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December 2017

Abstract

Little is known theoretically, and even less empirically, about the relationship between firm boundaries and the allocation of decision rights within firms. We develop a model in which firms choose which suppliers to integrate and whether to delegate decisions to integrated suppliers or keep them centralized. We test the predictions of this model using a novel dataset that combines measures of vertical integration and delegation for a large set of firms operating in many countries and industries. In line with the model's predictions, we find that integration and delegation co-vary positively, and that producers are more likely to integrate suppliers in input sectors with greater productivity variation.

Keywords: Vertical integration, delegation, real options.

*An earlier version of this paper was circulated under the title "All Together Now: Integration, Delegation, and Management." We are grateful for comments from Philippe Aghion, Jacques Crémer, Wouter Dessein, Luis Garicano, Bob Gibbons, Oliver Hart, Francine Lafontaine, Rocco Macchiavello, Jawwad Noor, Andrea Prat, Mike Powell, Veronica Rappoport, Birger Wernerfelt, and participants in the FOM Conference, the Fifth CEPR IMO Workshop, the MIT Empirical Management Conference, ASSA (IOS Session), the Organizational Economics Workshop at Berkeley, EEA-ESEM, and seminars at UCLA, NUS, Oxford, Collegio Carlo Alberto, MIT, Mannheim, Nova SBE, PUC-Rio, Unversitat Autònoma de Barcelona, LSE, King's College London, Southampton, and HSE Moscow.

1 Introduction

There is a paradoxical contrast between the way organization economists understand how efficient organizations work and the way they organize their own discipline. Virtually any of them would agree that the diverse elements of organizational design — ownership and financing, reporting structures, task allocations, compensation schemes, and the like — interact with each other and must work in concert for optimal performance (Milgrom and Roberts, 1990; Roberts, 2007). Yet, the economics of firm organization itself is starkly split into separate divisions (Gibbons and Roberts, 2013). There are theories of what determines the boundaries of the firm. Then there are theories of how a firm organizes itself internally, for example in the degree to which decisions are delegated from top- to mid-level managers. But how firm boundaries affect the allocation of decision-making inside the firm, or the manner in which those allocations feed back to the determination of boundaries, has scarcely been explored.

The intellectual divides notwithstanding, decisions over integration and delegation are clearly interdependent. Firm boundaries define whether and to whom a final good producer can delegate control and affect his ability to impose management practices such as monitoring or compensation schemes on his suppliers. Indeed, failure to align all these elements correctly can be disastrous: Boeing's infamous Dreamliner fiasco is a stark illustration of the consequences of underestimating these interdependencies.[1] Although some studies have emphasized the conceptual difference between integration and delegation (Baker, Gibbons and Murphy, 1999; Hart and Holmström, 2010), there has been little theoretical work to operationalize these differences. And, to the best of our knowledge, there is no systematic empirical work along those lines. More broadly, as evidence mounts that organization matters for the performance of whole industries and aggregate economies as well as individual firms (e.g., Hortaçsu and Syverson, 2007; Alfaro, Charlton, and Kanczuk, 2009; Forbes and Lederman, 2010; Bloom, Sadun and Van Reenen, 2012, 2016), it is becoming ever more compelling to understand the functioning of organizations as a whole rather than just their

[1] Boeing outsourced the design and manufacture of key components of the 787 Dreamliner (e.g., fuselage, wings, avionics) to independent suppliers, reserving for itself only the roles of primary designer and final assembler. This change in ownership structure meant that it handed "complete control of the design of [each] piece of the plane" to the suppliers. In sharp contrast to its prior practice of providing all designs, sourcing small components directly from subcontractors, and performing intermediate as well as final assembly, Boeing now made each major supplier "responsible for managing its own [small-component] subcontractors," which "operated largely out of Boeing's view." According to company engineers, this was the main reason behind poor quality components, strings of delays, and cost overruns of the 787 (Gates, 2013). By the time the first plane was delivered, 40 months late, the company had incurred cost overruns estimated at over $10 billion (Zhao and Xu, 2013). For a detailed discussion of the Dreamliner case, see also McDonald and Kotha (2015).

parts.

In this paper, we bring integration and delegation together, both theoretically and empirically. We first adapt the theoretical framework developed in Legros and Newman (2013) to analyze what factors determine these organizational design decisions. We then assess the evidence in light of the model, assembling a new dataset that contains information on vertical integration (based on Alfaro, Conconi, Fadinger and Newman, 2016),[2] and delegation (based on Bloom, Sadun and Van Reenen, 2012) for a sample with thousands of firms covering multiple countries and industries.

In our model, firm boundaries and the internal allocation of control are endogenous, the result of optimizing behavior by a headquarters (HQ) producing a final good. HQ has an exogenous "productivity", interpretable as a measure of entrepreneurial ability, product demand, or firm value. She first chooses which of its suppliers to integrate. Next, she decides whether and to which of the integrated suppliers to delegate decision making (for non-integrated suppliers, there is little question of delegation: the supplier retains the control as part of his bundle of ownership rights). An input (e.g., a car part like a seat), is more valuable if it is adapted to the final product (e.g., the car seats for different models of Mercedes are different), and adaptation requires the participation of the supplier. High-quality adaptation is costly to the supplier, but since it is both subtle and complex it is not amenable to formal contractual enforcement. If the transaction is at arms length, the final good producer has neither contracts nor authority to see it through, so adaptation is perfunctory at best. By contrast, if it is integrated, the final good producer can exercise authority to elicit complete adaptation from the supplier.[3]

The final good producer is ex-ante uncertain about the ability of suppliers to adapt inputs to her production needs and only learns this after the integration decision has been made. Integration has thus an *option value*, because among the rights of ownership acquired by the HQ under integration is the authority to choose whether to delegate (i.e. let the supplier direct the adaptation process) or centralize (retain control of the process).

The benefit of delegation is that HQ can take advantage of a supplier's level of expertise,

[2]The logic of our theoretical model also applies to lateral integration, involving goods sold in separate markets that are complementary either in production or consumption. However, data limitations make it difficult to construct firm-level measures of lateral integration: this would require information on firms' sales by product line for narrowly defined industries, which we do not observe in our dataset.

[3]In our model, integration is thus productivity-enhancing, but privately costly. Instead of adaptation of the inputs, one can think of a number of other non-contractible investments that will have the same effect. This view of integration is similar to that of Williamson (1975), and puts our model in the "ex-post non-contractible" branch of incomplete-contracts economics (e.g., the 2002 version of Hart and Holmström, 2010; Aghion, Dewatripont and Rey, 2002; Legros and Newman, 2008, 2013; Dessein, 2014).

particularly when it is higher than her own. But this comes at a cost: given that the supplier has preferences that are imperfectly aligned with HQ's, there is an incentive loss when he has control of the adaptation process. As the value of the firm increases, this incentive loss is attenuated, since the weight decision makers place on profit increases relative to the weight they place on private costs. By contrast, if HQ retains control, she will make the same decision for the supplier, independently of value. As a result, delegation increases with the value of the firm: a more productive HQ finds it more attractive to relinquish control to her integrated suppliers. Integration also increases with value: the more productive is the HQ, the more likely that the efficiency gains from adaptation offset the costs of integration. These two results yield our first main prediction: that integration and delegation should co-vary positively, or equivalently integration and centralization should move in opposite directions. This is because firms with more productive HQs have stronger incentives both to integrate suppliers and to delegate the adaptation process to them.

This prediction underscores a fundamental conceptual distinction between delegation and non-integration. Delegation is a (usually) non-contractible act of relinquishing control that can in principle be revoked at will by managerial fiat. Non-integration, by contrast, is the result of a formal sale of assets (Baker, Gibbons, and Murphy, 1999). "One-dimensional" organizational models that focus on the allocation of control have a hard time distinguishing between complete non-integration and complete delegation: both would seem to put decisions as far removed from the "center" as possible. From the perspective of such models, it would seem that integration and delegation ought to covary negatively. Contrary to this presumption, our model predicts a positive covariation between integration and delegation.

A second main prediction of our model is that final good producers should be more likely to integrate suppliers in "riskier" input industries, in which productivity is more dispersed. The intuition for this result is that, as we have already noted, integration creates a real option (to keep control or not), and the greater the risk about the ability of the supplier to do the adaptation, the more valuable the option becomes.

We show that the predictions of the theoretical model are remarkably consistent with the features of the novel dataset we have put together. We combine the survey of Bloom, Sadun, Van Reenen (2012), who have interviewed plant managers on the degree of autonomy granted to them by central headquarters, with a measure of the degree of vertical integration of the firm to which the given plant belongs. This latter measure has been constructed from WorldBase, a plant-level dataset covering millions of firms in many countries, that allows to link plants belonging to the same firm via a common-ownership identifier. Using the methodology employed in Alfaro, Conconi, Fadinger and Newman (2016), we combine information on reported production activities with detailed input-output data to measure the value of inputs for each dollar of final output that can be produced within the boundaries of the firm. Our matched sample consists of 2,661 firms, corresponding to 3,444 plants operating in 574 industries and 20 countries.

We find that plant-level delegation is robustly positively correlated with our measure of firm-level vertical integration. Our estimates imply that moving vertical integration from the 10th to the 90th percentile increases delegation by around 0.13 standard deviations. These results hold up in our baseline regressions and in a series of robustness checks (e.g., including different sets of fixed effects and controls, using different samples of firms).

To test the option-value prediction, we compute the coefficient of variation of labor productivity of independent suppliers in each upstream-industry-country pair using information from millions of plants in WorldBase. Ceteris paribus, a higher coefficient of variation corresponds to more risk in the productivity distribution of suppliers, increasing the option value of integrating a supplier in that industry. We find that the probability to vertically integrate a given input depends positively and very robustly on the riskiness of the distribution of labor productivity of suppliers, as measured by the coefficient of variation. A one-standard-deviation increase in the coefficient of variation of suppliers' labor productivity increases the probability to vertically integrate a given input by around 39 percent. This finding is extremely robust and holds for different set of fixed effects and samples.

Finally, we consider an extension of the model where inputs differ in terms of their relative importance for producing the final output. In this version of the model, the headquarters is more likely to integrate suppliers producing more important inputs and to delegate decision making to them. When proxying the importance of each input with the corresponding input-output coefficient, we find that final producers are indeed more likely to integrate suppliers of more imports inputs, and to delegate more decisions to these suppliers.

Our model is a plausible interpretation of the patterns we observe. We discuss alternative theories that can only account for subsets of our empirical findings. We see our model as a useful benchmark for understanding how elements of organizational design that were previously considered separately may fit together in theory and practice.

Our work is related to two main streams of literature, which focus on each of the organizational choices we bring together in this paper. First, we build on the vast literature on firm boundaries. Theoretical studies have looked at inter alia the technological/contractual determinants of vertical integration (e.g., Coase, 1937; Williamson, 1975; Grossman and Hart, 1986; Hart and Moore, 1990; Holmström and Milgrom, 1991; Hart and Holmström, 2010). Another strand has focused on market determinants (e.g., McLaren, 2000; Grossman and Helpman, 2002; Legros and Newman, 2008; Conconi, Legros and Newman, 2012). In this vein, Legros and Newman (2013, 2017) develop a "value theory" of firm boundaries, closely related to the model presented here, that emphasizes how product value helps determine the propensity for firms to vertically or laterally integrate. Empirical studies have tried to shed light on these determinants using firm-level data within specific industries (e.g., Joskow, 1987; Woodruff, 2002; Baker and Hubbard, 2003; Hortaçsu and Syverson, 2007), countries (e.g., Acemoglu, Aghion, Griffith and Zilibotti, 2010), or across countries (e.g., Acemoglu, Johnson and Mitton, 2009; Alfaro and Charlton, 2009; Alfaro, Conconi, Fadinger and Newman, 2016). Recent work studies integration decisions along value chains (Antràs and Chor, 2013; Alfaro, Antràs, Chor, and Conconi, 2017).

Looking at the literature on delegation, we relate to some classic theoretical studies including Aghion and Tirole (1997), Garicano (2000), Dessein (2002), Hart and Moore (2005), Alonso, Dessein and Matouschek (2008), Marin and Verdier (2008), Dessein, Garicano and Gertner (2010). On the empirical side, important contributions include Acemoglu, Aghion, Lelarge, Van Reenen, and Zilibotti (2007), Guadalupe and Wulf (2010), Bloom, Garicano, Sadun and Van Reenen (2014) and Bloom, Sadun and Van Reenen (2012).

A number of papers have studied pairwise interactions of organizational design elements from the theoretical point of view. Examples include Holmström and Tirole (1991); Holmström and Milgrom (1991; 1994); Legros and Newman (2008, 2013); Dessein, Garicano, and Gertner (2010); Rantakari (2013); Friebel and Raith (2010); Van den Steen (2010); Dessein (2014), and Powell (2015). As far as we are aware, of these papers, only Baker, Gibbons, and Murphy (1999) and Hart and Holmström (2010) consider delegation and firm boundaries together, and only from a theoretical perspective.

The structure of the paper is as follows. Section 2 presents the theoretical model. Section 3 describes the datasets and variables used in our empirical analysis. Section 4 presents the empirical results. Section 5 offers some concluding comments, particularly on the implications of our findings for the theory of the firm.

2 The Model

2.1 Production

We consider a production process in which a final good j is produced with n inputs indexed by i. An enterprise is composed of an HQ, who produces the final good, and n suppliers, S_i. HQ has "productivity" $A > 0$, an index of the profitability of her product or entrepreneurial ability. The value of the enterprise is

$$A \sum_{i=1}^{n} \pi_{ij}\, v_{ij}, \tag{1}$$

where the contribution $\pi_{ij} v_{ij}$ of supplier i depends on the technologically determined importance of the input π_{ij} for producing good j, as well as the value v_{ij} generated by the supplier. This value will depend partly on whether the input is "adapted" to HQ's specific needs, the result of an uncertain process that depends on the capabilities of the supplier and HQ as well as on investments and production decisions that are determined by the organizational environment, as discussed below.

Inputs can either be generic or adapted. We think of the inpuht being first produced in its generic form, through a process that is under the supplier's control. The generic input contributes value Ay_i to the enterprise, reflecting both HQ's productivity and the supplier's "capability" $y_i \geq 0$, a random variable with distribution $F_i(y)$. HQ also has a capability that we normalize to 1. The capabilities affect the value added by adaptation. If successful, the incremental increase in value is $\alpha_{ij} A(\mathbb{D}_i y + 1 - \mathbb{D}_i)$, where the indicator $\mathbb{D}_i$ denotes the identity of the director of the adaptation process ($\mathbb{D}_i = 1$ for S_i or $\mathbb{D}_i = 0$ for HQ) and α_{ij} measures the degree to which good j's value is dependent on the specificity of input i. If adaptation fails, the input retains its generic value Ay_i. For now we will consider the relationship between HQ and a typical supplier and suppress the index notation, setting $\pi_{ij} = 1$ and $\alpha_{ij} = 1$.

To model the adaptation process, we follow Legros and Newman (2013, 2015). In order for an input to be adapted, the supplier must first incur a fixed investment at private cost ϕ. For example, the supplier must learn about the specific features of the final good to which it needs to tailor its input. After this investment has been made, the adaptation process itself involves actions made by the supplier ($s \in [0, 1]$) and by HQ ($h \in [0, 1]$). These need to be coordinated for adaptation to be successful. To reflect the need for coordination, adaptation succeeds with probability $p(s, h) = 1 - (s - h)^2$.

HQ and the supplier have opposing preferences about how to carry out adaptation and find it costly to accommodate the other's approach. Specifically, HQ has private cost $(1 - h)^2$, while the supplier has private cost cs^2 ($c > 0$). Hence, HQ prefers the decision to be close to $h = 1$, while the supplier likes the adaptation decision to be close to $s = 0$.

To summarize, the contribution of an input to the final good depends on whether investment in adaptation ϕ is made, and whether HQ or the supplier directs adaptation. If there is no investment, the input is generic and the value of the input is Ay. If there is investment, the expected value of the input conditional on y is $Ay + p(s,h)A(\mathbb{D}y + 1 - \mathbb{D})]$.

2.2 Contracting and Timing

We assume that contracting is limited to fixed monetary payments m and transfers of ownership. In particular, payments contingent adaptation decisions or on adaptation outcomes are not possible (e.g., because they are not observable or, if they are, they are not verifiable by third parties). Moreover, only aggregate output, and not the (relatively small) contribution of individual suppliers, is contractible, so that profit shares would provide no meaningful incentives.

Ownership rights are contractible. If the supplier sells his asset to HQ, she gains the right to impose the initial adaptation investment and choice s on the supplier. However, she also has the (non-contractible) right to choose the control structure: she can choose whether to centralizalize (choose s for the supplier) or delegate (let the supplier choose s).

It is assumed that all parties have payoffs denominated in monetary terms, and that all have sufficient liquidity on hand to effectuate any side payments that might be needed to satisfy the distributional requirements among them. Thus, the enterprise will be choosing the organizational structure that maximizes the ex-ante total surplus.

Contracting occurs between HQ and all of the suppliers S_i simultaneously. First, HQ chooses the firm boundaries, by deciding which suppliers to integrate (the transfer can be interpreted as the asset purchase price in this case). Crucially, when making this choice, she does not yet know what their capabilities are, only the distributions $F_i(y)$. She can then invoke the authority garnered from ownership to force all integrated suppliers to make the initial adaptation investment, but she has no such authority over the non-integrated ones. After learning the capability of the suppliers, HQ can decide to which of the integrated ones she delegates the adaptation process.[4]

The timing for a single HQ-supplier relationship is summarized as follows:

1. Contract: integration decision and monetary transfer m

2. Adaptation investment choice at supplier cost ϕ

3. Supplier capability y observed by HQ and S

[4] Leaning about the capability of non-integrated suppliers is useless, given that HQ cannot force the initial adaptation investment on them.

4. Delegation decision for integrated supplier s

5. s and h are chosen at costs cs^2 and $(1-h)^2$

6. Output realized

2.3 Non-Integration

Here the supplier has ownership of his asset and will never make the initial adaptation investment, given that he bears the cost ϕ (which is non-contractible), while his continuation value cannot depend on the success of adaptation (also non contractible).

Hence under non-integration there is no adaptation. It follows that the expected value $\mathbb{E}v$ to HQ of a non-integrated supplier (which is also equal to the total surplus, since the private costs are zero) is given by

$$V^N = A\mathbb{E}y. \tag{2}$$

2.4 Integration

Now HQ has ownership of the supplier's asset and can impose the initial adaptation investment on him. Notice that she will always choose to do so, given that she does not bear the cost ϕ and the investment has positive expected value.

Under integration, HQ can also decide whether to centralize the adaptation decisions (s, h) or delegate them to her supplier. If HQ centralizes decision making, she will choose $s = h = 1$: this will maximize the probability that adaptation succeeds, while minimizing her private costs. The interim value to HQ of an integrated supplier under centralization is

$$v^C(A, y) = A(y + 1). \tag{3}$$

By contrast, if HQ decides to delegate the direction of the adaptation process to the supplier, by letting him choose s, she anticipates that he will set $s = 0$ (since this minimizes his private costs and he has no financial stake in the outcome of the process). HQ will then choose h to maximize $Ay(1 + (1 - h^2)y) - (1 - h)^2$, which yields $h = \frac{1}{1+Ay}$. It follows that the interim value to HQ of an integrated supplier under delegation is

$$v^D(A, y) = Ay + \frac{(Ay)^2}{1 + Ay}. \tag{4}$$

Notice that $v^D(A, y)$ is increasing and convex in A and y.

To decide whether to delegate, HQ compares $v^C(A, y)$ with $v^D(A, y)$. She will thus delegate whenever the realized capability of the supplier exceeds a cutoff value $y^*(A)$ defined by

$$v^C(A, y^*(A)) = v^D(A, y^*(A)). \tag{5}$$

From (3) and (4), $y^*(A)$ is the unique positive solution to $A\alpha(y^2 - y) = 1$. It is (i) greater than 1 (the HQ capability) and (ii) decreasing in A.

The reason for property (i) is that delegation suffers from an incentive distortion, since HQ and the supplier make their decisions independently, while centralization suffers relatively little (in this model, not at all) from incentive distortions. In order to compensate for the incentive loss, it takes a supplier capability strictly higher than HQ's to convince her to delegate. Property (ii) results from the relative rigidity of centralization: the decision there is the same regardless of A, whereas with delegation, decisions improve with firm value because of the incentive response (in this case HQ's). Thus, the value of delegation is more elastic with respect to A than is the value of centralization, implying that an HQ with a higher A is more willing to delegate.

The probability of delegation conditional on integration is $1 - F(y^*(A))$. Since the cutoff value $y^*(A)$ is decreasing, we have:

Lemma 1. *The probability that HQ delegates decisions to an integrated supplier is increasing in A.*

Firm Boundary Choices

At the date-1 contracting stage, HQ determines whether to integrate S. The total surplus of an integrated relationship is

$$V^I \equiv \mathbb{E} \max[v^C(A, y), v^D(A, y)] - cF(y^*(A)) - \phi. \tag{6}$$

The first term $\mathbb{E} \max[v^C(A, y), v^D(A, y)]$ is the expected value accruing to HQ under integration. The remaining terms are the (expected) costs of integration. Both are borne directly by the supplier and include the centralization cost c, which is incurred with probability $F(y^*(A))$, and the investment cost ϕ. In order for the supplier to agree to sell his asset, he must be compensated for these costs via the monetary transfer m. Thus, HQ will choose to integrate the supplier whenever $V^I \geq V^N$. Combining (2) with (6), the condition for integration can be written as

$$E \max[v^C(A,y), v^D(A,y)] - A\mathbb{E}y \geq cF(y^*(A)) + \phi. \tag{7}$$

The left-hand side is the option value of integration, which is increasing in A. This is because the incremental value of adaptation is increasing in A under both centralization and delegation. Meanwhile, since $y^*(A)$ is decreasing, the integration cost on the right-hand side decreases in A. It follows that producers with higher values of A are more likely to integrate a given supplier.

Lemma 2. *If an HQ with productivity A integrates a supplier, then an HQ with productivity $A' > A$ will also integrate.*

If we continue to assume that suppliers are symmetric ($F_i(y)$ as well as π_{ij} independent of i), then a corollary of this result is that the set of integrated suppliers will increase (in the set inclusion order) as A increases. That is, if an HQ with productivity A integrates a set $I(A) \subset \{1, 2, \ldots, n\}$, then an HQ with productivity $A' > A$ integrates $I(A') \supseteq I(A)$, all else equal.

We call the union $\{\text{HQ}\} \cup I$ a firm. Within this firm, the number of suppliers who are delegated will be a binomial random variable $d(A)$ with distribution $\text{Bin}(1 - F(y^*(A)), |I(A)|)$. From Lemmas 1 and 2, $1 - F(y^*(A))$ and $I(A)$ are increasing, so $d(A)$ is increasing in the stochastic dominance order. We define the degree of delegation to be $D(A) \equiv \mathbb{E}\frac{d(A)}{|I(A)|} = 1 - F(y^*(A))$, which is increasing in A.[5]

We can now state our first main result:

Proposition 1. *The degree of delegation D and the set of integrated suppliers I covary positively across firms.*

This result is driven by the fact that firms with a more productive HQ have stronger incentives both to integrate suppliers and to delegate the adaptation process to them.

2.5 Option Value of Integration

In our model, integration creates an option value. Namely, if the supplier turns out to be of low capability (low y), the producer is able to ensure at least a minimal level of input

[5] In our data, the delegation measure captures the degree of autonomy given by HQ to input suppliers on a set number of tasks (e.g. sales and marketing decisions, hiring a new employee). See Appendix A-1 for a version of the model in which suppliers perform multiple tasks.

contribution, by directing the production process herself. Such an option is not available under non-integration wherein the producer is entirely reliant on the supplier's capabilities.

We next consider the role of riskiness of suppliers. Consider a family of distributions $\{F(y;\sigma);\ \sigma \in [\underline{\sigma}, \overline{\sigma}]\}$, $0 < \underline{\sigma} < \overline{\sigma} < \infty$, where higher σ indicates greater Rothschild-Stiglitz riskiness. The option value $\mathbb{E}_\sigma \max[v^C(A,y), v^D(A,y)] - A\mathbb{E}_\sigma y$, which we denote by $R(A;\sigma)$, is increasing in σ, since the integrand of the first term is convex in y: riskier distributions increase the option value. It follows that whenever $F_\sigma(y^*(A);\sigma) \leq 0$, the condition (7) is more likely to be satisfied when σ increases.

However, if $F_\sigma(y^*(A);\sigma)$ is positive, it is necessary that the cost c is not too large. A local condition for riskier distribution to increase the benefit of integration is therefore

$$\begin{aligned} &\text{Either} \quad && F_\sigma(y^*(A);\sigma) \leq 0 \\ &\text{or} \quad && c < \frac{R_\sigma(A;\sigma)}{F_\sigma(y^*(A);\sigma)}. \end{aligned} \tag{8}$$

We can then state our second main result:

Proposition 2. *Suppose* (8) *holds. If a supplier is integrated at risk σ, it will also be integrated at the risk level $\sigma' > \sigma$.*

Notice that since $Ey \leq 1 < y^*(A)$, the first condition in (8) is satisfied for all single-crossing symmetric unimodal families of distributions (e.g., uniform, triangular, normal, symmetric beta). For such distributions, an increase in σ increases the probability that the supplier's capability is above $y^*(A)$, thus decreasing the probability of centralization.

For other families of distributions, the situation is a bit more subtle. For instance, consider a family of log-normal distributions $\{(\mu,\sigma)\}$ with same mean $e^m \equiv e^{\mu+\frac{\sigma^2}{2}}$ and increasing variance $e^{2m}(e^{\sigma^2}-1)$. It is well known that distributions with larger values of σ are riskier than distributions with lower values of σ (Levy, 1973). Simple algebra shows that $F_\sigma(y^*(A);\sigma)$ is non-positive whenever $\sigma \leq \sigma_0 \equiv \sqrt{2(\log(y^*(A)) - m)}$. If $\sigma > \sigma_0$ the second part of (8) holds for some interval of positive costs $(0,\overline{c})$ since $R_\sigma(y^*(A);\sigma)$, $F_\sigma(y^*(A);\sigma)$ and therefore their ratio are uniformly bounded away from 0 on $[\underline{\sigma}, \overline{\sigma}]$.[6]

[6]As an illustration of this possibility, suppose that on average suppliers have the same capability as HQ, that is $\mathbb{E}y = 1$ (hence $m = 0$) and suppose that $A = 1 > c$. Then, $y^*(1) = \frac{1+\sqrt{5}}{2}$, and $\sigma_0 = \sqrt{2\log\left(\frac{1+\sqrt{5}}{2}\right)}$. When σ is greater than 2, the variance of y is greater than 50. For "realistic" values of $\sigma \geq \sigma_0$, say $\sigma \in (\sigma_0, 4)$, the ratio $\frac{R_\sigma(1;\sigma)}{F_\sigma(y^*(1);\sigma)}$ is greater than 4, and therefore the second condition of (8) is satisfied since $c < 1$ is needed for integration.

2.6 Testable Predictions

We conclude this section by summarizing the key predictions of our model that we bring to the data. The first testable prediction follows directly from Proposition 1:

> P.1: More vertically integrated firms should have a higher degree of delegation.

Proposition 2 yields the second key prediction of our model:

> P.2: Final good producers should be more likely to integrate inputs when the capability of suppliers in the input industry is more uncertain.

3 Dataset and Variables

In this section, we first describe the two main datasets we use in our analysis. We then discuss the construction of our matched sample and define the key variables used in our empirical analysis.

3.1 Datasets

World Management Survey

Our international delegation data was collected in the context of the World Management Survey (WMS), a large scale project aimed at collecting high quality data organization design across firms around the world. The survey is conducted through interviews with plant managers in medium sized manufacturing firms.

The WMS survey was conducted by telephone without telling the managers they were being scored on organizational or management practices. This enabled scoring to be based on the interviewer's evaluation of the firm's actual organizational practices, rather than their aspirations, the manager's perceptions or the interviewer's impressions. Second, the interviewers were not informed of the firm's financial information or performance in advance of the interview. This was achieved by selecting medium sized manufacturing firms and by providing only firm names and contact details to the interviewers (but no financial details). The survey tool is thus "double blind" – managers do not know they are being scored and interviewers do not know the performance of the firm. Third, each interviewer ran 85 interviews on average, allowing for removal of interviewer fixed effects from all empirical specifications.

This helps to address concerns over inconsistent interpretation of responses. Fourth, information on the interview process itself (duration, day-of-the-week), on the manager (seniority, job tenure and location), and on the interviewer (for removing analyst fixed effects and subjective reliability score) was collected. These survey metrics are used as "noise controls" to help reduce residual variation.

The sampling frame was drawn from each country to be representative of medium sized manufacturing firms. The main wave of interviews was run in the summer of 2006, followed by smaller waves in 2009 and 2010.[7]

As discussed in detail in Section 3.3 below, we use the survey to construct our delegation measure, as well as additional plant-level controls included in our regressions.

WorldBase

The other dataset used in our empirical analysis is the WorldBase by Dun & Bradstreet, which provides coverage of public and private firms for more than 24 million plants in more than 200 countries and territories.[8]

The unit of observation in the dataset is the establishment/plant (namely a single physical location where industrial operations or services are performed or business is conducted). Each establishment in WorldBase is assigned a unique identifier, called a DUNS number (Data Universal Numbering System). The DUNS number allows to keep track of plant's histories, including name changes, ownership relations and, when applicable – that is, for non-single establishment firms – it supports the linking of plants within and across countries. In particular, plants belonging to the same firm can be linked via information on domestic and global parents using the DUNS numbers.[9]

For the purpose of this paper, WorldBase provides additional useful information on the year of establishment and location, primary and secondary activities of operation, and basic

[7]The survey achieved a 45% response rate, which is very high for company surveys, because (i) the interview did not discuss firm's finances, (ii) there were written endorsement of many institutions like the Bundesbank, Treasury and World Bank, and (iii) high quality MBA-type students were hired to run the surveys.

[8]WorldBase is the core database with which D&B populates its commercial data products that provide information about the "activities, decision makers, finances, operations and markets" of the clients' potential customers, competitors, and suppliers. The dataset is not publicly available but was released to us by Dun and Bradstreet. The sample was restricted to plants for which primary SIC code information and employment were available (due to cost considerations). For more information see: http://www.dnb.com/us/about/db_database/dnbinfoquality.html.

[9]The global ultimate is a business entity with legal and financial responsibility over another establishment. D&B Worldbase defines the "global ultimate" as the top, most important, responsible entity within the corporate family tree that has more than 50% ownership of the plant in question.

performance data (employment, sales, etc.). D&B uses the U.S. Standard Industrial Classification (SIC) Manual 1987 edition to classify business establishments.

The WorldBase dataset has been used extensively in the literature (e.g. Alfaro and Charlton, 2009; Acemoglu, Johnson and Mitton, 2009; Alfaro, Conconi, Fadinger, and Newman 2016; Alfaro, Antràs, Chor, and Conconi, 2017).[10]

Our main sample is based on the 2005 WorldBase dataset. As discussed below, we combine this dataset with information from Input-Output tables to construct firm-level measures of vertical integration. We use the additional information provided by WorldBase to construct auxiliary firm-level controls (e.g. employment, age).

3.2 Matched Sample

Combining WorldBase and the WMS, we construct a matched sample, which includes 2,661 firms in 20 countries, operating in 574 sectors (primary SIC codes of the firm), corresponding to 3,444 plants.[11] For the US and Canada we linked plants interviewed in the WMS to plants in WorldBase using a common plant identifier (the DUNS number). For the remaining countries, we did not have a common plant identifier available, so we used a string matching algorithm to link plants in WMS to plants in WorldBase using location information and company names. We then manually checked the results of the matching process. Finally, we used ownership information from Worldbase to assign any matched plant to a firm via the domestic parent.

Appendix Table A-1 presents summary statistics for all the variables used in our regressions, while Table A-2 reports the number of firms in each country.

3.3 Main Variables

Delegation

In the WMS, plant managers were asked four questions on delegation from the central headquarters to the local plant manager.[12] First, they were asked how much capital investment they could undertake without prior authorization from the corporate headquarters. This is a

[10]See Alfaro and Charlton (2009) for a more detailed discussion of the WorldBase data and comparisons with other data sources.

[11]For the vast majority of cases, we only observe a single plant in WMS corresponding to a given firm in Worldbase. In a number of instances, the same plant has been interviewed in more than one wave of the WMS. The WMS sample excludes plants where the CEO and the plant manager were the same person (only 4.9% of the interviews).

[12]In Appendix Figure A-1, we detail the individual questions in the same order as they appear in the survey.

continuous variable enumerated in national currency that is converted into dollars using PPPs. Plant managers had then to state the degree of autonomy they had in three other dimensions: (a) the introduction of a new product, (b) sales and marketing decisions, and (c) hiring a new full-time permanent shop floor employee. These more qualitative variables were scaled from a score of 1 (defined as all decisions taken at the corporate headquarters), to a score of 5 (defined as complete autonomy granted to the plant manager). Since the scaling may vary across questions, we have standardized the scores from the four autonomy questions to z-scores, by normalizing each question to mean zero and standard deviation one. The variable $Delegation_{f,p}$ is the average across the four z-scores for the manager of plant p belonging to firm f.

Vertical Integration

To measure vertical integration, we follow Alfaro, Conconi, Fadinger and Newman (2016), combining information from WorldBase on firms' production activities with data from Input-Output tables.

As mentioned above, the unit of observation in WorldBase is the establishment/plant, a single physical location at which business is conducted or industrial operations are performed.

For each establishment, we use different categories of data recorded in WorldBase:

1. Industry information: the 4-digit SIC code of the primary industry in which each establishment operates, and the SIC codes of up to five secondary industries.
2. Ownership information: information about the firms' family members (number of family members, domestic parent and global parent).[13]
3. Location information: country of each plant.
4. Additional information: sales, employment, age.

We combine information on plant activities and ownership structure from WorldBase with input-output data to construct a firm-level vertical integration index. The methodology used to construct this measure is based on Fan and Lang (2000) and has been used in several empirical studies on firm boundaries (e.g. Acemoglu, Johnson and Mitton, 2009; Alfaro, Conconi, Fadinger, and Newman, 2016; Alfaro, Antràs, Chor, and Conconi, 2017). Given

[13] D&B also provides information about the firm's status (joint-venture, corporation, partnership) and its position in the hierarchy (branch, division, headquarters).

the difficulty of finding input-output matrices for all the countries in our dataset, we follow Acemoglu, Johnson and Mitton (2009) and Alfaro and Charlton (2009) in using the U.S. input-output tables to provide a standardized measure of input requirements for each output sector. As the authors note, the U.S. input-output tables should be informative about input flows across industries to the extent that these are determined by technology.[14]

The input-output data are from the Bureau of Economic Analysis (BEA), Benchmark IO Tables, which include the make table, use table, and direct and total requirements coefficients tables. We use the Use of Commodities by Industries after Redefinitions 1992 (Producers' Prices) tables.[15]

For every pair of industries, ij, the input-output accounts provide the dollar value of i required to produce a dollar's worth of j. By combining information from WorldBase on firms' activities with U.S. input-output data, we construct the input-output coefficients for each firm f with primary activity j, IO^f_{ij}. Here, $IO^f_{ij} \equiv IO_{ij} * I^f_i$, where IO_{ij} is the direct requirement coefficient for the sector pair ij (i.e. the dollar value of i used as an input in the production of 1 dollar of j) at the 4-digit SIC level and $I^f_i \in \{0, 1\}$ is an indicator variable that equals one if and only if firm f owns plants that are active in sector i. A firm with primary activity j that reports i as a secondary activity is assumed to supply itself with all the i it needs to produce j.

To verify the first prediction of our model, we construct a firm's integration index:

$$\text{Vertical Integration}_{f,j} = \sum_i IO^f_{ij}, \tag{9}$$

which is the sum of the IO coefficients for each industry in which firm f is active. In the case of multi-plant firms, we link the activities of all plants that report to the same headquarters and consider the main activity of the headquarters as the primary sector.

As an illustration of the procedure used to construct the vertical integration index, consider an example, taken from Alfaro, Conconi, Fadinger, and Newman (2016), of a Japanese

[14] Note that the assumption that the U.S. IO structure carries over to other countries can potentially bias our empirical analysis against finding a significant relationship between delegation and vertical integration by introducing measurement error in the explanatory variable of our regressions. In addition, using the U.S. input-output tables to construct vertical integration indices for other countries mitigates the possibility that the IO structure is endogenous.

[15] While the BEA employs six-digit input-output industry codes, WorldBase uses the SIC industry classification. We thus convert the IO table to the 4-digit SIC 1987 classification. The BEA website provides a concordance guide, but it is not a one-to-one key. For codes for which the match was not one-to-one, we randomized between possible matches in order not to overstate vertical linkages. The multiple matching problem, however, is not particularly relevant when looking at plants operating only in the manufacturing sector (for which the key is almost one-to-one).

shipbuilder that has two secondary activities, Fabricated Metal Structures (SIC 3441/BEA IO code 40.0400) and Sheet Metal Work (3444/40.0700).[16] The IO_{ij} coefficients for these sectors are:

		Output (j)
		Ships
Input (i)	*Ships*	0.0012
	Fab. Metal	0.0281
	Sheet Metal	0.0001

This table is just the economy-wide IO table's output column for the firm's primary industry, Ship Building and Repairing (3731/61.0100), restricted to the input rows for the industries in which it is active. The IO_{ij} coefficient for fabricated metal structures to ships is 0.0281, indicating that 2.8 cents worth of metal structures are required to produce a dollar's worth of ships. The firm is treated as self-sufficient in the listed inputs but not any others, so its vertical integration index *Vertical integration*$_f$ is the sum of these coefficients, 0.0294: about 2.9 cents worth of the inputs required to make a dollar of primary output can be produced within the firm.[17]

To assess the validity of the second prediction of our model, we also construct the dummy variable *Integration*$_{f,j,i,c}$, which is equal to 1 if firm f (producing primary output j and with a domestic ultimate located in country c) integrates a supplier in input industry i within its boundaries. To keep the analysis tractable, we limit the sample to firms that integrate at least one input different from j, and to the top 100 inputs i used by j, as ranked by the IO coefficients (see also Alfaro, Antràs, Chor, and Conconi, 2017).

Riskiness of Input Industries

To assess the validity of the second prediction of our model, we need to verify how uncertainty in the productivity of suppliers in an input industry affects a firm's integration choices. To this purpose, we construct the variable *CV Productivity*$_{i,c}$, the coefficient of variation (standard deviation/mean) of productivity of suppliers in input industry i located in country c. We construct this variable using information on the labor productivity (sales per employee

[16]There is no concern about right censoring in reported activities: only 0.94 percent of establishments with primary activity in a manufacturing sector report the maximum number of five secondary activities.

[17]Many industries, including Ship Building and Repairing, have positive IO_{jj} coefficients: some "ships" are used to ferry parts around a shipyard or are actually crew boats that are carried on board large ships; machine tools are used to make other machine tools; etc. Any firm that produces such a product will therefore be measured as at least somewhat vertically integrated. In the empirical analysis, we control for output industry fixed effects, which takes care of this.

in thousands of US Dollars) of all independent (i.e., non-integrated) firms. We consider all suppliers present in the 20 countries considered by the WMS using the full WorldBase dataset (around 15 million independent firms) with primary sector i located in country c. We also compute the arithmetic average of suppliers' productivity in each sector-country pair $\textit{Mean Productivity}_{i,c}$. In some robustness checks, we restrict the analysis to input industries in which we have at least 50 independent suppliers in industry i country c to construct $\textit{CV Productivity}_{i,c}$.

Additional Controls

Using information from WorldBase, we construct auxiliary firm-level controls. These include $\textit{Employment}_f$, the total number of employees of the firm, and $\textit{Age}_f$, the number of years since its establishment.

The auxiliary plant-level controls drawn from the WMS data include the education of the workforce, captured by the variable $\textit{\% Workforce with a College Degree}_p$, defined as the percentage of a plant's employees who have a bachelor's degree or higher. In some specifications, we also control for a plant's adoption of basic management practices, using the methodology developed in Bloom and Van Reenen (2007) and extended in Bloom, Sadun and Van Reenen (2016). Figure A-2 in the Appendix lists these practices and gives a sense of how each was measured on a scale from 1 to 5. Our overall measure of the quality of a firm's management practices, $\textit{Management}_p$, is simply the average of the 18 individual management dimensions, after each has been normalized to a z-score (with a mean of zero and a standard-deviation of one). In some specifications, we replace the overall management score with individual components of the plant's management practices ($\textit{Operations}_p$, which measures the adoption of lean management practices; $\textit{Monitoring}_p$, which measures the adoption of practices related to performance monitoring and review; $\textit{Targets}_p$, which measures the adoption of practices related to targets setting and review; and $\textit{Incentives}_p$, which measures the adoption of practices related to the management of human capital, including monetary and non-monetary incentives.

4 Empirical Results

4.1 Relationship between Delegation and Integration

We first assess the validity of prediction P.1 concerning the relationship between delegation and integration. According to our model, firms with a more productive HQ will have stronger incentives both to integrate suppliers and to delegate the adaptation process to them. As a result, the two organizational variables should be endogeneously correlated.

We estimate the following:

$$\text{Delegation}_{f,p,i,c} = \beta_0+\beta_1 \text{ Vertical Integration}_{f,j,c}+\beta_2\mathbf{X}_p+\beta_3\mathbf{X}_f+\delta_i+\delta_j+\delta_c+\epsilon_{f,p,i,j,c}. \quad (10)$$

The dependent variable is the degree of autonomy granted to plant p (with primary activity i, located in country c) by the parent firm f (with primary activity j, located in country c). The main control of interest is *Vertical Integration*$_{f,i,c}$, the vertical integration index of firm f. $\mathbf{X}_p$ and $\mathbf{X}_f$ are vector of plant-level and firm-level controls, while δ_i, δ_j and δ_c are input-sector, output-sector (at the 3-digit SIC level), and country fixed effects.[18] We include input-sector (output-sector) fixed effects to control for the average amount of delegation to a given input industry (by a given output industry).[19] According to the first prediction of our theoretical model, the estimated coefficient β_1 should be positive and significant. We cluster standard errors at the firm level.

The results are reported in Table 1. Column 1 presents the results of a parsimonious specification, in which we regress *Delegation*$_{f,p,i,j,c}$ on our key control of interest *Vertical Integration*$_{f,j,c}$, including only country and input-industry fixed effects. In line with prediction P.1 of our model, the estimated coefficient of *Vertical Integration*$_f$ is positive and significant at the one-percent level. This result continues to hold when we add output-industry fixed effects (column 2), and we further control for the size and age of the parent firm, as well as the level of education of the plant's workforce (column 3).

In columns 4 and 5, we control for the overall quality of the plant's management practices and their individual components. The correlation between delegation and management remains positive and highly significant. As discussed in Section 4.4, these specifications help us to rule out an alternative explanation for the positive correlation between delegation and

[18] Given that the data on delegation were collected in different waves of surveys and by different interviewers, we also include in these regressions survey noise controls and fixed effects for the year in which the firm was surveyed to reduce measurement error in the dependent variable.

[19] Given that for the vast majority of firms we only observe delegation for a single plant, we cannot control for firm fixed effects.

vertical integration, based on idea that integration increases the headquarters' overload and thus the need for delegation.

Table 1
Delegation and Vertical Integration

	(1)	(2)	(3)	(4)	(5)
Vertical Integration$_f$	0.794***	0.691***	0.653***	0.587**	0.575**
	(0.244)	(0.248)	(0.249)	(0.247)	(0.249)
log(Employment$_f$)			-0.064	-0.057	-0.059
			(0.042)	(0.042)	(0.042)
log(Age$_f$)			0.038*	0.035*	0.035*
			(0.021)	(0.021)	(0.021)
log(% Workforce with a College Degree$_p$)			0.054***	0.039**	0.038**
			(0.016)	(0.016)	(0.016)
Management$_p$				0.110***	
				(0.020)	
Operations$_p$					-0.030
					(0.024)
Monitoring$_p$					0.023
					(0.031)
Targets$_p$					0.070*
					(0.037)
Incentives$_p$					0.118***
					(0.036)
Country FE	Yes	Yes	Yes	Yes	Yes
Output FE	No	Yes	Yes	Yes	Yes
Input FE	Yes	Yes	Yes	Yes	Yes
R-squared	0.198	0.205	0.209	0.217	0.219
N	3,444	3,393	3,393	3,393	3,392

Notes: The dependent variable is *Delegation*$_{f,p,i,j,c}$, the degree of autonomy granted to plant p (with primary activity i, located in country c) by the parent firm f (with primary activity j). *Vertical Integration*$_{f,j,c}$ is the vertical integration index of firm f. *Employment*$_f$ measures the firm's employment, *Age*$_f$ is the number of years since its establishment, *% Workforce with a College Degree*$_p$ is the percentage of the plant's employees with a bachelor's degree or higher. *Management*$_p$ is the normalized z-score capturing the quality of the plant's management practices. Output and input fixed effects are respectively the primary activities of the parent and of the plant (defined at 3-digits SIC). Standard errors clustered at the firm level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

In terms quantitative implications, the point estimates reported in column 3 of Table 1 indicate that, as we move from the 10th percentile to the 90th percentile of *Vertical Integration*$_f$, delegation increases by around 0.13 standard deviations.[20]

In Table 1 we have included broad industry fixed effects (defined at the SIC3 level) to control for the primary activities of the plant and its parent firm. As shown in Table A-3 in

[20] The 10th percentile of *Vertical Integration*$_f$ is 0.006 and the 90th percentile is 0.198, thus (0.198-0.006)*0.653=0.125.

the Appendix, the results are robust to using more disaggregated fixed effects (defined at the SIC4 level). The main drawback is that we lose some observations because they are absorbed by the fixed effects.[21]

One may be concerned about measurement error in the vertical integration index. In an influential study, Atalay *et al*. (2014) find little evidence of intra-firm shipments between related plants within the United States. This suggests that using Fan and Lang (2000)'s methodology to construct *Vertical Integration*$_f$ may lead us to mis-classify some inputs as being integrated, when the firm is actually sourcing them from the market. It should be stressed that measurement error in the vertical integration index should work against us by attenuating the coefficient β_1, making it harder to find support for our model's predictions. Nevertheless, we have verified that the results of Table 1 are robust to restricting the analysis to single-plant firms (see Table A-4 in the Appendix). For these firms, measurement error in the vertical integration index should be less of a concern, since it is unlikely that a parent would not use the inputs produced in its own establishment.

4.2 Option Value of Integration

In our model, ex-ante uncertainty about suppliers' capability creates an option value of integration, because HQ can decide whether and to which suppliers to delegate decisions. In this section, we focus on integration choices, which occur before capability realizations and delegation decisions.

According to the second prediction of our model, final good producers should be more likely to integrate inputs when the capability of suppliers in the upstream sector is more uncertain. To test this prediction, we exploit within-firm variation in integration choices, examining whether final good producers are more likely to integrate suppliers in input sectors with greater productivity variation.

To assess the validity of prediction P.2, we estimate the following linear probability model:

$$\text{Integration}_{f,j,c,i} = \gamma_0 + \gamma_1 \text{ CV Productivity}_{i,c} + \gamma_2 \text{ Mean Productivity}_{i,c} \gamma_3 X_f + \delta_i + \delta_f + \epsilon_{f,j,c,i}. \tag{11}$$

The dependent variable is *Integration*$_{f,j,i,c}$, which is equal to 1 if firm f (with primary activity in sector j and located in country c) integrates input i within its boundaries. The key control

[21] Results are also robust to controlling for the number of plants in the firm and whether the plant belongs to a multinational (parent is located in a different country).

of interest is *CV Productivity*$_{i,c}$, which captures the degree of uncertainty in the capability of suppliers faced by the firm ex-ante, before deciding whether or not to integrate a particular input. As explained in Section 3.3, this variable is constructed using information on the labor productivity of all independent firms with primary sector i in country c. We also control for *Mean Productivity*$_{i,c}$, the mean of input suppliers' productivity in a given country-input-sector pair. X_p and X_f are vectors of firm-level controls, while δ_i denotes input-industry fixed effects at the 4-digit SIC level. In the most stringent specifications, we include firm fixed effects (δ_f), which allow us to account for the role of unobservable firm characteristics. In alternative specifications, we replace firm fixed effects with output-sector and country fixed effects (δ_j and δ_c). We cluster standard errors at the input-industry i level, since the main variable of interest varies at the input-industry-country level.

According to prediction P.2, the estimated coefficient γ_1 should be positive and significant. Greater uncertainty implies that by integrating, the firm has a better chance to benefit from high productivity through delegation, while being insulated from low productivity through centralization. In other words, greater uncertainty increases the option value of integration, making it more likely. Since the possibility of delegation generates the option value but only happens ex-post, realized delegation (which is what our survey data measures) cannot have a causal impact on integration, and thus is not present in the regression.

The baseline results are reported in Table 2. We include the 2,661 firms in the matched sample and consider the top 100 inputs (based on the IO coefficients) necessary to produce the firm's output (see also Alfaro, Antràs, Chor, and Conconi, 2017). In column 1, we include our key control of interest, *CV Productivity*$_{i,c}$, as well as the mean of input suppliers' productivity and country and input fixed effects. We then further add output fixed effects (column 2) and additional firm-level controls (column 3).[22] In the last specification, we include firm fixed effects, exploiting only within-firm variation across inputs to identify how the riskiness of suppliers affects integration choices (column 4).[23] In all specifications, the estimated coefficient for *CV Productivity*$_{i,c}$ is positive and highly significant. These findings are consistent with the idea that higher uncertainty in the productivity of suppliers increases the option value of integration.

[22] Only the fraction of the workforce with a college degree is from the WMS and collected at the plant level.

[23] In this specification, the country and output-industry fixed effects are absorbed by the firm fixed effects, given that each firm is associated to one location and one primary activity.

Table 2

Option Value of Integration

	(1)	(2)	(3)	(4)
CV Productivity$_{i,c}$	0.00066***	0.00063***	0.00063***	0.00062***
	(0.00013)	(0.00013)	(0.00013)	(0.00013)
Mean Productivity$_{i,c}$	-0.00000**	-0.00000**	-0.00000**	-0.00000**
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
log(Employment$_f$)			0.00636***	
			(0.00037)	
log(1+ Age$_f$)			0.00007	
			(0.00028)	
log(% Workforce with a College Degree$_p$)			-0.00090***	
			(0.00023)	
Country FE	yes	yes	yes	no
Input FE	yes	yes	yes	yes
Output FE	no	yes	yes	no
Firm FE	no	no	no	yes
R-squared	0.018	0.036	0.048	0.079
N	250,925	250,925	250,925	250,925

Notes: The dependent variable is *Integration*$_{f,j,i,c}$, a dummy equal to 1 if firm f (producing final product j and located in country c) integrates input i within its boundaries. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the independent suppliers in input industry i located in country c, while *Mean Productivity*$_{i,c}$ is the mean of input suppliers' productivity. *Employment*$_f$ measures firm employment, *Age*$_f$ is the number of years since the firm's establishment and *% Workforce with a College Degree*$_p$ is the fraction of workers with a Bachelor's degree or higher (at the plant-level). Standard errors clustered at the input level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

As for the economic magnitude of the effect, according to the specification in column 2, a one-standard-deviation increase in *CV Productivity*$_{i,c}$ increases the probability to integrate a supplier by around 0.39 percentage points, which corresponds to a 39-percent increase compared to the baseline probability of one percent.[24]

As mentioned before, the results of Atalay *et al.* (2014) suggest that using the methodology of Fan and Lang (2000) may lead us to mistakenly classify some inputs as being sourced from plants owned by the parent, whereas they are actually bought on the market. In the regressions of Table 2, this would imply a measurement error in the dependent variable *Integration*$_{f,j,i,c}$. In turn, this should make our coefficient estimates less precise, making it harder to find support for prediction P.2. However, the coefficient for *CV Productivity*$_{i,c}$ is always positive and highly significant.

We have carried out a series of robustness checks to verify the validity of prediction P.2.

[24]The standard deviation of *CV Productivity*$_{i,c}$ is 6.11. Thus, 0.38493=0.00066*6.11*100.

In particular, the results of Table 2 continue to hold when we restrict the analysis to input industries in which there are at least 50 suppliers in each input industry-country, for which *CV Productivity*$_{i,c}$ can be measured more precisely (see Table A-5) and for which concerns that parents integrate suppliers in order to assure supply of inputs are not a concern. The results are also robust to using all the firms in the WorldBase sample that have integrated at least one input different from their primary output to study firms' integration decisions (see Table A-6). When using this much larger sample, we have also verified that the results continue to hold when we restrict the analysis to the single-establishment firms, for which measurement error in the dependent variable should be less of a concern (see Table A-7).

4.3 Technological Asymmetries across Inputs

In our baseline model, we have assumed symmetry of inputs: the technological parameters π_{ij} and α_{ij}, as well as the capability distributions $F_i(y)$ are identical across sectors.

An implication of the "value theory" of integration expressed by our model is that the technological importance of the inputs should affect delegation and integration decision. In particular, a corollary of Lemma 1 is that HQ should have stronger incentives to delegate decisions to suppliers of more important inputs, i.e. with larger π_{ij}. The reason for this is that in $v^C(A, y)$ and $v^D(A, y)$ A becomes $A\pi_{ij}$; then larger π_{ij} implies more delegation, just as larger A does. Following the same logic, a corollary of Lemma 2 is that HQ should be more likely to integrate suppliers of more important inputs.[25]

To verify how the technological importance of an input affects delegation choices, we include in regression (10) the input-output coefficient *IO*$_{ij}$. The results are reported in Table 3. As expected, the coefficient of *IO*$_{ij}$ is positive and significant, indicating that final good producers are more likely to delegate decisions to suppliers of more important inputs.[26] The coefficient of the overall vertical integration index of the firm is also positive and significant and remains similar in magnitude, confirming prediction P.1 of our model that more integrated firms tend to give more autonomy to their suppliers. In terms of economic magnitudes, according to the specification in column 3 increasing the input-output coefficient by one standard deviation increases delegation by around 0.06 standard deviations.[27]

[25] Very nearly the same logic implies that more adaptable inputs (larger α_{ij}), are more likely to be delegated and integrated.

[26] Standard errors are clustered at the firm level. Results are practically identical if we cluster at the industry-pair level (the level of variation of the IO coefficient). In Table 3, we include 3-digit input and output industry fixed effects. Results are robust to including 4-digit fixed effects.

[27] The standard deviation of *IO*$_{ij}$ is 0.05, so 0.913*0.055=0.05.

Table 3

Delegation and Vertical Integration

	(1)	(2)	(3)	(4)	(5)
IO_{ij}	0.862**	0.852*	0.913**	0.904**	0.903**
	(0.372)	(0.446)	(0.447)	(0.445)	(0.449)
Vertical Integration$_f$	0.754***	0.628**	0.572**	0.513**	0.498**
	(0.245)	(0.252)	(0.252)	(0.251)	(0.252)
log(Employment$_f$)			-0.076*	-0.070	-0.070
			(0.044)	(0.044)	(0.044)
log(Age$_f$)			0.051**	0.047**	0.048**
			(0.022)	(0.022)	(0.022)
log(% Workforce with a College Degree$_p$)			0.054***	0.040**	0.039**
			(0.017)	(0.017)	(0.017)
Management$_p$				0.107***	
				(0.021)	
Operations$_p$					-0.026
					(0.025)
Monitoring$_p$					0.013
					(0.032)
Targets$_p$					0.076**
					(0.038)
Incentives$_p$					0.115***
					(0.037)
Country FE	Yes	Yes	Yes	Yes	Yes
Output FE	No	Yes	Yes	Yes	Yes
Input FE	Yes	Yes	Yes	Yes	Yes
R-squared	0.200	0.203	0.208	0.215	0.217
N	3,179	3,133	3,133	3,133	3,132

Notes: The dependent variable is *Delegation*$_{f,p,i,j,c}$, the degree of autonomy granted to plant p (with primary activity i, located in country c) by the parent firm f (with primary activity j). IO_{ij} is the IO coefficient capturing the importance of input i in the production of good j. *Vertical integration*$_f$ is the vertical integration index of firm f. *Employment*$_f$ measures the firm's employment, *Age*$_f$ is the number of years since its establishment, *% Workforce with a College Degree*$_p$ is the percentage of the plan't employees with a bachelor's degree or higher. *Management*$_p$ is the normalized z-score capturing the quality of the plant's management practices. Output and input fixed effects are respectively the primary activities of the parent and of the plant (defined at 3-digits SIC). Standard errors clustered at the firm level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

We next verify that final good producers are more likely to integrate suppliers of more important inputs. We re-estimate the linear probability model (11) including the input-output coefficient IO_{ij} as a covariate. The results are reported in Table 4.

As expected, the coefficient of IO_{ij} is positive and significant, indicating that final good producers are more likely to produce in house more important inputs. In particular, according to the specification in column 3 moving the input-output coefficient by one standard deviation increases the probability to vertically integrate the supplier of this input by 0.38 percentage points – a 38 percent increase compared to the baseline probability of one percentage point.[28] The coefficient of *CV Productivity*$_{i,c}$ remains positive and significant, in line with the prediction P.2 of our model.

Table 4

Option Value of Integration

	(1)	(2)	(3)	(4)
IO$_{ij}$	0.07605***	0.12436***	0.12674***	0.13557***
	(0.01182)	(0.01482)	(0.01470)	(0.01576)
CV Productivity$_{i,c}$	0.00066***	0.00063***	0.00063***	0.00061***
	(0.00013)	(0.00013)	(0.00013)	(0.00013)
Mean Productivity$_{i,c}$	-0.00000**	-0.00000**	-0.00000**	-0.00000**
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
log(Employment$_f$)			0.00637***	
			(0.00037)	
log(1+ Age$_f$)			0.00004	
			(0.00028)	
log(% Workforce with a College Degree$_p$)			-0.00091***	
			(0.00023)	
Country FE	yes	yes	yes	no
Input FE	yes	yes	yes	yes
Output FE	no	yes	yes	no
Firm FE	no	no	no	yes
R-squared	0.019	0.037	0.049	0.080
N	250,925	250,925	250,925	250,925

Notes: The dependent variable is *Integration*$_{f,j,i,c}$, a dummy equal to 1 if firm f (producing final product j and located in country c) integrates input i within its boundaries. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the independent suppliers in input industry i located in country c, while *Mean Productivity*$_{i,c}$ is the mean of input suppliers' productivity. *IO*$_{i,j}$ is the IO coefficient capturing the importance of input i in the production of good j. *Employment*$_f$ measures firm employment, *Age*$_f$ is the number of years since the firm's establishment. *% Workforce with a College Degree*$_p$ is the fraction of the workforce with a Bachelor's degree or higher at the plant level. Standard errors clustered at the input level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

4.4 Alternative Mechamisms

Our empirical analysis establishes two main regularities:

1. Firms that delegate more tend to be more vertically integrated.
2. Firms are more likely to integrate "riskier" inputs, i.e. industries in which supplier productivity is more dispersed.

[28] The standard deviation of IO_{ij} is 0.03. Thus, 0.127*0.03*100=0.38

These results are consistent with a model in which integration enhances efficiency and creates a real option for HQ to retain control or delegate according to comparative advantage.

Of course, there could be other explanations for our findings. In particular, the covariation of delegation and integration might be rationalized by models in which headquarters attention is a scarce corporate resource (e.g., Geanakoplos and Milgrom, 1991; Aghion and Tirole, 1995). If vertical integration increases the scope of a firm, HQ may simply need to cede control to lower-level managers. We believe that this mechanism does not provide a rationale for our empirical findings. There are three reasons for this. First, the positive correlation between delegation and integration is robust to controlling for the size of the firm as captured by its total number of employees (columns 3-5 of Table 1). Second, these theories would view delegation and management as substitutes, to the extent that good management reduces headquarters' overload. This would then expect coefficient of the management variable to be negative in column 4 of Table 1, while it is positive and significant. By the same logic, if we control for the quality of management, the partial correlation between delegation and vertical integration should become larger. Instead, we find that the impact of *Vertical Integration*$_f$ on delegation becomes *smaller* once we control for management.[29] Finally, theories of limited managerial attention do not address how input risk could provide a positive incentive to integrate and thus cannot provide an explanation for the results of Table 2.

This last finding might be explained by "supply assurance" theories (e.g., Carlton, 1979; Bolton and Whinston, 1993). In these models, firms integrate in order to assure a stable supply of inputs. Broadly speaking, one would expect less integration when there is less of a risk of suppliers coming up short, whether for technological or behavioral reasons. This might then provide an explanation for the positive coefficient of *CV Productivity*$_{i,c}$ in our regressions. Typically, the assurance motive for integration would be mitigated when there are many suppliers in an input industry. Against this hypothesis, when we focus on input industries in which there are many suppliers, we find that the coefficient of *CV Productivity*$_{i,c}$ remains positive and highly significant (Table A-5). Notice that this is still true in the specification in which we include firm fixed effects, which account for demand for these inputs by other firms in the same country-output sector (column 4). More importantly, supply assurance theories have nothing to say about the interplay between integration and delegation, and thus cannot explain our first empirical regularity.

[29] The difference between the *Vertical Integration*$_f$ coefficients of columns 3 and 4 is significant at the 5% level.

5 Conclusion

Organizations are complicated. Understanding them entails simplification, and a lot has been learned by isolating distinct organizational design elements. But there are costs to isolation. To take a salient example, based on "one-dimensional" organizational models, one might expect non-integration and delegation to covary positively, given that both seem to put decisions as far removed from the "center" as possible.

Yet non-integration and delegation are conceptually distinct. Non-integration is formal, delegation informal.[30] And if there are many types of decisions that must be made, non-integration is at best a blunt, all-or-nothing instrument for achieving "decentralized" decision-making. On the other hand, a manager with considerable authority could fine tune decentralization by delegating some decisions and retaining control over others. In this paper, we develop a simple theoretical model that captures these different dimensions of organizational design and show, theoretically and empirically, that delegation and non-integration are likely to move in *opposite* directions.

Our framework also suggest that, on top of enhancing productive efficiency, integration creates an option value: a producer can delegate key decisions to an integrated supplier, if he turns out to be of high capability, and retain control of these decisions otherwise. Such an option is not available under non-integration wherein the producer is entirely reliant on the supplier's capabilities.

We hope the exercise is an encouraging illustration of what can be learned by bringing together disparate elements of organizational design, as well as datasets rich enough to measure them, within a single framework. Our empirical results show that firms in which central headquarters give more autonomy to their subordinates tend to adopt better management practices. This suggests a complementarity between delegation and management. It would be interesting to exploring the mechanisms behind this complementarity, both theoretically empirically. More broadly, an understanding of how choices of management practices depend on the organizational environment, and how these decisions affect firm performance, is an important avenue for future research.

[30] The law treats delegation and non-integration differently. It regulates and registers asset sales and adjudicates disputes between parties who hold separate titles. Once they are integrated, however, the parties largely forego the intervention of the law in most of their disputes, and via the business judgment rule, are immune to its intervention in many matters, in particular who will make various business decisions.

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Appendix

A-1 Multiple tasks to generate a continuous delegation measure

Without loss of generality, let's set $\alpha = 1$. Suppose that adaptation involves a fixed set T of steps or tasks t. The capability of supplier S on each task is $y + \epsilon_t$, where the ϵ_t are i.i.d. across t and independent of y, with distribution $G(\epsilon)$, density $g(\epsilon)$, and $\mathbb{E}\epsilon = 0$. The ϵ_t as well as the single draw of y are realized and observed before task assignment. We think of the distribution of task-specific capability G as independent of input i, while the overall capability F depends on i as before. HQ always has capability 1.

Centralization yields incremental payoff to HQ of A/T. Delegation adds $(1/T)A(y + \epsilon_t)(1-(s-h)^2)$ to value at cost $(1/T)(1-h)^2$ to HQ, $(1/T)cs^2$ to S. As before $s = 0$ so now delegation of task t yields $(A(y+\epsilon_t))^2/(1+A(y+\epsilon_t))$, provided $y + \epsilon_t > 0$ (there is never delegation if $y+\epsilon_t \leq 0$). In other words, $y+\epsilon_t$ replaces y, and delegation occurs when $y + \epsilon_t > y^*(A)$. Since $y + \epsilon_t$ has distribution given by the convolution

$$C(x) \equiv \int_0^\infty G(x-y)f(y)dy,$$

the centralization probability $C(y^*)$ is increasing in y^*, therefore decreasing in A ($C'(y^*) = \int_0^\infty g(y^*-y)f(y)dy > 0$).) So the probability of delegation $1 - C(y^*)$ is increasing in A.

In this setting, we can derive two continuous delegation measures: the number and the fraction of tasks delegated. Both are binomial r.v.'s with parameters $(1-C(y^*), T)$, stochastically increasing in A.

Of course this formulation modifies the value of integration somewhat. For each task, HQ obtains value

$$v_t = \begin{cases} A, \ y + \epsilon_t \leq 0 \\ \max\{A, \frac{[A(y+\epsilon_t)]^2}{1+A(y+\epsilon_t)}\}, \ y + \epsilon_t > 0. \end{cases}$$

Equivalently, $v_t = A$ for $y \leq y^* - \epsilon_t$, and $\frac{[A(y+\epsilon_t)]^2}{1+A(y+\epsilon_t)}\}$ for $y > y^* - \epsilon_t$. We can reformulate Proposition 2 as follows:

Proposition 3. *The option value of integration in the tasks model increases with A and in the riskiness of $F(y)$.*

Proof. There is integration if

$$\mathbb{E}\frac{1}{T}\sum_t v_t > C(y^*)c - \phi. \tag{12}$$

Since $\mathbb{E}\frac{1}{T}\sum_t v_t = \frac{1}{T}\sum_t \mathbb{E}v_t$, it's enough to show that each term in the second sum is increasing in A to ensure the validity of Proposition 1. Each term is

$$\int_{-\infty}^{\infty} g(\epsilon) \left[\int_0^{y^*-\epsilon} Af(y)dy + \int_{y^*-\epsilon}^{\infty} \frac{[A(y+\epsilon)]^2}{1+A(y+\epsilon)} f(y)dy \right] d\epsilon. \tag{13}$$

Differentiate w.r.t. A to obtain

$$\int_{-\infty}^{\infty} g(\epsilon) \left[F(y^* - \epsilon) + \int_{y^*-\epsilon}^{\infty} \frac{2A(y+\epsilon) + [A(y+\epsilon)]^2}{[1+A(y+\epsilon)]^2} (y+\epsilon) f(y)dy \right] d\epsilon.$$

The term in brackets is always positive since in the region of integration $y + \epsilon > y^* > 0$. Thus the option value is increasing in A as desired.

For riskiness, it is enough that v_t is convex in y for each ϵ. For then increases in riskiness of F raise the value of $\left[\int_0^{y^*-\epsilon} Af(y)dy + \int_{y^*-\epsilon}^{\infty} \frac{[A(y+\epsilon)]^2}{1+A(y+\epsilon)} f(y)dy\right]$, therefore increase expression (13), and consequently the option value. Since v_t is equal to A on $[0, y^* - \epsilon]$ and the strictly convex function $[A(y + \epsilon)]^2/[1 + A(y + \epsilon)]$ on $(y^* - \epsilon, \infty)$, convexity of v_t is assured. 

The issue of the effect of riskiness on the cost of integration provides similar to challenges to those in the baseline model. Note, however, that a sufficient condition for the integration cost to fall with risk is that G has a decreasing density: then $G(y^* - y)$ is concave in y, and riskier F distributions therefore reduce the probability of centralization.

A-2 Descriptive Statistics

Table A-1
Descriptive Statistics of Matched Sample

	Mean	Median	Standard deviation	N. observations	N. firms
Delegation$_p$	0.13	0.07	0.99	3,444	2,661
% Workers with College Degree$_p$	15.20	10.00	16.34	3,225	2,661
Management$_p$	3.053	3.056	0.651	3,444	2,661
Targets$_p$	2.828	2.833	0.667	3,444	2,661
Incentives$_p$	3.016	3	0.772	3,444	2,661
Operations$_p$	3.007	3	1.062	3,443	2,661
Monitoring$_p$	3.376	3.4	0.774	3,444	2,661
Employment$_f$	674.89	300.00	1,043.32	3,444	2,661
Age$_f$	40.08	30.00	35.02	3,443	2,661
Vertical Integration$_f$	0.10	0.08	0.08	3,444	2,661
Integration$_{f,i}$	0.01	0	0.12	251,992	2,661
Mean Productivity$_{i,c}$	996	279	67,085	251,992	2,661
CV Productivity$_{i,c}$	3.58	2.02	6.11	251,992	2,661
IO$_{i,j}$	0.04	0.04	0.03	251,992	2,661

Table A-2

Observations by Country

Country	Number of Observations	Percentage
Argentina	100	2.90
Australia	133	3.86
Brazil	234	6.79
Canada	207	6.01
Chile	95	2.76
China	64	1.86
France	212	6.16
Germany	224	6.50
Greece	104	3.02
India	104	3.02
Italy	106	3.08
Ireland	75	2.18
Japan	102	2.96
Mexico	86	2.50
New Zealand	118	3.43
Poland	27	0.78
Portugal	78	2.26
Sweden	330	9.58
United Kingdom	432	12.54
United States	613	17.80

Figure A-1: Survey on Delegation

For Questions D1, D3, and D4 any score can be given, but the scoring guide is only provided for scores of 1, 3, and 5.

Question D1: "*To hire a FULL-TIME PERMANENT SHOPFLOOR worker what agreement would your plant need from CHQ (Central Head Quarters)?*"

Probe until you can accurately score the question—for example if they say "*It is my decision, but I need sign-off from corporate HQ.*" ask "*How often would sign-off be given?*"

	Score 1	Score 3	Score 5
Scoring grid:	No authority—even for replacement hires	Requires sign-off from CHQ based on the business case. Typically agreed (i.e. about 80% or 90% of the time).	Complete authority—it is my decision entirely

Question D2: "*What is the largest CAPITAL INVESTMENT your plant could make without prior authorization from CHQ?*"

Notes: (a) Ignore form-filling

(b) Please cross check any zero response by asking "*What about buying a new computer—would that be possible?*" and then probe….

(c) Challenge any very large numbers (e.g. >$¼m in US) by asking "*To confirm your plant could spend $X on a new piece of equipment without prior clearance from CHQ?*"

(d) Use the national currency and do not omit zeros (i.e. for a U.S. firm twenty thousand dollars would be 20000).

Question D3: "*Where are decisions taken on new product introductions—at the plant, at the CHQ or both*"?

Probe until you can accurately score the question—for example if they say "*It is complex, we both play a role*," ask "*Could you talk me through the process for a recent product innovation?*"

	Score 1	Score 3	Score 5
Scoring grid:	All new product introduction decisions are taken at the CHQ	New product introductions are jointly determined by the plant and CHQ	All new product introduction decisions taken at the plant level

Question D4: "*How much of sales and marketing is carried out at the plant level (rather than at the CHQ)*"?

Probe until you can accurately score the question. Also take an average score for sales and marketing if they are taken at different levels.

	Score 1	Score 3	Score 5
Scoring grid:	None—sales and marketing is all run by CHQ	Sales and marketing decisions are split between the plant and CHQ	The plant runs all sales and marketing

Question D5: "*Is the CHQ on the site being interviewed*"?

Notes: The electronic survey, training materials and survey video footage are available on www.worldmanagementsurvey.com

Figure A-2: Management Practices

Categories	*Score from 1–5 based on:*
1) Introduction of modern manufacturing techniques	What aspects of manufacturing have been formally introduced, including just-in-time delivery from suppliers, autonomation, flexible manpower, support systems, attitudes, and behavior?
2) Rationale for introduction of modern manufacturing techniques	Were modern manufacturing techniques adopted just because others were using them, or are they linked to meeting business objectives like reducing costs and improving quality?
3) Process problem documentation	Are process improvements made only when problems arise, or are they actively sought out for continuous improvement as part of a normal business process?
4) Performance tracking	Is tracking ad hoc and incomplete, or is performance continually tracked and communicated to all staff?
5) Performance review	Is performance reviewed infrequently and only on a success/failure scale, or is performance reviewed continually with an expectation of continuous improvement?
6) Performance dialogue	In review/performance conversations, to what extent is the purpose, data, agenda, and follow-up steps (like coaching) clear to all parties?
7) Consequence management	To what extent does failure to achieve agreed objectives carry consequences, which can include retraining or reassignment to other jobs?
8) Target balance	Are the goals exclusively financial, or is there a balance of financial and nonfinancial targets?
9) Target interconnection	Are goals based on accounting value, or are they based on shareholder value in a way that works through business units and ultimately is connected to individual performance expectations?
10) Target time horizon	Does top management focus mainly on the short term, or does it visualize short-term targets as a "staircase" toward the main focus on long-term goals?
11) Targets are stretching	Are goals too easy to achieve, especially for some "sacred cows" areas of the firm, or are goals demanding but attainable for all parts of the firm?
12) Performance clarity	Are performance measures ill-defined, poorly understood, and private, or are they well-defined, clearly communicated, and made public?
13) Managing human capital	To what extent are senior managers evaluated and held accountable for attracting, retaining, and developing talent throughout the organization?
14) Rewarding high performance	To what extent are people in the firm rewarded equally irrespective of performance level, or are rewards related to performance and effort?
15) Removing poor performers	Are poor performers rarely removed, or are they retrained and/or moved into different roles or out of the company as soon as the weakness is identified?
16) Promoting high performers	Are people promoted mainly on the basis of tenure, or does the firm actively identify, develop, and promote its top performers?
17) Attracting human capital	Do competitors offer stronger reasons for talented people to join their companies, or does a firm provide a wide range of reasons to encourage talented people to join?
18) Retaining human capital	Does the firm do relatively little to retain top talent or do whatever it takes to retain top talent when they look likely to leave?

A-3 Robustness Checks

Table A-3

Delegation and Vertical Integration (4-digits SIC Industry FE)

	(1)	(2)	(3)	(4)	(5)
Vertical Integration$_f$	0.725***	0.792***	0.740**	0.691**	0.675**
	-0.277	-0.305	-0.306	-0.303	-0.304
log(Employment$_f$)			-0.089*	-0.079	-0.083
			-0.051	-0.052	-0.052
log(Age$_f$)			0.041	0.037	0.038
			-0.025	-0.025	-0.025
log(% Workforce with a College Degree$_p$)			0.061***	0.044**	0.043**
			-0.02	-0.02	-0.02
Management$_p$				0.124***	
				-0.024	
Operations$_p$					-0.008
					-0.029
Monitoring$_p$					0.002
					-0.035
Targets$_p$					0.083*
					-0.044
Incentives$_p$					0.125***
Country FE	Yes	Yes	Yes	Yes	Yes
Output FE	No	Yes	Yes	Yes	Yes
Input FE	Yes	Yes	Yes	Yes	Yes
R-squared	0.206	0.215	0.22	0.229	0.23
N	3444	3072	3072	3072	3071

Notes: The dependent variable, *Delegation*$_{f,p}$, is the overall autonomy index of plant p (belonging to firm f). *Vertical integration*$_f$ is the vertical integration index of firm f. *Employment*$_f$ measures the firm's employment, *Age*$_f$ is the number of years since its establishment, *% Workforce with a College Degree*$_p$ is the percentage of the plant's employees with a bachelor's degree or higher. *Management*$_p$ is the normalized z-score capturing the quality of the plant's management practices. Output and input fixed effects are respectively the primary activities of the parent and of the plant (defined at 4-digits SIC). Standard errors clustered at the firm level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

Table A-4

Delegation and Vertical Integration (Single-plant Firms)

	(1)	(2)	(3)	(4)
Vertical Integration$_f$	1.010**	1.016**	1.002**	0.983**
	(0.447)	(0.445)	(0.434)	(0.440)
log(Employment$_f$)		-0.099	-0.087	-0.090
		(0.066)	(0.066)	(0.066)
log(Age$_f$)		0.000	0.010	0.011
		(0.036)	(0.036)	(0.036)
log(% Workforce with a College Degree$_p$)		0.068***	0.046*	0.046*
		(0.025)	(0.025)	(0.025)
Management$_p$			0.132***	
			(0.031)	
Operations$_p$				-0.007
				(0.035)
Monitoring$_p$				0.067
				(0.047)
Targets$_p$				0.043
				(0.052)
Incentives$_p$				0.112**
				(0.056)
R-squared	0.204	0.210	0.222	0.222
N	1,480	1,480	1,480	1,480
Country FE	Yes	Yes	Yes	Yes
Output FE	No	Yes	Yes	Yes
Input FE	Yes	Yes	Yes	Yes

Notes: The dependent variable, *Delegation*$_p$, is the overall autonomy index of plant p (belonging to firm f). *Vertical integration*$_f$ is the vertical integration index of firm f. *Employment*$_f$ measures the firm's employment, *Age*$_f$ is the number of years since its establishment, *% Workforce with a College Degree*$_p$ is the percentage of the plan't employees with a bachelor's degree or higher. *Management*$_p$ is the normalized z-score capturing the quality of the plant's management practices. Output and input fixed effects are respectively the primary activities of the parent and of the plant (defined at 3-digits SIC). Standard errors clustered at the firm level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

Table A-5

Option Value of Integration (50+ Suppliers per Input Sector)

	(1)	(2)	(3)	(4)
CV Productivity$_{i,c}$	0.00056***	0.00054***	0.00054***	0.00052***
	(0.00012)	(0.00011)	(0.00011)	(0.00012)
Mean Productivity$_{i,c}$	-0.00000**	-0.00000*	-0.00000**	-0.00000*
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
log(Employment$_f$)			0.00765***	
			(0.00045)	
log(1+Age$_f$)			0.00003	
			(0.00035)	
log(% Workforce with a College Degree$_p$)			-0.00106***	
			(0.00030)	
Country FE	yes	yes	yes	no
Input FE	yes	yes	yes	yes
Output FE	no	yes	yes	no
Firm FE	no	no	no	yes
R-squared	0.022	0.043	0.057	0.097
N	178,609	178,609	178,609	178,609

Notes: The dependent variable is *Integration*$_{f,j,i,c}$, a dummy equal to 1 if firm f (producing final product j and located in country c) integrates input i within its boundaries. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the independent suppliers in input industry i located in country c, while *Mean Productivity*$_{i,c}$ is the mean of input suppliers' productivity. *Employment*$_f$ measures firm employment, *Age*$_f$ is the number of years since the firm's establishment. *% Workforce with a College Degree*$_p$ is the fraction of the workforce with a Bachelor's degree or higher at the plant level Standard errors clustered at the input level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

Table A-6

Option Value of Integration (WorldBase Sample)

	(1)	(2)	(3)	(4)
CV Productivity$_{i,c}$	0.00073***	0.00073***	0.00073***	0.00073***
	(0.00012)	(0.00012)	(0.00012)	(0.00012)
Mean Productivity$_{i,c}$	-0.00000	-0.00000	-0.00000	-0.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
log(Employment$_f$)			0.00146***	
			(0.00012)	
log(1+Age$_f$)			0.00018	
			(0.00011)	
Country FE	yes	yes	yes	no
Input FE	yes	yes	yes	yes
Output FE	no	yes	yes	no
Firm FE	no	no	no	yes
R-squared	0.023	0.023	0.024	0.017
N	6,658,070	6,658,070	6,658,070	6,658,070

Notes: The dependent variable is *Integration*$_{f,j,i,c}$, a dummy equal to 1 if firm f (producing final product j and located in country c) integrates input i within its boundaries. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the independent suppliers in input industry i located in country c, while *Mean Productivity*$_{i,c}$ is the mean of input suppliers' productivity. *Employment*$_f$ measures firm employment, *Age*$_f$ is the number of years since the firm's establishment. Standard errors clustered at the input level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

Table A-7

Option Value of Integration
(WorldBase Sample, Single-Plant Firms)

	(1)	(2)	(3)	(4)
CV Productivity$_{i,c}$	0.00069***	0.00068***	0.00068***	0.00068***
	(0.00012)	(0.00012)	(0.00012)	(0.00012)
Mean Productivity$_{i,c}$	-0.00000	-0.00000	-0.00000	-0.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
log(Employment$_f$)			0.00011	
			(0.00010)	
log(1+Age$_f$)			0.00015	
			(0.00012)	
Country FE	yes	yes	yes	no
Input FE	yes	yes	yes	yes
Output FE	no	yes	yes	no
Firm FE	no	no	no	yes
R-squared	0.024	0.024	0.024	0.017
N	6,039,596	6,039,596	6,039,596	6,039,596

Notes: The dependent variable is *Integration*$_{f,j,c,i}$, a dummy equal to 1 if firm f (producing final product j and located in country c) integrates input i within its boundaries. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the independent suppliers in input industry i located in country c, while *Mean Productivity*$_{i,c}$ is the mean of input suppliers' productivity. *Employment*$_f$ measures firm employment, *Age*$_f$ is the number of years since the firm's establishment. Standard errors clustered at the input level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.