

Turning to the results for FVI (Table 6), we find qualitatively the same results for the competitors' characteristics. Customers are less likely to become vertically integrated if they are connected to more suppliers and to suppliers with a high propensity to gain from integrating the customer as well. For FVI, the effect of the other suppliers' capital intensity aligns with the predictions of the model, whereas is was insignificant for BVI.

On the side of the customer's own customer network, we don't find conclusive evidence for the hypothesis that these firms act as competitors in the acquisition. While the average sales of the linked customers and the distance to the customers have significant effects in line with the hypothesis, the other characteristics that matter on the supplier side are not significant or have the opposite sign.

Table 5: Determinants of BVI: Target characteristics

Dep. variable:	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔBVI_{t+1}
$\ln Sales$	0.0028***	0.0023***	0.0005***	0.0024***	0.0021***	0.0019***
	(0.0003)	(0.0003)	(0.0000)	(0.0003)	(0.0003)	(0.0002)
$\ln Distance$	-0.0003***	-0.0004***	-0.0001***	-0.0006***	-0.0005***	-0.0002**
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
$Similarity$	0.0294***	0.0279***	0.0043***	0.0303***	0.0300***	0.0166***
	(0.0049)	(0.0056)	(0.0008)	(0.0054)	(0.0060)	(0.0045)
$Duration$	0.0001**	0.0003***	0.0000***	0.0003***	0.0003***	0.0002***
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
$\ln N^{CUS}$	-0.0065***	-0.0050***	-0.0010***	-0.0046***	-0.0051***	-0.0037***
	(0.0007)	(0.0006)	(0.0001)	(0.0006)	(0.0006)	(0.0005)
$\overline{\ln Sales}^{CUS}$		-0.0005***	-0.0001***	-0.0004***	-0.0005***	-0.0004***
		(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
$\overline{\ln CapInt}^{CUS}$		0.0007*	0.0001	-0.0004	0.0006	0.0004
		(0.0004)	(0.0001)	(0.0004)	(0.0004)	(0.0004)
$\overline{Duration}^{CUS}$		-0.0005***	-0.0001***	-0.0005***	-0.0004***	-0.0004***
		(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
$\overline{\ln Distance}^{CUS}$		0.0009***	0.0002***	0.0007***	0.0009***	0.0006***
		(0.0002)	(0.0000)	(0.0002)	(0.0002)	(0.0002)
$\overline{Similarity}^{CUS}$		-0.0134***	-0.0021***	-0.0156***	-0.0103**	-0.0043
		(0.0041)	(0.0007)	(0.0039)	(0.0043)	(0.0036)
$\ln N^{SUP}$	0.0004				0.0005*	0.0005**
	(0.0003)				(0.0003)	(0.0002)
$\overline{\ln Sales}^{SUP}$					-0.0001	-0.0000
					(0.0001)	(0.0001)
$\overline{\ln CapInt}^{SUP}$					-0.0001	-0.0004
					(0.0005)	(0.0004)
$\overline{Duration}^{SUP}$					-0.0003***	-0.0001
					(0.0001)	(0.0001)
$\overline{\ln Distance}^{SUP}$					0.0004**	0.0003***
					(0.0001)	(0.0001)
$\overline{Similarity}^{SUP}$					-0.0056*	-0.0041
					(0.0033)	(0.0028)
Fixed effects	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$	$c \times t, reg_s \times t$	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$
N	347,822	309,253	1,686,786	306,499	296,384	290,378

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Columns 1,2,3,5,6 include customer time and supplier-industry-time fixed effects. Column 4 includes customer-time supplier-region-time fixed effects. Columns 1,2,4-6 are based on subsample including only customers that acquire a supplier and all of their suppliers. In column 6, customers with less than 20 suppliers are dropped. Standard errors clustered by acquirer (customer).

Table 6: Determinants of FVI: Target characteristics

Dep. variable:	ΔFVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}
$\ln Sales$	0.0036***	0.0030***	0.0005***	0.0029***	0.0031***	0.0026***
	(0.0004)	(0.0004)	(0.0000)	(0.0004)	(0.0004)	(0.0004)
$\ln Distance$	-0.0012***	-0.0012***	-0.0002***	-0.0018***	-0.0014***	-0.0005**
	(0.0002)	(0.0002)	(0.0000)	(0.0004)	(0.0003)	(0.0002)
$Similarity$	0.0391***	0.0497***	0.0064***	0.0521***	0.0505***	0.0316***
	(0.0087)	(0.0104)	(0.0011)	(0.0097)	(0.0106)	(0.0083)
$Duration$	0.0005***	0.0007***	0.0001***	0.0008***	0.0008***	0.0004***
	(0.0001)	(0.0001)	(0.0000)	(0.0002)	(0.0002)	(0.0001)
$\ln N^{CUS}$	-0.0002				-0.0002	-0.0003
	(0.0004)				(0.0005)	(0.0004)
$\overline{\ln Sales}^{CUS}$					-0.0007***	-0.0005***
					(0.0002)	(0.0002)
$\overline{\ln CapInt}^{CUS}$					0.0029***	0.0019***
					(0.0009)	(0.0007)
$\overline{Duration}^{CUS}$					-0.0004*	-0.0002
					(0.0002)	(0.0002)
$\overline{\ln Distance}^{CUS}$					0.0008**	0.0006**
					(0.0003)	(0.0003)
$\overline{Similarity}^{CUS}$					0.0000	-0.0004
					(0.0067)	(0.0055)
$\ln N^{SUP}$	-0.0070***	-0.0070***	-0.0011***	-0.0069***	-0.0075***	-0.0036***
	(0.0009)	(0.0009)	(0.0001)	(0.0009)	(0.0010)	(0.0008)
$\overline{\ln Sales}^{SUP}$		-0.0017***	-0.0003***	-0.0016***	-0.0015***	-0.0008***
		(0.0003)	(0.0000)	(0.0002)	(0.0003)	(0.0002)
$\overline{\ln CapInt}^{SUP}$		-0.0017*	-0.0004**	-0.0004	-0.0024**	-0.0015*
		(0.0010)	(0.0002)	(0.0010)	(0.0011)	(0.0009)
$\overline{Duration}^{SUP}$		-0.0010***	-0.0001***	-0.0010***	-0.0008***	-0.0007***
		(0.0002)	(0.0000)	(0.0002)	(0.0002)	(0.0002)
$\overline{\ln Distance}^{SUP}$		0.0010***	0.0001**	0.0008**	0.0006*	0.0002
		(0.0003)	(0.0001)	(0.0003)	(0.0003)	(0.0003)
$\overline{Similarity}^{SUP}$		-0.0315***	-0.0042***	-0.0258***	-0.0319***	-0.0187**
		(0.0077)	(0.0011)	(0.0074)	(0.0089)	(0.0072)
Fixed effects	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$	$s \times t, reg_c \times t$	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$
N	155,374	131,896	1,066,171	128,159	126,872	120,825

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Columns 1-3,5,6 include supplier-time and customer-industry-time fixed effects. Columns 4 includes supplier-time and customer-region-time fixed effects. Columns 1,2,4-6 are based on subsample including only suppliers that acquire a customer and all of their customers. In column 6, suppliers with less than 20 customers are dropped. Standard errors clustered by acquirer (supplier).

6 Conclusions

In this paper, we use detailed data on production and ownership linkages in Japan to study the choice of the organizational form of customer-supplier relationships. For the first time, we document the tantamount prevalence of forward and backward vertical integration across firms and industries in an economy as a whole. We also confirm existing evidence showing that absolute and relative capital intensity at the industry level are key determinants of the propensity for and the direction of vertical integration, supporting a property-rights-theory based view of vertical integrations. Turning to the firm-level determinants of vertical integration, we examine the role of the production network in shaping organizational choices, both theoretically and empirically. To that end, we build a model describing a network of production linkages in which ownership rights, that mitigate contracting frictions in the spirit of Grossman and Hart (1986) and Antras (2003), are allocated in a market for corporate control. The explicit description of the market for corporate control is the key novelty in our framework. Existing models of VI describe the integration decision as a choice made by a given firm pair in isolation. However, in a network of production linkages, several potential acquirers may be competing for the same target. Hence, a given pairs' decision to integrate cannot be viewed independently of integration choices of other firms. We formalize the interaction between multiple potential targets and acquirers that are linked through the production network in our model of the market for corporate control. Our empirical analysis confirms the importance of competition in the market for corporate control: Customers are more likely to acquire suppliers that have fewer other customers with strong integration incentives, supplier are more likely to acquire customers that are not attractive targets for many other suppliers.

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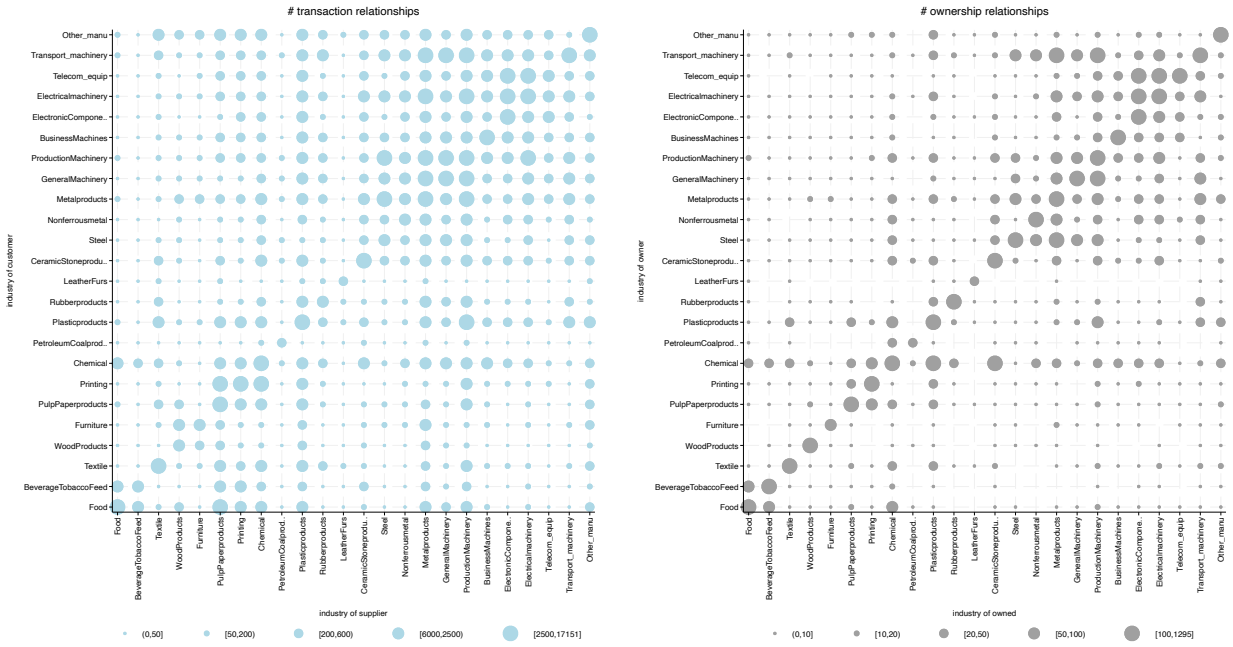
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Figure 6: Number of transaction and ownership relationships



Note: The figure shows the number of transaction relationships (left panel) and the number of ownership relationships by sector pair. Averages across time period 2010-2016.

Appendix

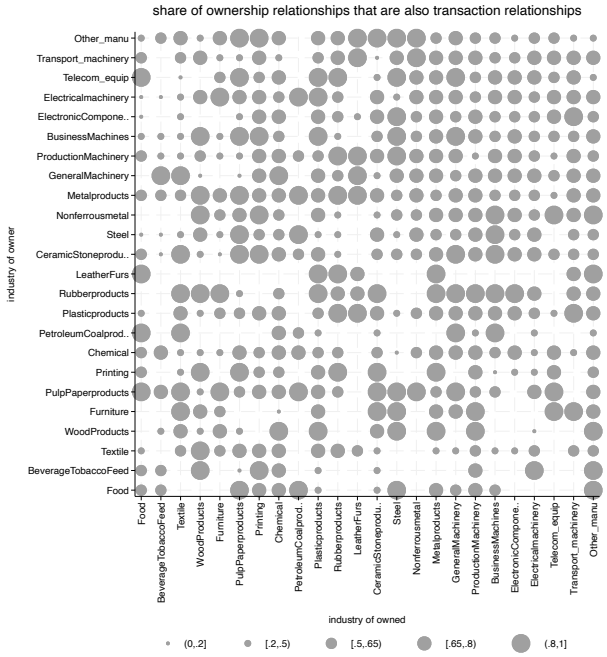
6.1 Data description

Here we document summary of transaction relation and ownership relation for the manufacturing sectors. We average the number of transaction relations and the number of ownership relations during the sample period from 2010 to 2016 shown in Figure 6. We see that there are more relations for diagonal between the same 2-digit industry especially for ownership relations.

Regarding the overlap of these relations, we look at the share of the transaction relations that are also ownership relations in Figure 2. Here, we look at the share of the ownership relation that are also transaction relations in Figure 7. We see that there are only a few pairs of industries with high ratio of BVI and FVI in Figure 2, while there are many pairs of industries where the majority of ownership relations are also transaction relations.

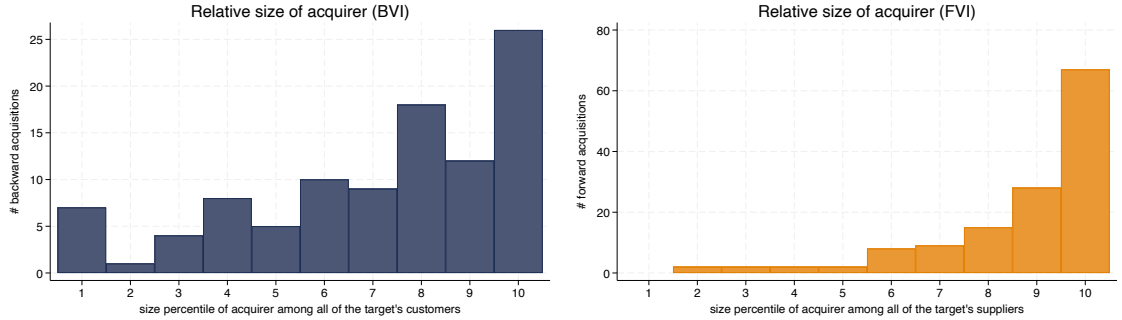
Lastly, we show the net surplus of BVI and FVI depending on γ and η in Figure 10.

Figure 7: Probability of VI, II



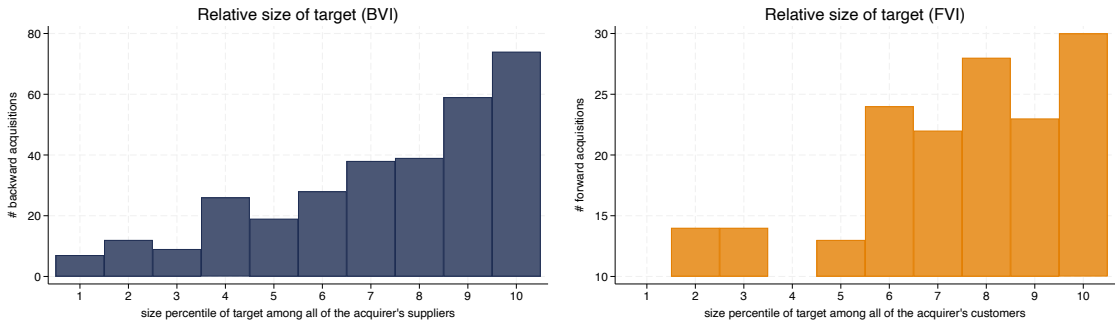
Note: The figure shows the share of ownership relationships that overlap with a transaction relationship, by sector pair. Averages across time period 2010-2016.

Figure 8: Relative size of acquirer



Note: The left (right) figure shows the number of backward (forward) acquisitions in which the acquirer is in a given percentile of the size distribution of the target's customers (suppliers). Time period: 2010-2016. Acquisitions where the targets has less than 10 customers (suppliers) are dropped.

Figure 9: Relative size of target



Note: The left (right) figure shows the number of backward (forward) acquisitions in which the target is in a given percentile of the size distribution of the acquirer's suppliers (customers). Time period: 2010-2016. Acquisitions where the acquirer has less than 10 suppliers (customers) are dropped.

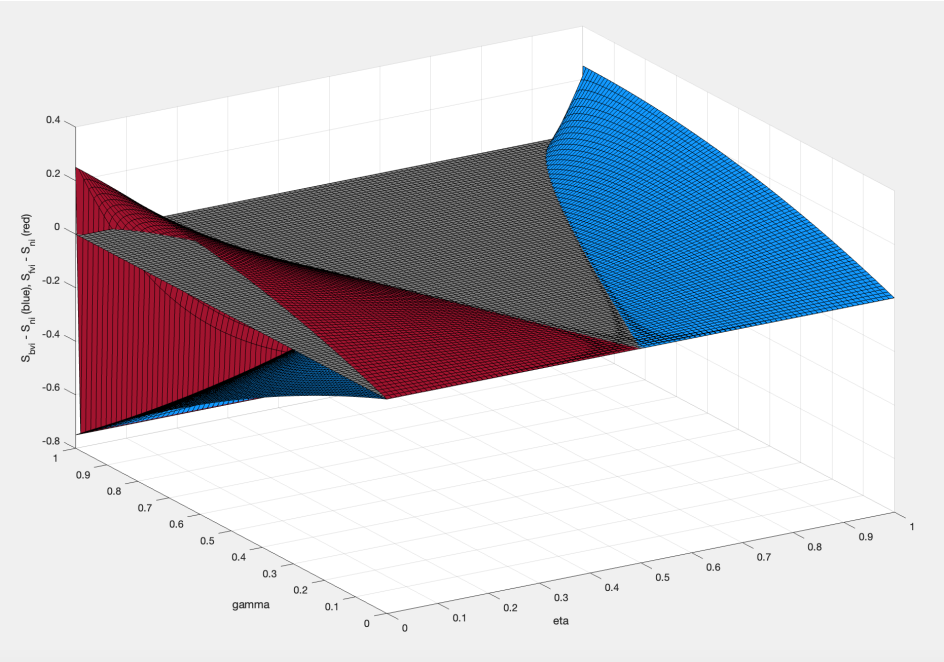


Figure 10: Net surplus of BVI (blue) and FVI (red)