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Vertical Integration with Two-sided Heterogeneity and Firm-to-firm Network Structure of Production[1]

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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, smaller, and less capital-intensive 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.

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Keywords: Vertical Integration, Production network
JEL classification: L22, L23, L24, L60

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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 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 population of domestic firms in Japan. This data allows us to document the incidence of VI among 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 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 novel 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 2010 to 2016 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 concept of a market for corporate control is well established (see, e.g. Nocke and Yeaple, 2007), but – to the best of our knowledge – has not been used to study determinants of vertical integration. Existing models of VI describe the integration decision as a choice made by a given firm pair in isolation. Accordingly, the existing empirical literature has focused on characteristics of the owner and the integrated firm to explain observed ownership patterns. However, in a network of production linkages, several potential acquirers may be competing for the same target. Hence, the a given pairs' decision to integrate cannot be viewed independently of the integration 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 productivity.

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. Also consistent with the model, we find no systematic relationship between network strength and the propensity to become a forward or backward acquirer. Lastly, 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.

Our paper contributes to the literature studying VI through 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). 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) and managerial overload (Aghion and Tirole, 1997). Neither of these theories, however, gives systematic guidance on the direction of VI. One competing explanatory factor for the choice between FVI and BVI are credit constraints (Aghion and Tirole, 1994). However, our finding that targets tend to be large speaks against this mechanism. On the contrary, our finding of the importance of relative capital intensity strongly support the property-right based theory of VI.

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"). 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, 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 2010 to 2016. 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 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.

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

3 Descriptives

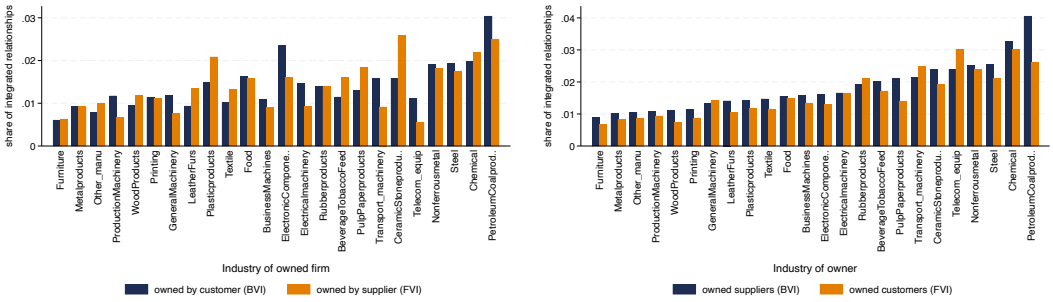
In this section, we describe the incidence of vertical integration, both forward and backward, across industries and for the Japanese economy as a whole. The unique coverage of our data permits us to draw – for the first time – a nearly complete picture of vertical integration among the population of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

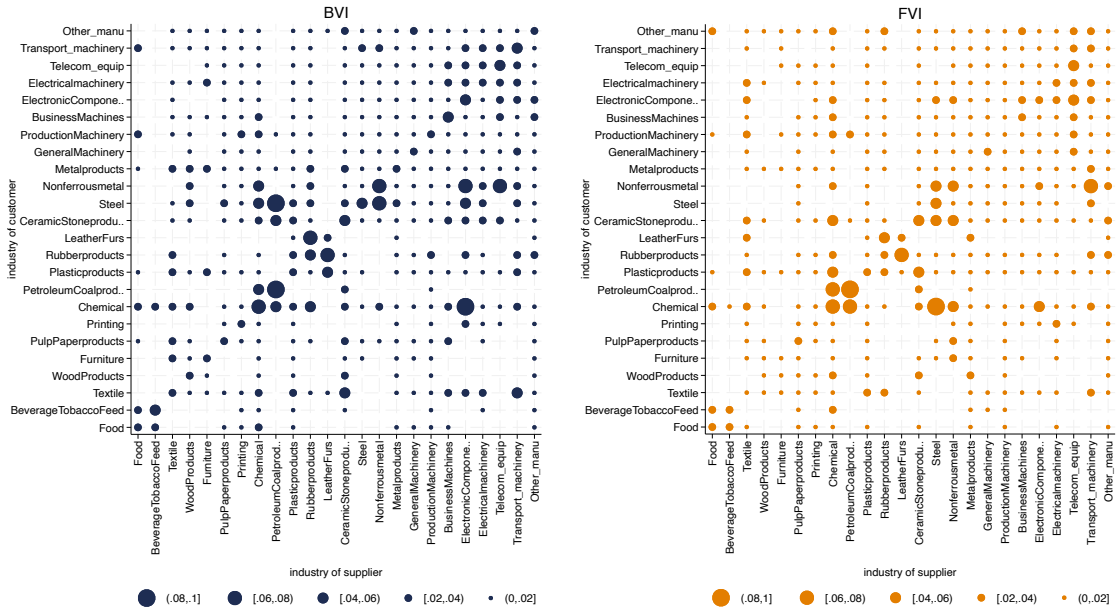
Note: The figure shows the share of integrated customer-supplier relationships in the total number of customer-supplier relationships by industry of the owned firm (a) and industry of the owner (b). Time period: 2010-2016.

Figure 2 computes 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

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

Figure 2: Probability of VI



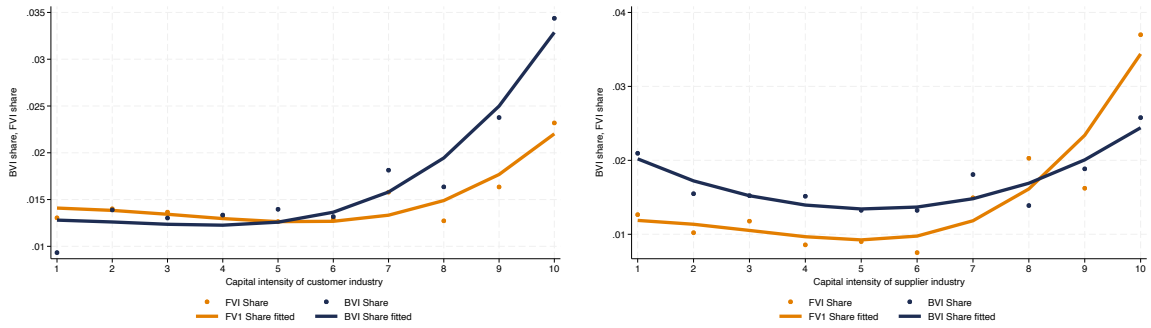
Note: The figure shows the share of integrated customer-supplier relationships (BVI left panel, FVI right panel) in total number of customer-supplier relationships by sector pair. Time period: 2010-2016.

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, 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

[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 3: Absolute capital intensity

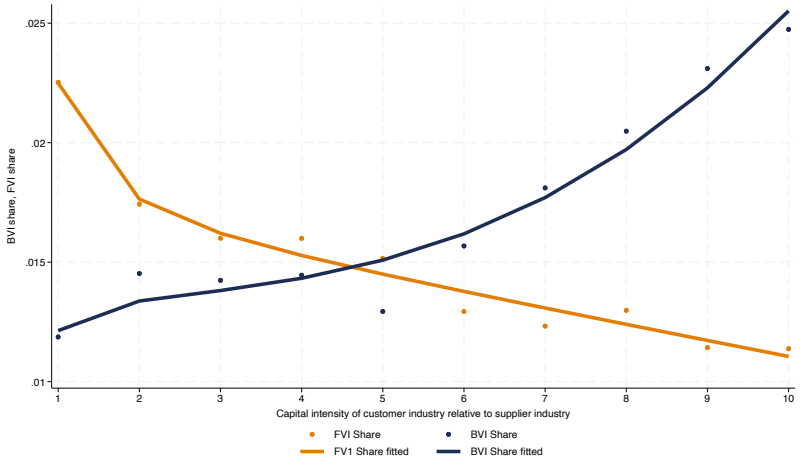


Note: The figure shows the average share of integrated customer-supplier relationships across industries in 10 bins, defined by the 10 deciles of the distribution of capital intensity of the customer industry (left panel) and supplier industry (right panel). Capital intensity is measures as $ln(fixed\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

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 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.

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.

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

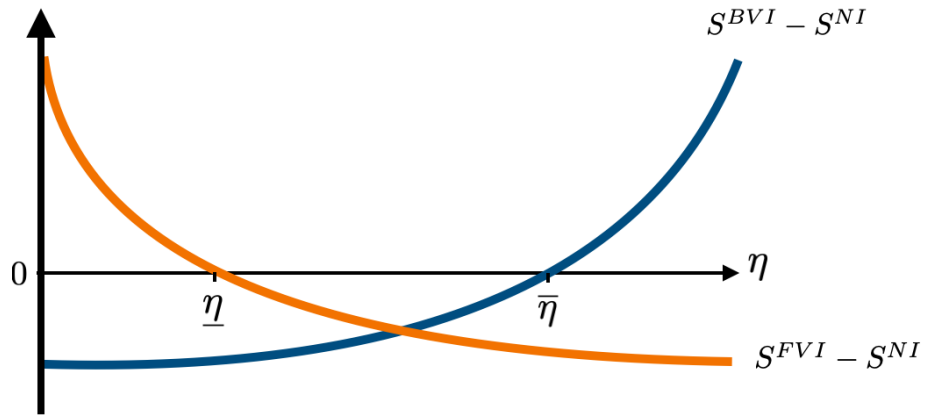


Figure 5: Net surplus of BVI and FVI

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. Part b), especially the predictions regarding the target productivity, is less well established. Part c) is completely novel. In the next section, we will 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 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. We use firm size measured by sales as proxy for firm productivity.

To study how a firm's production network and its size affect the likelihood to be backward integrated, we estimate the following regression:

$$\begin{aligned}\Delta BVI_{cs,t+1} =& \alpha \ln Sales_{s,t} + \underbrace{\beta_1 \ln N_{s,t}^{CUS} + \beta_2 \overline{\ln Sales}_{s,t}^{CUS,-c} + \beta_3 \overline{\ln Assets}_{s,t}^{CUS,-c}}_{\text{target's other customers}} \\ &+ \underbrace{\beta_4 \ln N_{s,t}^{SUP} + \beta_5 \overline{\ln Sales}_{s,t}^{SUP} + \beta_6 \overline{\ln Assets}_{s,t}^{SUP}}_{\text{target's suppliers}} + \delta_{c,t} + \delta_{Ind_s,t} + \varepsilon_{cs,t}\end{aligned} \tag{11}$$

The dependent variable $\Delta BVI_{cs,t+1}$ is one if c integrates s in $t+1$. The regression aims at isolating firm characteristics that differentiate suppliers that become integrated from suppliers that remain independent. Supplier characteristics are measured in the year prior to the acquisition. Heterogeneity on the customer side is fully absorbed by fixed effects $\delta_{c,t}$. On the right-hand side, we include the size of the supplier and measures of the strength of the supplier's production network. For the latter, we

include the number of customers the supplier has together with proxies for the quality of these customers (their average sales $\overline{\ln Sales}_{s,t}^{CUS,-c}$ and average capital intensity $\overline{\ln Assets}_{s,t}^{CUS,-c}$).[9] Similarly, we capture the strength of the supplier's supplier network by the number of upstream connections $\ln N_{s,t}^{SUP}$ and the average size $\overline{\ln Sales}_{s,t}^{SUP}$ and capital intensity $\overline{\ln Assets}_{s,t}^{SUP}$ of the supplier's own suppliers. We also control for industry-time specific factors, such as the supplier's own capital intensity (at the industry level), with fixed effects.

Analogously, we examine how a firm's size and its production network affects the likelihood to be forward integrated through the lens of the following regression:

$$\begin{aligned}\Delta FVI_{cs,t+1} =& \alpha \ln Sales_{c,t} + \underbrace{\beta_1 \ln N_{c,t}^{SUP} + \beta_2 \overline{\ln Sales}_{c,t}^{SUP,-s} + \beta_3 \overline{\ln Assets}_{c,t}^{SUP,-s}}_{\text{target's other suppliers}} \\ &+ \underbrace{\beta_4 \ln N_{c,t}^{CUS} + \beta_5 \overline{\ln Sales}_{c,t}^{CUS} + \beta_6 \overline{\ln Assets}_{c,t}^{CUS}}_{\text{target's customers}} + \delta_{s,t} + \delta_{Ind_c,t} + \varepsilon_{cs,t}.\end{aligned} \tag{12}$$

In this regression, supplier fixed effects control for acquirer characteristics. Hence, we compare the acquired customer to non-acquired customers of the same supplier. We include the customers upstream and downstream networks, dropping the potential acquirer s from the upstream network quality measures.

Table 2: Sample characteristics: BVI

Explaining $\Delta BVI_{cs,t}$		Explaining $\Delta FVI_{cs,t}$	
# customers	62,518	# suppliers	79,927
# suppliers per customer (median)	26	# customers per supplier (median)	11
# backward acquisitions	414	# forward acquisitions	302
# acquirers	356	# acquirers	260

The sample for the estimation of (11) is summarized in Table 2 (left panel). There are 62,518 customers, and the median customer has 26 suppliers. Identification comes from 414 backward acquisitions that are accounted for by 356 firms. We run two sets of regressions: The first ones include all customers (we call this "unconditional"), the second one including only those customers that integrate at least one of their suppliers in t (we call this "conditional"). Table 2 (right panel) summarizes the sample underlying regression (12). There are 79,927 suppliers, with a median number of 11 customers. Identification comes from 302 forward acquisitions, accounted for by 260 acquirers.

Tables 3 and 4 present the results for backward and forward acquisitions, respectively. Across

[9] We exclude c itself from these averages.

Table 3: Determinants of BVI: The target's production network

	Unconditional		Conditional	
Dependent variable:	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔBVI_{t+1}
$\ln Sales_s$	0.00017***	0.00017***	0.00528***	0.00527***
	(0.00002)	(0.00002)	(0.00093)	(0.00093)
$\ln N_s^{CUS}$	-0.00009	-0.00007	-0.00577**	-0.00568**
	(0.00006)	(0.00007)	(0.00224)	(0.00226)
$\overline{\ln Sales_s}^{CUS,-c}$	-0.00003***	-0.00003***	-0.00095***	-0.00073**
	(0.00001)	(0.00001)	(0.00029)	(0.00030)
$\overline{\ln Assets_s}^{CUS,-c}$		-0.00006		-0.00258**
		(0.00004)		(0.00130)
$\ln N_s^{SUP}$	-0.00021***	-0.00023***	-0.00516***	-0.00523***
	(0.00006)	(0.00006)	(0.00175)	(0.00176)
$\overline{\ln Sales_s}^{SUP}$	0.00002***	0.00002***	0.00044***	0.00044*
	(0.00001)	(0.00001)	(0.00014)	(0.00022)
$\overline{\ln Assets_s}^{SUP}$		0.00004		-0.00002
		(0.00006)		(0.00187)
Fixed effects	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$
N	1,775,319	1,775,319	43,393	43,393
Baseline prob.	.00023	.00023	.00917	.00917

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Standard errors clustered by customer and supplier. In columns titled "conditional", the estimation sample includes only supplier relationships of those customers that actually integrate at least one of their suppliers in t.

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 fixed effects model implies 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. In Tables 5 and 6 in the appendix we document a similar positive effect of acquirer size, which also supports part b) of Proposition 1. 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.[10] These findings on target and 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.[11] This implies that our results are not driven by assortative matching of customers and suppliers.

[10] Figures 9 and 8 show this pattern in the raw data, without conditioning on other firm variables.

[11] 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). As regards the absolute productivity of acquired firms, Guadalupe et al. (2012) provide evidence that foreign acquirers select the most productive firms.

Table 4: Determinants of FVI: The target's production network

	Unconditional		Conditional	
Dependent variable:	ΔFVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}
$\ln Sales_c$	0.00007***	0.00007***	0.00413***	0.00378***
	(0.00002)	(0.00002)	(0.00139)	(0.00136)
$\ln N_c^{CUS}$	0.00004**	0.00004**	0.00222*	0.00219*
	(0.00002)	(0.00002)	(0.00126)	(0.00125)
$\overline{\ln Sales_c}^{CUS}$	0.00001	0.00001	0.00012	0.00006
	(0.00001)	(0.00001)	(0.00047)	(0.00047)
$\overline{\ln Assets_c}^{CUS}$		-0.00000		0.00004
		(0.00004)		(0.00201)
$\ln N_c^{SUP}$	-0.00015***	-0.00015***	-0.00892***	-0.00874***
	(0.00003)	(0.00003)	(0.00311)	(0.00308)
$\overline{\ln Sales_c}^{SUP,-s}$	-0.00005***	-0.00004***	-0.00183***	-0.00113**
	(0.00001)	(0.00001)	(0.00059)	(0.00056)
$\overline{\ln Assets_c}^{SUP,-s}$		-0.00010**		-0.00739**
		(0.00005)		(0.00303)
Fixed effects	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$
N	1,854,997	1,854,997	18,199	18,199
Baseline prob.	.00016	.00016	.01538	.01538

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Standard errors clustered by customer and supplier. In columns titled "conditional", the estimation sample includes only customer relationships of those suppliers that actually integrate at least one of their customers in t.

In line with part c) of Proposition 1, we find that a weaker customer network is associated with a higher backward-integration probability: Customer c is more likely to integrate s if s has fewer other customers and if these other customers are smaller and less capital intensive. The effect of s's supply network, in contrast, is less clear.

Table 4 presents the results. Consistent with part b) of Proposition 1, higher sales of a customer are positively associated with the probability to be forward integrated. Regarding the production network, we find that a weaker supplier network is associated with a higher forward integration probability, which is in line with part c) of Proposition 1. The quality of the customer network, in contrast, does not matter in this case.

Tables 3 and 4 show the results from our preferred specification, that studies firm characteristics prior to *changes* in the organizational form in order to avoid endogeneity concerns. However, we find a similar pattern for the relationship between supplier and customer networks and the probability of BVI and FVI when using contemporaneous firm characteristics and the status of the organizational form. In these analyses, we capture many more ownership relationships because we don't require the organizational form of a firm pair to change during our sample period. Tables 7 and 8 in the appendix

shows that the coefficients are qualitatively very similar. The same holds true for the effect of firm size. In tables 5 and 6 in the appendix we also analyze whether the network of the acquirer (rather than the network of the target) has predictive power for VI choices. Our model does not make any prediction on the sign of the network variable in those specification and we do not find any systematic relationships in our data.

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, the 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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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.

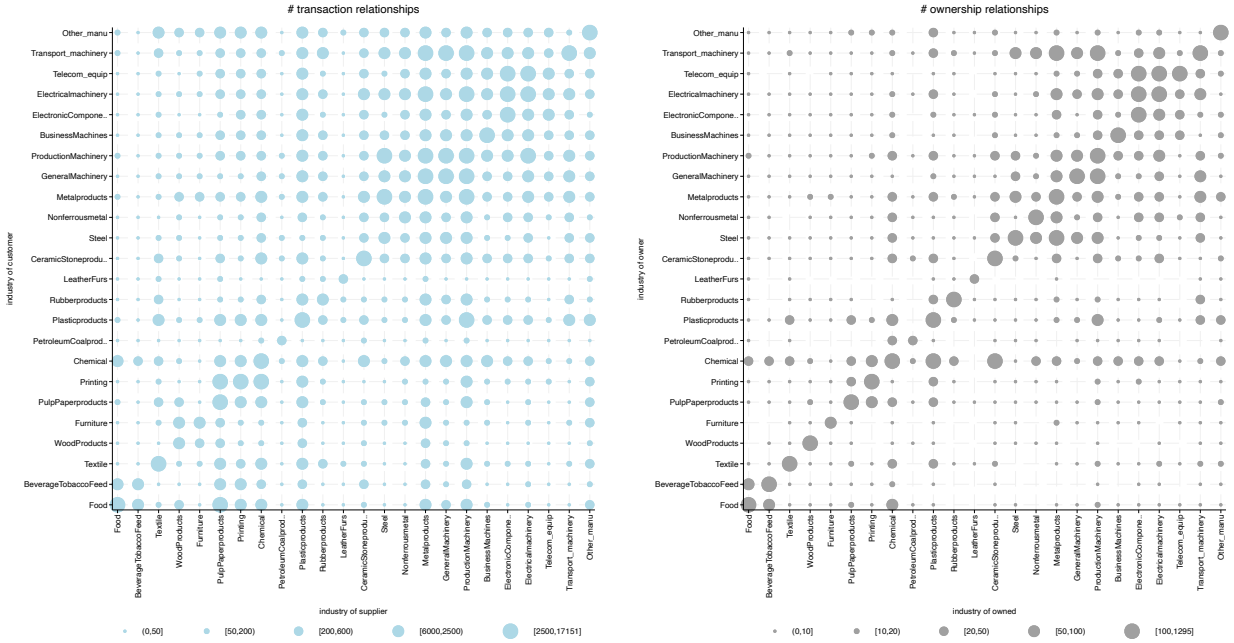
6.2 Additional stylized facts

Here, as a determinant of BVI and FVI, we look at the acquirer's production network, while we look at the target's production network in the main document. We see that there are negative effect from firm size of other potential targets in Tables 5 and 6.

Next, in Tables 7 and 8, we look at determinant of BVI and FVI using contemporaneous firm characteristics. In the baseline regressions, we use forward variable of BVI and FVI with current condition of BVI and FVI as zero. Since ownership relations are stale, there are few relations of new overlap. The coefficients are higher in contemporaneous version of regressions, while sign of them are qualitatively the same.

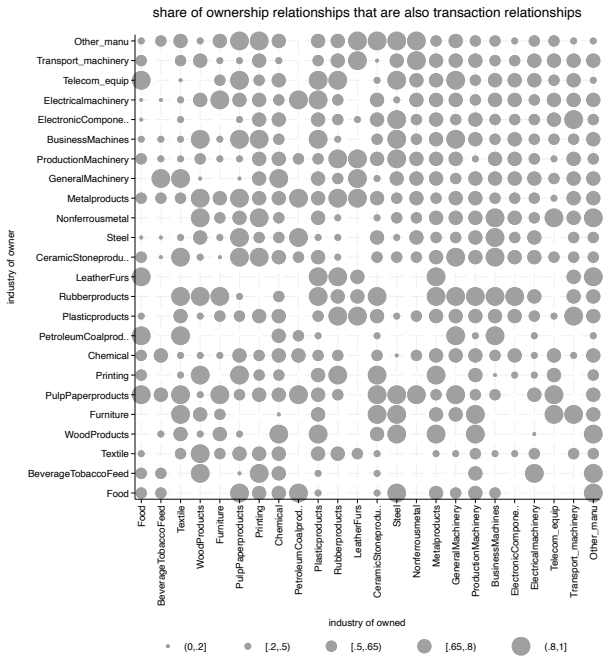
Lastly, we show the net surplus of BVI and FVI depending on γ and η in Figure 10.

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.

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.

Table 5: Determinants of BVI: The acquirer's production network

	Unconditional		Conditional	
Dependent variable:	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔBVI_{t+1}	ΔBVI_{t+1}
$\ln Sales_c$	0.00005***	0.00005***	0.01440**	0.01510**
	(0.00001)	(0.00001)	(0.00706)	(0.00716)
$\ln N_c^{CUS}$	0.00002	0.00002	0.01028	0.00996
	(0.00001)	(0.00001)	(0.01008)	(0.01015)
$\overline{\ln Sales}_c^{CUS}$	0.00001	0.00001	0.00458	0.00462
	(0.00001)	(0.00001)	(0.00407)	(0.00434)
$\overline{\ln Assets}_c^{CUS}$		0.00001		-0.00042
		(0.00003)		(0.01939)
$\ln N_c^{SUP}$	-0.00003	-0.00003	0.01161	0.01194
	(0.00002)	(0.00002)	(0.01456)	(0.01466)
$\overline{\ln Sales}_c^{SUP,-s}$	-0.00001**	-0.00001**	-0.00569**	-0.00771**
	(0.00000)	(0.00001)	(0.00234)	(0.00357)
$\overline{\ln Assets}_c^{SUP,-s}$		0.00002		0.02108
		(0.00003)		(0.02217)
Fixed effects	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$
N	1,848,108	1,848,108	2,562	2,562
Baseline prob.	.00018	.00018	.09562	.09562

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Standard errors clustered by customer and supplier. In columns titled "conditional", the estimation sample includes only supplier relationships of those customers that actually integrate at least one of their suppliers in t.

Table 6: Determinants of FVI: The acquirer's production network

	Unconditional		Conditional	
Dependent variable:	ΔFVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}	ΔFVI_{t+1}
$\ln Sales_s$	0.00004***	0.00004***	0.01582***	0.01583***
	(0.00001)	(0.00001)	(0.00580)	(0.00596)
$\ln N_s^{CUS}$	0.00000	-0.00000	0.00743	0.00743
	(0.00003)	(0.00003)	(0.01359)	(0.01286)
$\overline{\ln Sales}_s^{CUS,-c}$	-0.00001**	-0.00001**	-0.00175	-0.00220
	(0.00000)	(0.00000)	(0.00124)	(0.00150)
$\overline{\ln Assets}_s^{CUS,-c}$		0.00002		0.00539
		(0.00002)		(0.01092)
$\ln N_s^{SUP}$	0.00007**	0.00007***	0.01418	0.01420
	(0.00003)	(0.00003)	(0.01039)	(0.00991)
$\overline{\ln Sales}_s^{SUP}$	0.00000	0.00000	-0.00031	-0.00037
	(0.00000)	(0.00000)	(0.00065)	(0.00134)
$\overline{\ln Assets}_s^{SUP}$		-0.00001		0.00062
		(0.00003)		(0.01044)
Fixed effects	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$
N	1,784,899	1,784,899	3,818	3,818
Baseline prob.	.00018	.00018	.055	.055

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Standard errors clustered by customer and supplier. In columns titled "conditional", the estimation sample includes only customer relationships of those suppliers that actually integrate at least one of their customers in t.

Table 7: Determinants of BVI: The target's production network (contemporaneous firm characteristics)

	Unconditional		Conditional	
Dependent variable:	BVI_t	BVI_t	BVI_t	BVI_t
$\ln Sales_s$	0.00805***	0.00806***	0.01976***	0.01977***
	(0.00036)	(0.00036)	(0.00102)	(0.00102)
$\ln N_s^{CUS}$	0.00050	0.00140	-0.02381***	-0.02311***
	(0.00127)	(0.00130)	(0.00315)	(0.00310)
$\overline{\ln Sales}_s^{CUS,-c}$	-0.00224***	-0.00215***	-0.00429***	-0.00403***
	(0.00014)	(0.00014)	(0.00033)	(0.00033)
$\overline{\ln Assets}_s^{CUS,-c}$		-0.00075		-0.00285*
		(0.00073)		(0.00165)
$\ln N_s^{SUP}$	-0.01705***	-0.01779***	-0.02144***	-0.02199***
	(0.00112)	(0.00114)	(0.00214)	(0.00214)
$\overline{\ln Sales}_s^{SUP}$	0.00192***	0.00167***	0.00263***	0.00240***
	(0.00010)	(0.00014)	(0.00017)	(0.00026)
$\overline{\ln Assets}_s^{SUP}$		0.00289**		0.00243
		(0.00114)		(0.00212)
Fixed effects	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$	$c \times t, ind_s \times t$
N	2,093,381	2,093,381	681,008	681,008
Baseline prob.	.011	.011	.035	.035

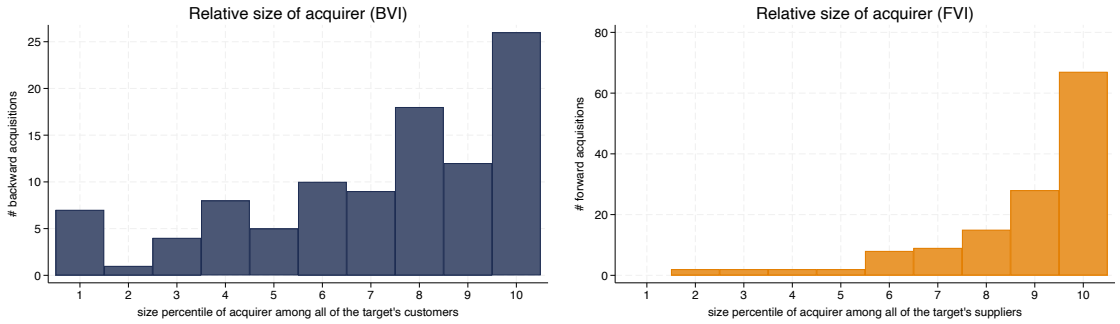
Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Standard errors clustered by customer and supplier. In columns titled "conditional", the estimation sample includes only supplier relationships of those customers that actually own at least one of their suppliers in t.

Table 8: Determinants of FVI: The target's production network (contemporaneous firm characteristics)

	Unconditional		Conditional	
Dependent variable:	FVI_{t+1}	FVI_{t+1}	FVI_{t+1}	FVI_{t+1}
$\ln Sales_c$	0.00405***	0.00392***	0.02840***	0.02768***
	(0.00030)	(0.00030)	(0.00185)	(0.00184)
$\ln N_c^{CUS}$	0.00058**	0.00056**	0.00244	0.00256
	(0.00025)	(0.00025)	(0.00187)	(0.00186)
$\overline{\ln Sales}_c^{CUS}$	0.00038***	0.00035***	0.00267***	0.00240***
	(0.00010)	(0.00010)	(0.00069)	(0.00069)
$\overline{\ln Assets}_c^{CUS}$		0.00002		0.00165
		(0.00052)		(0.00315)
$\ln N_c^{SUP}$	-0.00700***	-0.00698***	-0.05220***	-0.05211***
	(0.00049)	(0.00049)	(0.00379)	(0.00380)
$\overline{\ln Sales}_c^{SUP,-s}$	-0.00079***	-0.00045***	-0.00327***	-0.00132**
	(0.00011)	(0.00012)	(0.00057)	(0.00066)
$\overline{\ln Assets}_c^{SUP,-s}$		-0.00351***		-0.01998***
		(0.00070)		(0.00432)
Fixed effects	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$	$s \times t, ind_c \times t$
N	2,175,399	2,175,399	209,267	209,267
Baseline prob.	.006	.006	.061	.061

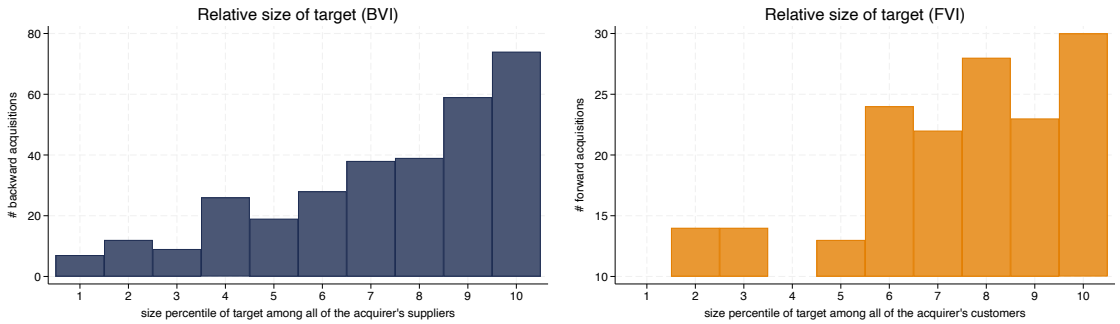
Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Standard errors clustered by customer and supplier. In columns titled "conditional", the estimation sample includes only customer relationships of those suppliers that actually own at least one of their customers in t.

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.

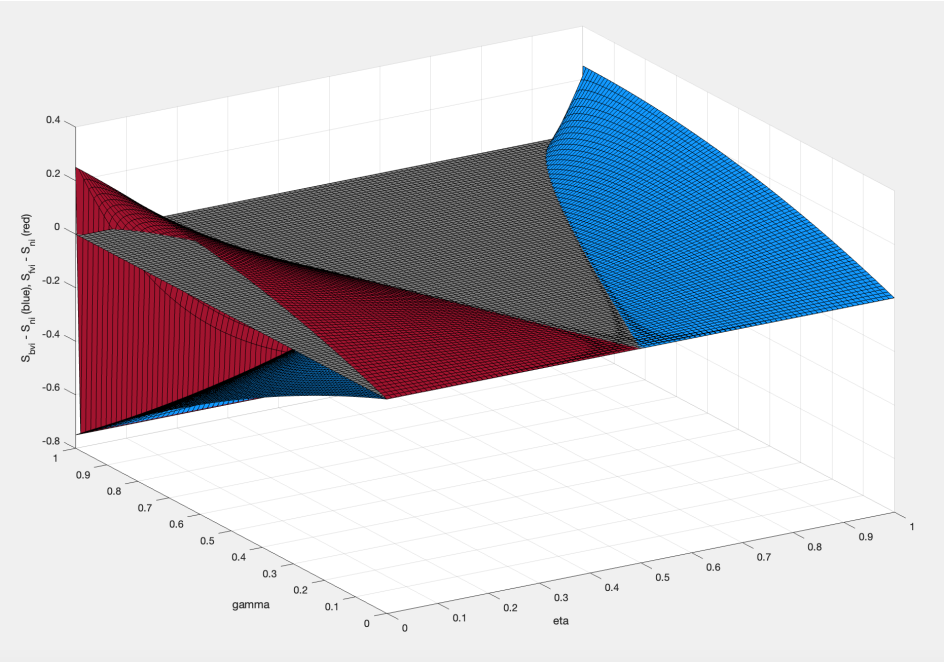


Figure 10: Net surplus of BVI (blue) and FVI (red)