Vertical integration with two-sided heterogeneity and network structure*

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Abstract

In this paper, we study the overlap of the production and ownership relationships between firms in Japan. We leverage data of unprecedented detail to revisit existing empirical evidence on the determinants of vertical integration and to document new sector-level and firm-level characteristics that explain variation in vertical integration across and within industries. We show that a firm's position in the production network is a key predictor of the organizational choice. We then build a model of organizational choice within production network and a market for corporate control to show that general equilibrium forces, that have so far been neglected by the literature, can rationalize the patterns in the data.

JEL Classification Codes: L22, L23, L24, L60

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1 Introduction

The boundary of the firm takes centre stage in microeconomics. How firms organize production within and across firm boundaries is crucial for aggregate productivity and observed organizational choices allow to infer the type and relevancy of frictions facing firms. In this paper, we study the overlap of the production and ownership relationships between firms in Japan to study the choice between vertical integration and outsourcing. We leverage data of unprecedented detail to revisit existing empirical evidence on the determinants of vertical integration and to document new sector-level and firm-level characteristics that explain variation in vertical integration across and within industries. Our key novel finding is that a firm's position in the production network is a strong predictor of the organizational choice. We then build a model of a production network and a market for corporate control to show that general equilibrium forces, that have so far been neglected by the literature, can rationalize the patterns in the data.

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 vertical integration decisions at the firm-pair level. This owes to the unprecedented detail and scope of our dataset on firm-to-firm linkages, which spans two firm-to-firm networks; i.e., we observe both supplier-customer relationships and ownership relationships for the population of domestic firms in Japan. In the first part of the paper, we document four stylized facts that complement or refine patterns documented in the literature.

Our first empirical finding is the tantamount importance of forward and backward vertical integration. Even though the most prominent theories of sourcing generate symmetric predictions for the choice to integrate a supplier (backward vertical integration, BVI) and the choice to integrate a customer (forward vertical integration, FVI), empirical research has mostly overlooked FVI. The bulk of empirical evidence on vertical integration decisions 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); Corcos et al. (2013); Berlingieri et al. (2020). Acemoglu et al. (2010) study multiplant firms in the UK and argue that FVI is empirically not relevant. In stark contrast, we find that in the Japanese economy FVI is just as important as BVI. Across manufacturing sectors, the share of production relationships that are integrated ranges between 1 and 6%. Interestingly, we find that within sectors, the propensity to integrated 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 predicts the direction of integration.

Our second stylized fact focuses on 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 and that this relationship holds for both FVI and BVI and it is true 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 does also help predicting the direction of integration. 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.

Our finding of a positive association between BVI and absolute capital intensity complements the empirical evidence that, amongst others, Antras (2003); Corcos et al. (2013); Berlingieri et al. (2020) have provided for the case of BVI. Our result for BVI is also in line with the property-rights-theory (PRT) model of Antras (2003) where 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. Our findings of higher levels of FVI in more capital-intensive industries and the dependence of the direction of VI on relative capital intensity are documented for the first time – to the best of our knowledge. We show below that these findings are consistent with a PRT model that allows either the downstream firm or the upstream firm to provide the (essential) capital services.

Next, we zoom in on firm-level and firm-pair-level determinants of BVI and FVI. To circumvent endogeneity issues, 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. The third stylized fact we document is a strong positive association between the propensity of VI and firm productivity on both sides of the relationship. Specifically, we find that a customer which backward integrates a supplier is relatively large compared to this supplier's other customers. Likewise, a supplier that forward integrates a customer is relatively large compared to this customers other suppliers.

Perhaps more surprisingly, we find that targets of vertical acquisitions are also relatively large. That is, we find 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 customer of that supplier. These results complement a large body of empirical evidence on the positive relationship between the *absolute* productivity of customers and their propensity to source inputs from related parties; see, e.g. the summary and evidence in Kohler and Smolka (2014). As regards the absolute productivity of targets, Guadalupe et al. (2012) provide evidence that foreign acquirers select the most productive firms.

The fourth stylized fact that we highlight is a relationship between the production network structure of firms and the propensity to be integrated forward or backward. We find that suppliers that become backward integrated have weaker production 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" production network in our setting refers to a smaller number of connections, and a smaller size and lower capital intensity of the connected firms. We find no systematic relationship between network strength and the propensity to become a forward or backward acquirer.

In sum, our descriptive analysis highlights three novel determinants of vertical integration that have not been studied before: relative capital intensity of acquirer and target, relative productivity among customers and suppliers of a transaction partner, and the strength of potential targets' production networks. The first and third characteristic are also informative about the *direction* of integration.

In the second part of the paper, we build a PRT model for the organizational choice into a network of customer-supplier relationship to explore mechanisms that can jointly rationalize all of the four stylized facts. Our model for the organizational choice builds on key elements of the PRT-based mechanisms described by Antras (2003) and Acemoglu et al. (2010), but extends these frameworks along several dimensions. We allow for suppliers or customers to provide the more capital-intensive input for the production relationship which implies that both FVI and BVI are observed in equilibrium (fact 1) and that both types are more likely in capital intensive industries (fact 2). In these industries, the more capital intensive firm within the supplier-customer relationship has the stronger incentive to preserve ownership rights over the final output. Hence, in line with fact 2, we observe BVI when the customer is relatively more capital intensive and FVI when the supplier is relatively more capital intensive. Moreover, we assume that the quality of both parties' inputs are complements and that the cost of

investing in quality depend on firm productivity. This implies that the surplus of the relationship rises in the productivity of both firms, in line with fact 3. In this setting, the productivity and capital intensity of both parties determine the net surpluses from choosing BVI or FVI over arms-length relationships. 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. Hence, potential acquirers compete for the majority share of the target in a market for corporate control. In our exogenous production network model where the only motive for acquisition is vertical integration, 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. This prediction matches fact 4.

A key novel aspects of our model is to show that an extended version of the PRT model that is commonly studied in the literature on (international) sourcing building on Antras (2003) and Antràs and Helpman (2004) can explain the prevailing pattern of BVI and FVI at the sector-pair level. The PRT pioneered by Grossman and Hart (1986) stipulates that vertical integration can mitigate the hold-up problem that arises when suppliers and customers make relationship-specific, non-contractible investments. A key implication of the PRT is that the consequences of contracting frictions are minimized when ownership rights are given to the firm that makes the larger contribution to the joint output. Naturally, the PRT can thus explain the choice between FVI, BVI, and outsourcing.[1] Other motives for vertical integration studied in the literature comprise transaction cost economies (TCE) (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, give 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 tends to be large speaks against this mechanism.

A second novel aspect of our theoretical model is the market for corporate control. This concept is

[1]The model by Acemoglu et al. (2010) also yields this result but does not link relative contributions of the customer and supplier to observables like capital intensity. Moreover, Acemoglu et al. (2010) do not explore the case of FVI empirically.

not new as such (see, e.g. Nocke and Yeaple, 2007), but – to the best of our knowledge – has not been used in a general equilibrium model of vertical integration. Instead, the theoretical models of sourcing have studied each firm-pairs' choice in isolation. We show theoretically and verify empirically that the VI decision depends on the characteristics of other firms to which the potential target is linked through the production network.

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 transaction relationships and ownership relationship, which enables us to examine the overlap of relationships in addition to firm characteristics while creating industry-level characteristics 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 whilesaler, and 11% for retailers. There are 4 million transaction relations and 160 thousands ownership relations. The # of the overlap of the relations, that is, owner is suppler or customer, 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 overlap of the relations are shown in the next section, in terms of # of overlap relations divided by # of transaction relation, which is around

2%. When it comes to the ratio where the owner is supplier or customer, it is around 67% and majority of ownership relations are accompanied with transaction relations.

2.2 BSBA

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

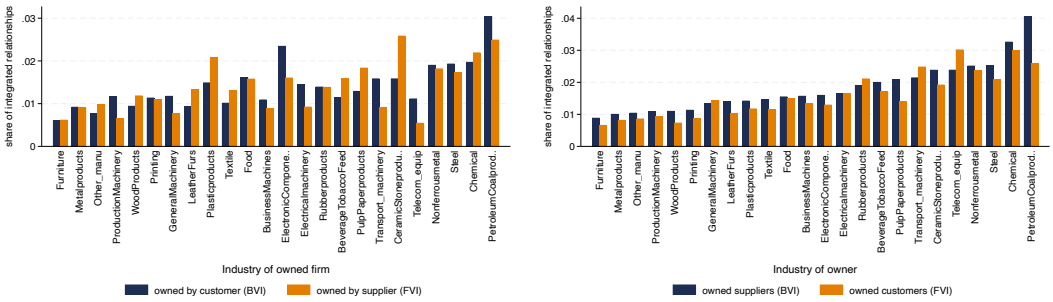
Notes: fixed assets / employees is average across firms. Time period: 2016

3 Stylized facts

Fact 1: FVI is as common as BVI. The first stylized fact that we highlights is the similar prevalence of forward and backward VI across all industries. In Figure 3 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 3 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.

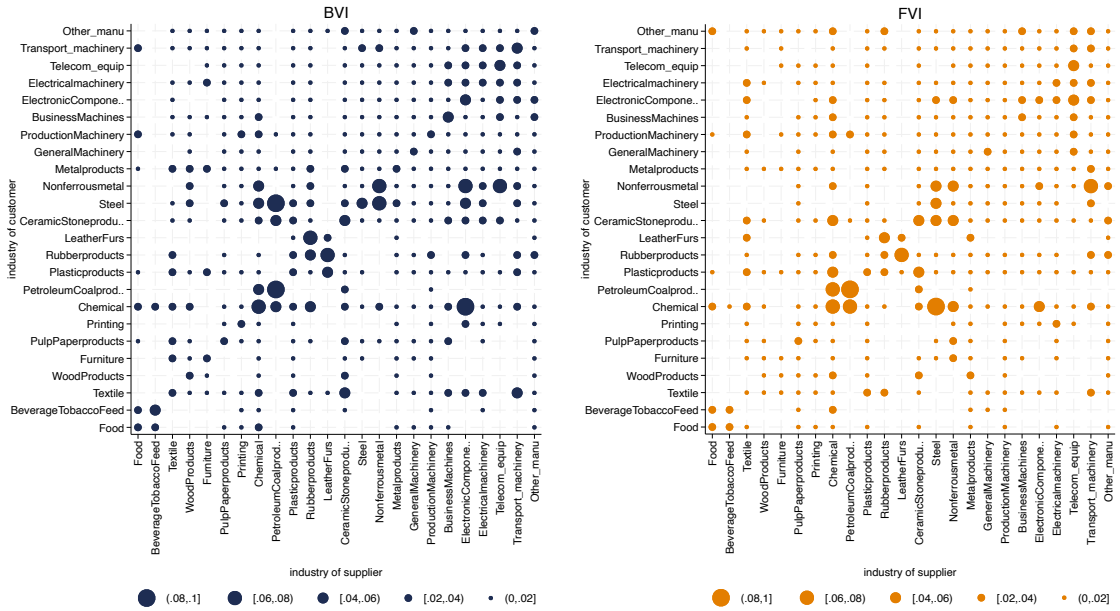
Figure 2 computes backward and forward integration shares at the sector-pair level.[2] The left (right) panel shows the share of BVI (FVI) relationships in total customer-supplier relationships. At the sector-pair level, starker differences between the likelihood of FVI and BVI emerge. For example, Steel 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.

However, there is still a strong positive correlation between forward and backward integration probabilities across sector pairs, leaving room for firm-level heterogeneity to explain the choice of the integration direction. In the following, we look for determinants of the directional choice, first at the sector-pair level and then at the firm-pair level.

Fact 2: 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'

[2]Figure 8 in the appendix shows the number of transaction relationships and the number of ownership relationships.

Figure 2: Probability of VI



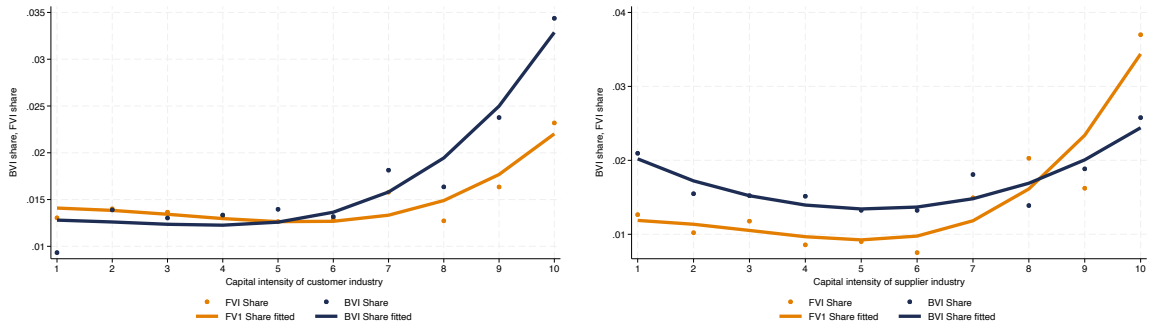
Note: The figure shows the share of integrated customer-supplier relationships (BVI left panel, FVI right panel) in total number of customer-supplier relationships by sector pair. Time period: 2010-2016.

investment into the success of the relationship. Antras (2003) proposed that in more capital intensive industries, 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 in Fact 2. 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).[3] 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

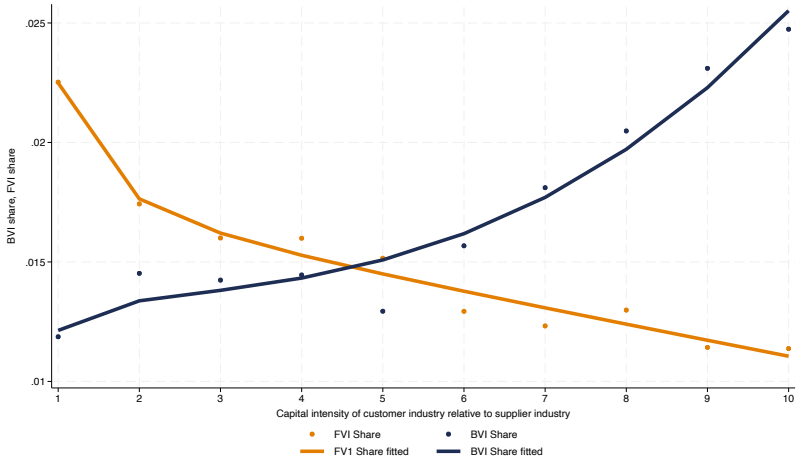
[3]Table 1 ranks sectors according to their capital intensity. In line with Figure 3, the most capital intensive sectors with the highest probabilities of vertical integration are Petroleum and Coal, Steel, and Chemicals.

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.

Figure 4: Relative capital intensity

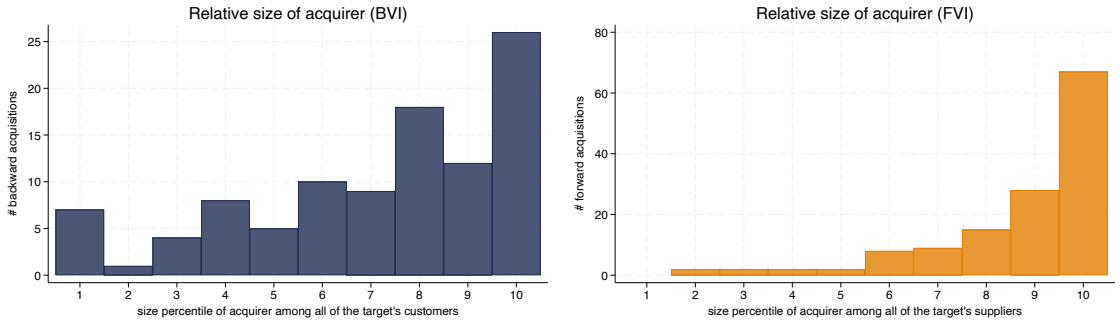


Note: The figure shows the average share of integrated customer-supplier relationships across industry pairs in 10 bins, defined by the 10 deciles of the distribution of relative capital intensity. Relative capital intensity is measured as $ln(fixed\ assets/\#employees)_{customer\ industry} - ln(fixed\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

regard to the capital intensity of the upstream firm. Upstream firms in more capital intensive sector have a higher likelihood to integrate their customer, 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.

Figure 5: Relative size of acquirer

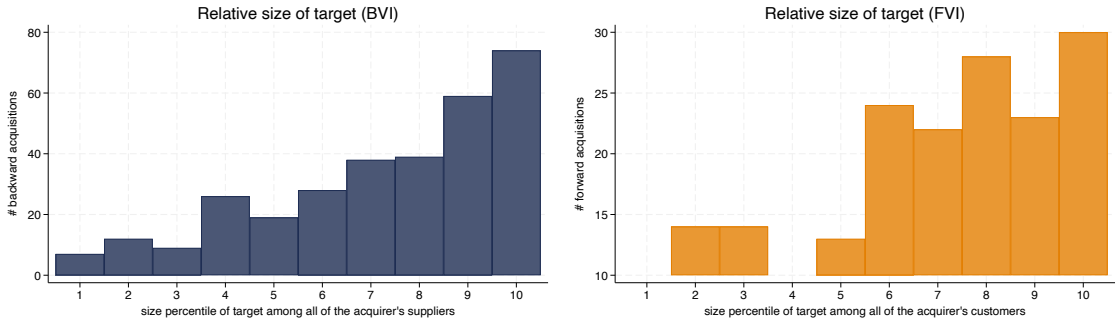


Note: The left (right) figure shows the number of backward (forward) acquisitions in which the acquirer is in a given percentile of the size distribution of the target's customers (suppliers). Time period: 2010-2016. Acquisitions where the targets has less than 10 customers (suppliers) are dropped.

Fact 3: Acquirers and targets are relatively large. Next, we turn to firm-level determinants of BVI and FVI, starting with productivity. Since firm-level outcomes are likely endogenous to the organizational choice, we study incidences of changes in the organizational mode (forward and backward *acquisitions*) and take firm characteristics from the year *prior* to the ownership change. The data reveal a very strong relationship between the relative size of suppliers and customers. Specifically, when comparing a customer that acquires one of its suppliers to the other customers of that same supplier, then the acquiring customer tends to be larger than the non-acquiring customers. In other words, suppliers tend to be acquired by their best customer (or one of their better customers to be precise). Figure 5, left panel, visualizes this relationship by showing that acquiring customers are more common in the higher percentiles of the size distribution of the customers of the acquired supplier. Figure 5, right panel, shows that this pattern is even more pronounced to forward acquisitions: Customers tend be acquired by their largest supplier.

Figure 6 shows the relative size of the target. Contrary to our expectations, relative target size is also positively associated with acquisitions. That is, the left panel of Fig 6 shows that customers tend to integrate their largest suppliers. The right panel of Figure 6 shows that acquiring suppliers tend to integrate the largest one among their customers.

Figure 6: 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.

Fact 4: Targeted suppliers have weaker customer networks and targeted customers have weaker supplier networks. Our fourth result is a systematic relationship between customer and supplier networks and the probability of BVI and FVI. To study how a firm's production network affects its likelihood to be backward integrated, we estimate the following regression:

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

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 $\overline{\ln Assets}_{s,t}^{CUS,-c}$).[4] 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.

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 (1) 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

[4] 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.

at least one of their suppliers in t (we call this "conditional").

Table (3) presents the results. We find a positive relationship between (pre-acquisition) sales of suppliers and their probability to be backward integrated, confirming Fact 3. Moreover, 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.

Analogously, we study how a firm's production network affects its likelihood to be forward integrated through the lens of the regression

$$\Delta FVI_{cs,t+1} = \alpha \ln Sales_{c,t} + \underbrace{\beta_1 \ln N_{c,t}^{SUP} + \beta_2 \overline{\ln Sales}_{c,t}^{SUP,-s} + \beta_3 \overline{\ln Assets}_{c,t}^{SUP,-s}}_{\text{target's other suppliers}} + \underbrace{\beta_4 \ln N_{c,t}^{CUS} + \beta_5 \overline{\ln Sales}_{c,t}^{CUS} + \beta_6 \overline{\ln Assets}_{c,t}^{CUS}}_{\text{target's customers}} + \delta_{s,t} + \delta_{Ind_c,t} + \varepsilon_{cs,t}. \quad (2)$$

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

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.

upstream and downstream networks, dropping the potential acquirer s from the upstream network quality measures.

Table 2 (right panel) summarizes the sample underlying regression (2). There are 79,927 suppliers, with a median number of 11 customers. Identification comes from 302 forward acquisitions, accounted for by 260 acquirers. Table 4 presents the results. Consistent with fact 3, 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. The quality of the customer network, in contrast, does not matter.

Tables 3 and 4 show the results from our preferred specification, that studies firm characteristics prior to *changes* in the organizational form, avoiding endogeneity concerns. However, we find a similar pattern in 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.

In sum, our descriptive analysis confirms the importance of absolute capital intensity and highlights three novel determinants of vertical integration that have not been studied before: relative capital intensity of acquirer and target, relative productivity among customers and suppliers of a transaction partner, and the strength of potential targets' production networks. In what follows, we study theoretical mechanisms that can rationalize these findings.

4 Theory

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.[5] 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.

The customer and supplier produce their components at a cost

$$\Gamma_c = \frac{1}{2z_c} q_c^2 \qquad \text{and} \qquad \Gamma_s = \frac{1}{2z_s} q_s^2, \tag{3}$$

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

[5] 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.

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 $i \in c, s$

$$y_i^o = O_i^o + \frac{1}{2}\left(y - O_c^o - O_s^o\right) \tag{4}$$

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[6]

$$O_c^{NI} = 0 \qquad \text{and} \qquad O_s^{NI} = 0. \tag{5}$$

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

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

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

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

$$y^{BVI} = \frac{1}{2}\left(z_c(1+\gamma)\eta\right)^{\eta}\left(z_s(1-\gamma)(1-\eta)\right)^{1-\eta}, \tag{6}$$

[6]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.

$$y^{FVI} = \frac{1}{2}\left(z_c(1-\gamma)\eta\right)^{\eta}\left(z_s(1+\gamma)(1-\eta)\right)^{1-\eta} \tag{7}$$

and

$$y^{NI} = \frac{1}{2}\left(z_c\eta\right)^{\eta}\left(z_s(1-\eta)\right)^{1-\eta}. \tag{8}$$

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

$$S_{cs}^{BVI} - S_{cs}^{NI} \geq \max\left\{0, S_{c's}^{BVI} - S_{c's}^{NI}, S_{s's}^{FVI} - S_{s's}^{NI} | c' \in N_s^{CUS}, s' \in N_s^{SUP}\right\} \tag{9}$$

In (9), 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

$$S_{cs}^{FVI} - S_{cs}^{NI} \geq \max\left\{0, S_{cs'}^{FVI} - S_{cs'}^{NI}, S_{c'c}^{BVI} - S_{c'c}^{NI} | s' \in N_c^{SUP}, c' \in N_c^{CUS}\right\}. \tag{10}$$

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

$$\frac{\partial(S^{BVI} - S^{NI})}{\partial \eta} > 0 \qquad \text{and} \qquad \frac{\partial(S^{FVI} - S^{NI})}{\partial \eta} < 0. \tag{11}$$

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 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 7 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:

$$\frac{\partial(S^{BVI} - S^{NI})}{\partial z_i} > 0 \qquad \text{for } i \in c, s \qquad \text{and} \qquad \frac{\partial(S^{FVI} - S^{NI})}{\partial z_i} > 0 \qquad \text{for } i \in c, s \tag{12}$$

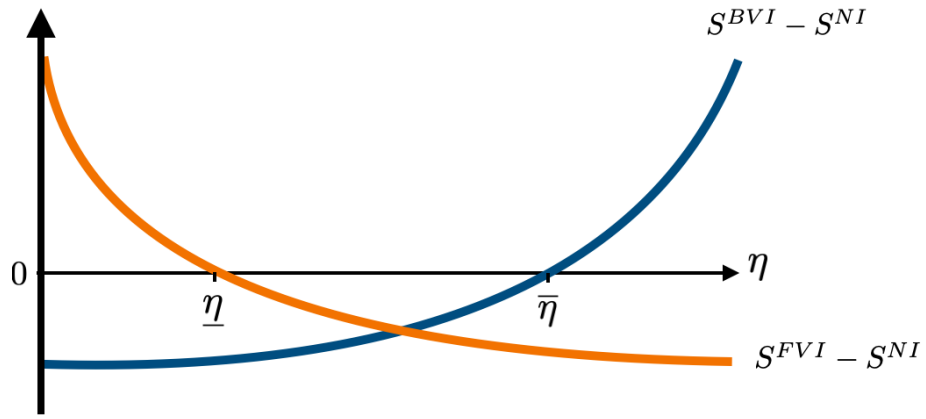


Figure 7: Net surplus of BVI and FVI

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, the probability that $o_{cs} = BVI$ is *i)* increasing in $\eta(cs)$ and increasing in both parties' productivity and *ii)* 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 $s' \in N_s^{SUP}$.

The probability that $o_{cs} = FVI$ is *iii)* decreasing in $\eta(cs)$ and increasing in both parties' productivity and *iv)* 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 $s' \in N_c^{SUP,-s}$.

The model predictions summarized in Proposition 1 are in line with our four stylized facts: Both BVI and FVI occur in equilibrium (fact 1). BVI is more likely if the customer's input is relatively more important (fact 2) and if both the customer and supplier are more productive (fact 3). BVI is also more likely if the supplier is connected to fewer firms and to firms that have weaker incentives to integrate the supplier (fact 4). Likewise, FVI is more likely if the supplier's input is relatively more important (fact 2) and if both the customer and supplier are more productive (fact 3). FVI is also more likely if the customer is connected to fewer firms and to firms that have weaker incentives to integrate the customer (fact 4).

5 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 document that absolute and relative capital intensity at the industry level are key determinants of the propensity for and the direction of vertical integration. Relative productivity of targets and acquirers also matters, as well as the number and quality of their production network linkages. We show that those empirical regularities can be explained by 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.

References

Acemoglu, D., Griffith, R., Aghion, P., and Zilibotti, F. (2010). Vertical integration and technology: Theory and evidence. *Journal of the European Economic Association*, 8(5):989–1033.

Aghion, P. and Tirole, J. (1994). The management of innovation. *The Quarterly Journal of Economics*, 109(4):1185–1209.

Aghion, P. and Tirole, J. (1997). Formal and real authority in organizations. *Journal of Political Economy*, 105(1):1–29.

Antras, P. (2003). Firms, contracts, and trade structure. *The Quarterly Journal of Economics*, 118(4):1375–1418.

Antràs, P. and Helpman, E. (2004). Global sourcing. *Journal of Political Economy*, 112(3):552–580.

Berlingieri, G., Pisch, F., and Steinwender, C. (2020). Organizing global supply chains: Input-output linkages and vertical integration. *Journal of the European Economic Association*, 19(3):1816–1852.

Bernard, A., Moxnes, A., and Yukiko, S. (2019). Production networks, geography, and firm performance. *Journal of Political Economy*, 127(2):639–688.

Corcos, G., Irac, D. M., Mion, G., and Verdier, T. (2013). The determinants of intrafirm trade: Evidence from french firms. *The Review of Economics and Statistics*, 95(3):825–838.

Grossman, S. J. and Hart, O. D. (1986). The costs and benefits of ownership: A theory of vertical and lateral integration. *Journal of Political Economy*, 94(4):691–719.

Guadalupe, M., Kuzmina, O., and Thomas, C. (2012). Innovation and foreign ownership. *American Economic Review*, 102(7):3594–3627.

Klein, B., Crawford, R. G., and Alchian, A. A. (1978). Vertical integration, appropriable rents, and the competitive contracting process. *The Journal of Law & Economics*, 21(2):297–326.

Kohler, W. and Smolka, M. (2014). Global sourcing and firm selection. *Economics Letters*, 124(3):411–415.

Nocke, V. and Yeaple, S. (2007). Cross-border mergers and acquisitions vs. greenfield foreign direct investment: The role of firm heterogeneity. *Journal of International Economics*, 72(2):336–365.

Ordover, J. A., Saloner, G., and Salop, S. C. (1990). Equilibrium vertical foreclosure. *The American Economic Review*, 80(1):127–142.

Williamson, O. E. (1985). *The Economic Institutions of Capitalism*. The Free Press, New York.

Appendix

5.1 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 8. 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 9. 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.

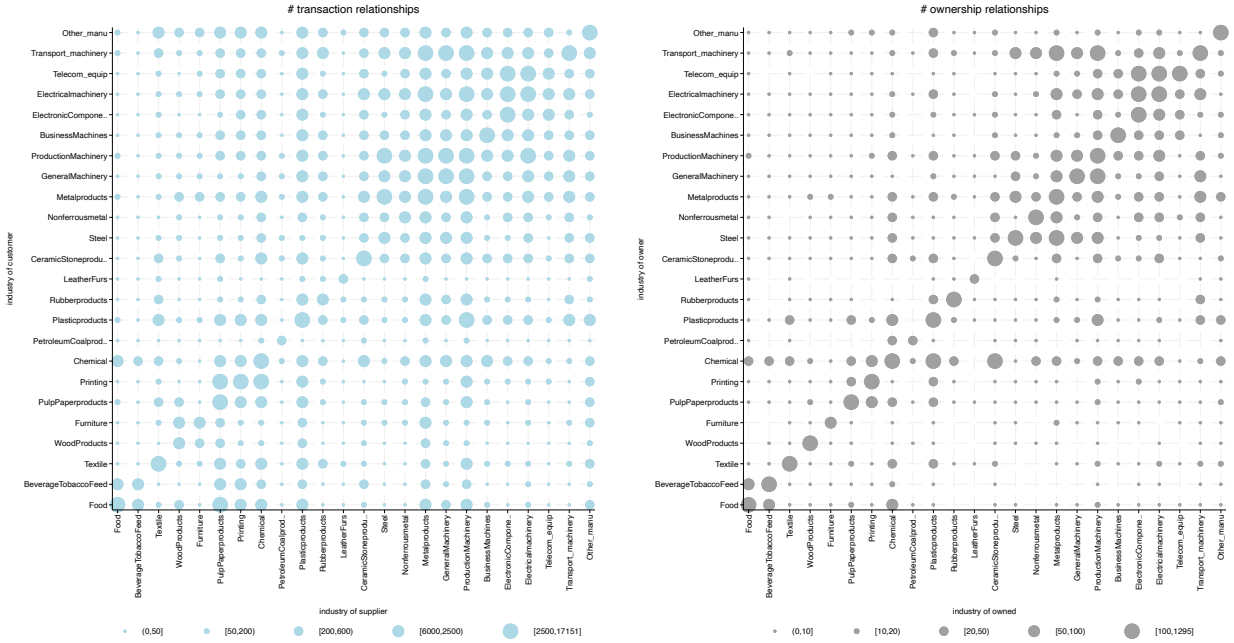
5.2 Additional stylized facts

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 qualitatatively the same.

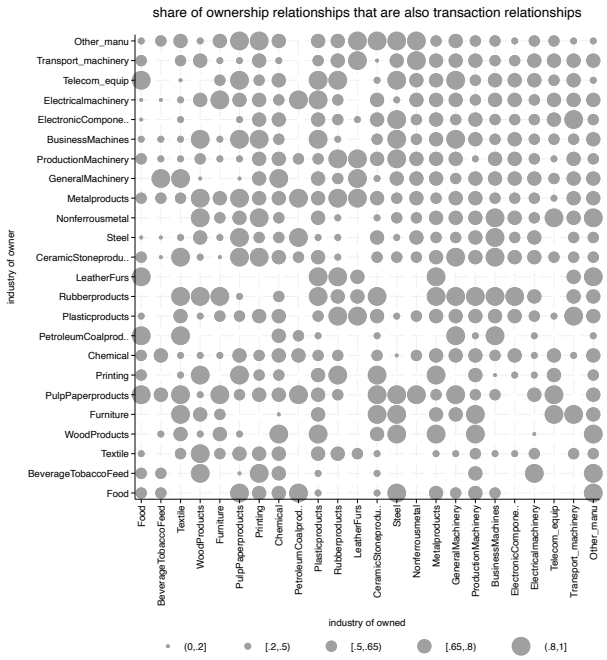
Lastly, we show the net surplus of BVI and FVI depending on γ and η in Figure 10.

Figure 8: 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 9: 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.

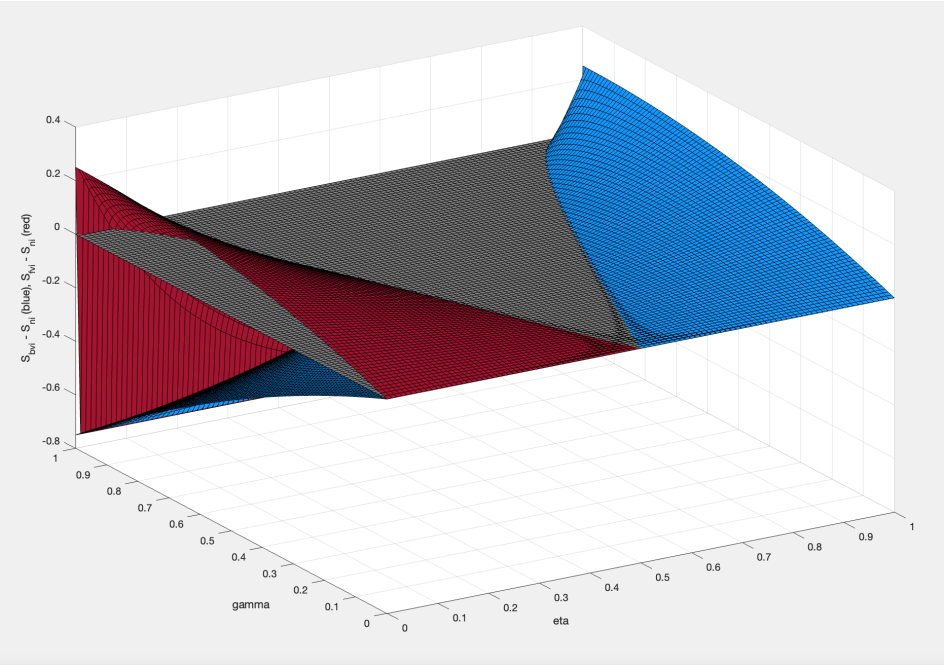


Figure 10: Net surplus of BVI (blue) and FVI (red)