All Together Now: Integration, Delegation and Management*

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Abstract

Little is known theoretically, and even less empirically, about the relationship among firm boundary choices, the allocation of decision rights within firms, and their impact on managers' ability to affect firm performance. We develop a model in which firms choose which suppliers to integrate, whether to delegate decisions to integrated suppliers or keep them centralized, and the quality of management. We test the predictions of this model using a matched dataset that combines measures of vertical integration, delegation, and management practices 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, that this effect vanishes once management is controlled for, and that suppliers from sectors with greater productivity variation are more likely to be integrated with their downstream customers.

Keywords: Firm boundaries, decentralization, authority, productivity, real options.

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1 Introduction

There is a paradoxical contrast between the way organization and management 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. And abstracting from these elements of organizational design, there is a more recent strand focusing on management practices, systematically measuring them and assessing their impact on economic performance (e.g. Bloom and Van Reenen, 2007; Bloom, Eifert, Mahajan, McKenzie, and Roberts, 2013).

Despite these intellectual divides, decisions over integration, delegation, and management practices are clearly interdependent. Firm boundaries define where 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. An ideal allocation of control may be of little value if it is not managed with appropriate targets and oversight. 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] And although there has been a trickle of theoretical papers that considers pairs of organizational design elements together, there is little empirical work along those lines, and even less on either front that consider more complex interactions (we discuss the literature below). 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

[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).

Reenen, 2012, 2015) it is becoming ever more compelling to understand the functioning of organizations as a whole rather than just their parts.

In this paper, we bring the integration, delegation, and management streams together, both theoretically and empirically. We first operationalize and extend the theoretical framework developed in Legros and Newman (2015) 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 firm-level information on vertical integration (based on Alfaro, Conconi, Fadinger and Newman, 2016), delegation (based on Bloom, Sadun and Van Reenen, 2012) and management practices (based on Bloom, Sadun and Van Reenen, 2014). To the best of our knowledge, data of this type have not been combined before, at least for a sample with thousands of firms covering multiple industries and countries.

In our model, management practices, firm boundaries and the internal allocation of control, are all endogenous, the results of optimizing behavior. A final good producer first chooses which of its suppliers to integrate, and how much to invest in management practices. Once the integration choices are made, he can also decide whether and to which of the integrated suppliers to delegate decision making (for non-integrated suppliers, there is there is little question of delegation: the supplier retains the control as part of his bundle of ownership rights). An intermediate good (e.g. a car part like a seat), is more valuable if it is adapted or customized to the final product (e.g. the car seats for a Mercedes are different than for a Prius), 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 his supplier.[2]

The final good producer is *ex-ante* uncertain about the ability of suppliers to customize inputs to his production needs. The supplier may have a comparative advantage in customization, something that is learned *after* the integration decision has been made. Thus, integrating suppliers has an *option value*, because among the rights of ownership acquired by the final goods producer under integration is the authority to choose whether to delegate adaptation decisions to a supplier or instead to keep complete control.[3]

[2]The view of integration embodied by the model is similar to that of Williamson (1975), and puts it in the "ex-post non-contractible" branch of incomplete-contracts economics (e.g., the 2002 version of Hart-Holmström, 2010; Aghion-Dewatripont-Rey, 2002; Legros-Newman, 2013, or Dessein, 2014): integration is productivity-enhancing, but privately costly.

[3]The model thus shares with Baker, Gibbons and Murphy (1999) the view that delegation is an informal means

Management practices affect the performance of input suppliers. Management is costly, but is productivity-enhancing regardless of the authority structure in which it is conducted. But since it partly involves getting the most out of self-interested agents, it is more valuable under integration, where there is scope for extracting more than perfunctory performance, than under non-integration. And within integrated relationships, the return to management is increasing in the amount of discretion the agent has. Thus management is increasingly valuable as one moves from non-integration to centralization to delegation.

The model produces several intuitive predictions. First, integration, delegation, and management practices all covary positively. This is because final good manufacturers that have high value or "productivity" (the exogenous primitive of the model, capturing entrepreneurial ability or product appeal) are able to provide relatively more surplus in an integrated relationship with a supplier and will therefore integrate more suppliers. Higher productivity also gives a greater incentive to invest in management, but since management in turn makes delegation more productive, this implies more delegation. In other words, management, delegation and integration are complements. Note that the causality flows here from productivity to integration, delegation and management.

A second prediction is that the positive relationship between delegation and integration is mediated through management. Hence, conditional on the management practices, there should be no systematic relationship between integration and delegation. This sharp result is driven by the fact that the correlation between integration and productivity is direct, whereas the relationship between delegation and integration is indirect, working through the incentive to invest in management.

A third prediction of our model is that final good producers should be more likely to integrate "riskier" input industries, in which supplier productivity is more dispersed. 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 customization, the more valuable the option becomes.

We show that the three sets of predictions of the theoretical model are remarkably consistent with the features of the novel firm-level dataset we have put together. They hold up in our baseline regressions and in a series of robustness checks (e.g. including different sets of controls and using different samples of firms). 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 allocating control to a supplier, in contrast to asset divestiture (non-integration), which is formal.

of organizational design that were previously considered separately may fit together in theory and practice.

Related Literature

Our work is related to three 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, 2013; Conconi, Legros and Newman, 2012). 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, 2015).

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 Gertler (2010). On the empirical side, important contributions include Acemoglu, Aghion, Lelarge, Van Reenen, and Zilibotti (2007), Guadalupe and Wulf (2011), Bloom, Garicano, Sadun and Van Reenen (2014) and Bloom, Sadun and Van Reenen (2012).

Work on management practices includes Woodward (1958), Bloom and Van Reenen (2007), Gibbons and Roberts (2013), Bloom, Eifert, Mahajan, McKenzie, and Roberts (2013), and Bloom, Sadun and Van Reenen (2016).

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 (1994); boundaries and incentive schemes, based on the HM91 multi task model – so there is no choice of reallocating control/tasks in the pure version of the model 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, only one – Hart and Holmström (2010) – considers delegation and firm boundaries together; none bring those elements together with management practices.

Legros and Newman (2015) also studies a "three-dimensional" model of firm boundaries and delegation, integrating them with profit sharing schemes rather than management practices.

Finally, our empirical strategy is closely related to the analysis in Holmström and Milgrom (1994) on empirical implications of complementarity among organizational design elements in cross-sectional data.

The structure of the paper is as follows. Section 2 presents the theory, Section 3 the data and Section 4 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

We consider industries in which production of the final good requires the use of a large finite number of inputs indexed by $i \in N \equiv \{1, \cdots, n\}$. An "enterprise" is the union of the set of suppliers together with the final-good producer (whereas a "firm" is a set of suppliers that are integrated together with a common final good producer). All participants are risk-neutral. The final-good producer (HQ) will make all organizational decisions. First she chooses which input suppliers to integrate and what type of management practice to put in place in the enterprise. Next, after observing their comparative advantage, HQ decides to which of its integrated suppliers it will cede control (delegate) and over which it will retain control (centralize) of customization decisions.

The final good producer in sector j has "productivity" $A_j \geq 0$, capturing the exogenous value of the enterprise (e.g. entrepreneurial ability, product coolness, or demand/price). The production function is additive and one unit of each input is required for obtaining one unit of output. The contribution to enterprise value of input i is $\pi_i \in (0, 1)$, which will depend on not only on technology, but also on management and organization. Total output is

$$A_j \sum_{i=1}^{n} \pi_i.$$

The final output is observable, but not the contributions of individual suppliers.

2.1 Management and Organizational Design

Management practices are mult-faceted. Some involve techniques for streamlining the production process, for improving logistics, for bringing inputs to the production line, or for

dealing with inventory. Let us call this the "technological role" of management. But management also has significant "human" dimensions, involving techniques to monitor or motivate workers and suppliers, putting bounds on their discretion; this aspect is likely to be especially crucial in the presence of agency problems or incomplete contracting.The technological role is likely to affect all inputs, whether they are integrated or not. By contrast, the human role of management is more likely to affect integrated suppliers, who are under HQ's authority.

We will assume (our Assumptions 1 and 2 below) that the sensitivity of input performance to management is more pronounced when it is more important to ensure that the supplier behaves in HQ's interest. Hence, the sensitivity to management is greater under delegation — when the supplier has discretion — than under centralization — when the supplier is instructed on what to do and therefore has a relatively limited set of choices. On the other hand, with non-integration, where HQ has no authority to implement monitoring functions or where firing threats would have the least bite, essentially only the technological role of management would be at play and the marginal benefit of overall management is therefore smallest.

Adaptation and Management

A supplier i can produce a generic input or adapt it to the production of a final good j. Adaptation of input i entails a non-contractible cost $\phi_i > 0$ borne by the supplier. The ability of a supplier of input i to adapt the input is y_i, which is drawn from a distribution $G_i(y)$ with support $[0, 1]$. We assume that the random variables y_i $(i = 1, \cdots, n)$ are independently distributed. For each supplier i, the distribution G_i is common knowledge, but the value of y_i is realized only after the adaptation process gets started, at which time it is revealed to the final good producer as well as the supplier.[4]

HQ designs the organization that maximizes the total surplus of the enterprise, including expected revenue, private adaptation costs, and costs of management.[5] He first chooses which input suppliers to integrate and what type of management practices to put in place in

[4]Several interpretations are possible. First, the information is revealed only as the adaptation process itself begins, but since there is no authority to enforce adaptation under non-integration, there is no information revelation in that case. Second, the information *is* revealed for nonintegrated suppliers as well, though is itself non-verifiable (so contracting on it is not possible); but since authority to induce the supplier to adapt is still missing, HQ cannot do anything with the information, so it has no value. And third, as a general matter, integration provides the owner with the right to impose non-contractible forms of monitoring, which therefore results in better information under integration than non-integration.

[5]Maximizing total surplus is equivalent to maximizing HQ's payoff subject to the participation constraints of the suppliers, under the assumption that all participants have sufficient liquidity to make ex-ante side payments; in most instances, HQ would be making the transfers to the suppliers.

the enterprise. Next, after observing their comparative advantage, he decides to which suppliers it will delegate the adaptation decisions; HQ retains control over adaptation for the remaining suppliers it owns. And of course, suppliers that are non-integrated retain control over adaptation, since they are effectively out of his jurisdiction.

Before supplier abilities $\{y_i\}$ are realized, the final good producer (HQ) chooses a management practice $M \in [0, \overline{M}]$ at cost $c(M)$. For simplicity we view this choice as common to all suppliers. Little would change qualitatively in our model, particularly with respect to implications that are testable with our data, if HQ could tailor management decisions individually to each of its suppliers, as long as this tailoring occurs before the $\{y_i\}$ realizations. The cost function $c(M)$ is differentiable and strictly increasing with $c(0) = 0$.[6]

Management practices facilitate adaptation and improve performance. We will assume a multiplicative effect of management on performance. If HQ uses a generic input, its performance is $\pi_i = \nu(M)\underline{\pi}_i$, where $1 > \underline{\pi}_i \geq 0$. If HQ integrates supplier i and centralizes the adaptation decision, the performance is $\pi_i = \sigma(M)\overline{\pi}_i$, where $1 > \overline{\pi}_i \geq \underline{\pi}_i$. Finally, if HQ delegates the adaptation decision to the integrated supplier, the performance is $\pi_i = \delta(M)y_i$. The functions $\nu(\cdot), \sigma(\cdot), \delta(\cdot)$ are increasing and concave in M, differentiable, and assume values in $[0, 1]$.[7] To ensure interior solutions, assume that $c(\cdot)$ or the three management functions $\nu(\cdot), \sigma(\cdot), \delta(\cdot)$ satisfy the standard Inada conditions.

As suggested above, it is natural to assume that this human role of management is less important for suppliers producing generic inputs, who need not (or cannot) be induced to bear the cost ϕ_i, than for integrated suppliers, who will be tailoring the inputs to the specific needs of the final good producer under her direction.

Assumption 1. *(a)* $\sigma'(M) > \nu'(M)$ *for all* $M > 0$ *and (b)* $\sigma(0) \geq \nu(0)$.

In light of the discussion of management practices at the beginning of this section, we assume performance is more *management elastic* under delegation than under centralization: $\frac{M\sigma'(M)}{\sigma(M)} < \frac{M\delta'(M)}{\delta(M)}$ (in other words, supplier performance is log-supermodular in management and delegation). Equivalently,

Assumption 2. *The ratio* $\frac{\sigma(M)}{\delta(M)}$ *is a strictly decreasing function of* M.

Some direct evidence for this assumption is discussed in Appendix A-3.

[6] We have also considered a version of the model in which HQ can choose management M_i *after* observing the realization of y_i. As discussed in Section 4, this variant makes nearly the same predictions *except* that it has trouble providing a rationale for one of our key empirical findings: the correlation between delegation and vertical integration is entirely explained by a firm's management practices.

[7] In this section, we use "increasing" in its weak sense and apply the modifier "strictly" where appropriate.

Note that Assumption 2 implies neither that $\sigma'(M) < \delta'(M)$ nor that $\sigma(M) < \delta(M)$. The last two conditions would be implied by imposing $\sigma(0) \leq \delta(0)$ in addition to Assumption 2, but this seems to be a strong requirement: indeed, without enough management, giving control to a subordinate, even a very capable one, may well be a recipe for disaster.[8] To avoid trivialities, however, we shall require $\delta(\overline{M}) > \sigma(\overline{M})$.

Firm Boundaries and Delegation

Simultaneous with the M decision, HQ chooses a subset $I \subseteq N$ of suppliers to integrate by purchasing their non-human assets. There are no financial frictions (specifically, cash endowments are sufficiently large for all parties to make any compensatory transfers at the integration stage). Along with risk neutrality of all parties, this allows us to consider only total-surplus-maximizing integration, delegation, and management decisions. We now describe the implications for supplier performance of being within (integrated) or outside (non-integrated) firm boundaries.

Under non-integration, HQ has no authority (and no other contractible means) to ensure that the supplier adapts, so HQ has to buy the generic input.[9] Nevertheless, since the management practices chosen by HQ may improve performance of generic inputs, non-integrated supplier i will contribute $\nu(M)\underline{\pi}_i$ to the enterprise surplus.

HQ now has authority over the integrated suppliers and can impose at least the initial steps of adaptation. Once y_i is realized, HQ can further choose to centralize and direct the final steps or delegate them to supplier of the input.

We assume that the integrated supplier's bears the same adaptation cost ϕ_i under centralization and delegation. Our results are unchanged if we assume a small difference in private costs under delegation and centralization.

Figure 1 summarizes the sequence of events and the output generated by different organizational choices for the relationship between HQ and a typical supplier $i \in \{1, \ldots, n\}$. Of course, HQ has a similar decision tree for every supplier.

[8] In a similar vein, Dessein, Garicano and Gertler (2010) shows, in a model of imperfect communication, that when the incentive problem is important, centralization may be chosen over delegation even if the agent has superior information.

[9] While input i contributes in expectation π_i to the final output, only the final output is observed and deviations from π_i are not observable. This makes incentive contracts for non-integrated suppliers that are based on aggregate output low power if n is large and will be ignored.

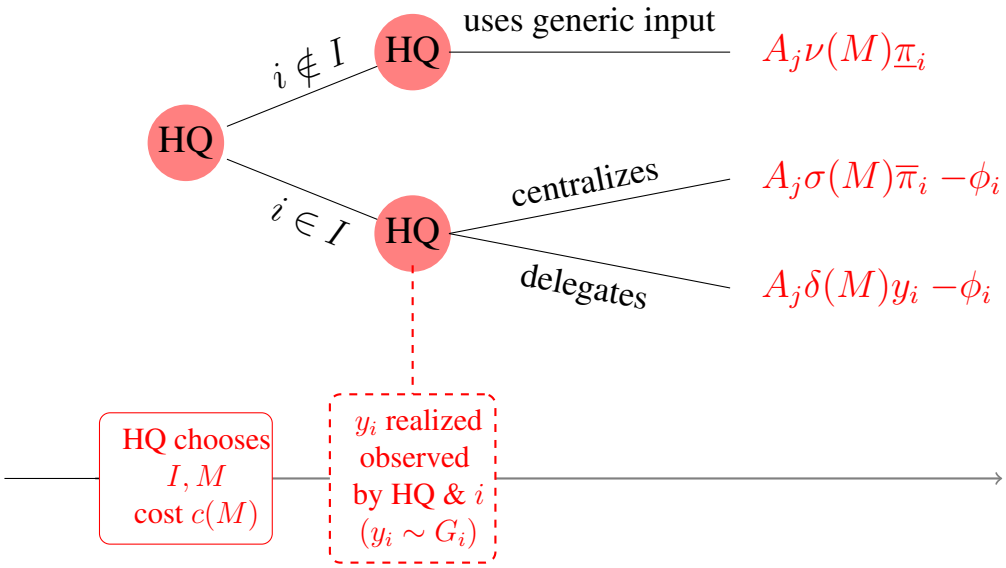


Figure 1: Timing

2.2 Main Results on Organizational Design

Delegation and Management

Consider an integrated supplier i with realization y_i. HQ prefers to delegate to i if the expected contribution is larger when the supplier decides than when HQ decides, that is when $\delta(M)y_i \geq \sigma(M)\overline{\pi}_i$.[10]

The probability of delegation is therefore equal to $1 - G_i\left(\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\right)$, which from Assumption 2 is increasing in M. Since $\delta(\overline{M}) > \sigma(\overline{M})$, for each i, there is $M_i < \overline{M}$ (possibly zero) such that $\frac{\sigma(M)\overline{\pi}_i}{\delta(M)} < 1$ if and only if $M > M_i$, i.e., the probability that HQ delegates is positive above M_i and zero below M_i.

The number of suppliers to whom decisions are delegated is a random variable with a Poisson-binomial distribution of order $|I|$ ($|S|$ denotes the number of elements of a set S):

$$D_I \equiv \left| \left\{ i \in I | y_i \geq \frac{\sigma(M)\overline{\pi}_i}{\delta(M)} \right\} \right|. \tag{1}$$

[10] Since the integrated supplier's cost is assumed to be the same regardless of who makes the adaptation decision, the decision whether to delegate will always be efficient. In a more general formulation with a difference in costs, it is natural to suppose that HQ makes the delegation decision without internalizing the supplier's cost, and therefore uses the same decision rule; the supplier is compensated ex-ante for the expected cost whenever he is integrated.

Our empirical measure of delegation proxies for realized values of D_I; the expected value D of D_I is just the sum of the delegation probabilities over all integrated suppliers. Thus, as management increases, the level of delegation increases on average.

Proposition 1. *Under Assumption 2, the expected level of delegation D increases with better management practices M.*

Integration, Delegation, and Management

Expected output from integrating supplier i is $A_j q_i(M)$ where

$$\begin{aligned} q_i(M) \equiv\ & E_i \max\{\sigma(M)\overline{\pi}_i, \delta(M) y_i\} \\ & = \sigma(M)\overline{\pi}_i G_i\left(\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\right) + \int_{y_i \geq \frac{\sigma(M)\overline{\pi}_i}{\delta(M)}} \delta(M) y_i dG_i(y_i). \end{aligned}$$

This function is the payoff of a real option created by integration, namely the option to delegate. This value is strictly increasing in M because $q_i(M)$ is strictly increasing (since $\sigma(M)$ and $\delta(M)$ are), and its integrand is convex in y_i. The monotonicity of the option value with respect to management will play a crucial role in the analysis. Furthermore, the marginal value of management under integration exceeds that under non-integration (proof in Appendix):

Lemma 1. *Under Assumptions 1 and 2, the marginal value of management under integration exceeds that under non-integration: $q_i'(M) > \nu'(M)\underline{\pi}_i$.*

HQ chooses (I, M) to maximize the total surplus of the enterprise, that is the sum of the surpluses obtained from integrated suppliers $i \in I$ and the surpluses from non-integrated suppliers $i \notin I$, less the cost $c(M)$ of the management practice M:

$$W(I, M; A_j) = \sum_{i \in I} (A_j q_i(M) - \phi_i) + \sum_{i \notin I} A_j \nu(M)\underline{\pi}_i - c(M),$$

A first observation is that there are complementarities in I, M, A_j. Specifically, $W(I, M; A_j)$ is supermodular in the choices (I, M), and there are (strictly) increasing differences in $(A_j, (I, M))$. This becomes apparent when rewriting the surplus function as

$$\begin{aligned} W(I, M; A_j) = A_j \sum_{i \in I} & (q_i(M) - \nu(M)\underline{\pi}_i) \\ & + A_j \sum_{i=1}^{n} \nu(M)\underline{\pi}_i - \sum_{i \in I} \phi_i - c(M). \end{aligned} \tag{2}$$

Supermodularity in (I, M) depends only on the first term, $A_j \sum_{i \in I}(q_i(M) - \nu(M)\underline{\pi}_i)$, and is a consequence of the fact that integrated production units have higher marginal values of management than non-integrated units (Lemma 1). Increasing differences in (A_j, M) is also a consequence of this lemma and of the non-negative marginal value of management over non-integrated units. Increasing differences in (A_j, I) follows from Assumptions 1 and 2, which imply that integration output is larger than non-integration output, so that increases in A_j are more valuable under integration.

It follows that the solution $(I(A_j), M(A_j))$, is increasing in A_j.[11] Higher enterprise value not only results in better management, but in a (weakly) larger set of integrated suppliers. One way we will measure integration empirically sums the input-output contribution of each of the inputs that are produced inside the firm. This proxies for $\sum_{i \in I(A_j)} \underline{\pi}_i$ or for $\sum_{i \in I(A_j)} q_i(M(A_j))$, both of which are increasing A_j. Details of the proof are in the Appendix.

Lemma 2. *More productive enterprises are more integrated and use better management practices.*

In Lemma 2, it is productivity that determines the choices of management and integration. Hence, the covariation of integration and management practice is indirect, i.e., not to be interpreted as causal. Proposition 1 on the other hand establishes a direct link between the management practice and the expected level of delegation for a given level of integration. Since the expected level of delegation also increases in the number of integrated suppliers, combining the two results, we obtain a positive covariation between integration and delegation.

However, this covariation finds its source in the endogenous choice of the management practices. Thus, if we keep M fixed, then since both are determined by A, the set of integrated suppliers I should also be fixed and (trivially) uncorrelated with the (random) level of delegation D_I.

Proposition 2. *(i) Under Assumptions 1 and 2, there is a positive covariation between integration and delegation.*

(ii) If M is fixed, there is no covariation between integration and delegation.

The variation in delegation is driven entirely by variation in M, while integration is directly influenced by A_j. Thus the second part of this proposition implies that, if we control

[11] While $M(A_j)$ is strictly increasing, the set of integrated suppliers may not strictly increase when A increases by a small amount because of discreteness.

for M in the empirical analysis, the covariation of integration and delegation should vanish.

2.3 Unpacking Management

As discussed in Section 3.3, firms adopt different types of management practices. Some are more "human," related to the management of personnel, while others are more "technical," related to the firm's operations. And as discussed at the beginning of this section, we should expect the human aspects to be more sensitive in terms of productive performance to the organizational environment in which they are applied.

To capture the effects of different practices, suppose that management has two components (the extension to more than two is straightforward), a human one (M_H) and a technical one (M_T). Management functions are now $\sigma(M_T, M_H)$, $\delta(M_T, M_H)$, both supermodular, with centralization and delegation equally M_T-elastic, but delegation more M_H-elastic, as before. The non-integration productivity $\nu(M_T, M_H)$ is also supermodular, while the cost $c(M_T, M_H)$ is submodular.[12]

In this setting, our results will only apply to the human component of management. Thus M_H and delegation will co-vary as before, while M_T and delegation will not. Moreover, controlling for M_T could preserve co-variation of integration and delegation, while controlling for M_H would eliminate it.

2.4 Riskiness of Suppliers

The mechanism driving the co-variation in integration and delegation in Proposition 2 also implies that integration should have an option value. In what follows, we derive an additional theoretical result, which we can bring to the data to verify the validity of this mechanism.

From the point of view of final good producer j, the valuation of the option value of integration depends on the riskiness of the supplier, that is on the properties of the distribution $G_i(y_i)$. To highlight this, assume that suppliers have the same potential productivities ($\overline{\pi}$ and $\underline{\pi}$), the same private cost of adaptation, and that the distributions functions G_i have common mean.[13] However, suppliers differ in terms of their distributions G_i.

Assumption 3. *For all suppliers i, $\underline{\pi}_i = \underline{\pi}$, $\overline{\pi}_i = \overline{\pi}$, $\phi_i = \phi$, and $E_i y_i = \overline{y}$.*

[12] Assumption 1(a) is modified to $\sigma_{M_T}(M_T, M_H) \geq \nu_{M_T}(M_T, M_H)$ and $\sigma_{M_H}(M_T, M_H) > \nu_{M_H}(M_T, M_H)$; 1(b) now requires $\sigma(0, M_H) \geq \nu(0, M_H)$ and $\sigma(M_T, 0) \geq \nu(M_T, 0)$.

[13] In the empirical analysis, we will control for input-output coefficients and proxies for the mean of the G_i.

The surplus from integrating a supplier is equal to $A_j(q_i(M) - \nu(M)\underline{\pi}) - \phi$, and, for M given, this value increases whenever $q_i(M) = E_i \max\{\sigma(M)\overline{\pi}, \delta(M)y_i\}$ increases, since the integrand is a convex function of y_i. It follows that, if the distributions functions G_i are ordered by decreasing risk, $q_i(M)$ is decreasing in i.

Proposition 3. ***(Co-variation of Integration and Risk)*** *Under Assumption 3, the final good producer is more likely to integrate suppliers for which the distribution of y_i is riskier.*

It is well known that if the distributions $G_i(y)$ are log-normal with a common mean, greater risk is equivalent to a higher coefficient of variation (Levy, 1973). We will make use of this observation in the empirical analysis.

2.5 Testable Predictions

In our model, a firm's choices over integration, delegation, and management practices are driven by its exogenous productivity (A). Given that this is unobservable to us, our empirical strategy is to verify in the data the validity of the model's predictions concerning the endogenous relationship between the firm's organizational choices.

Our model delivers two results about the relationship between integration, delegation, and management practices (Propositions 1 and 2). For the purpose of our empirical analysis, the key predictions of our model can be stated as follows:

P.1 Delegation and management practices (in particular those related to people management) should be positively correlated at the firm level.

P.2 Vertical integration and delegation should be positively correlated at the firm level. The correlation should vanish when controlling for management practices (in particular those related to people management).

Beyond establishing a novel relationship among three organizational design elements — integration, delegation and management practices — the model also provides insights on the relationship between integration decisions and characteristics of input industries (Proposition 3). This delivers an additional prediction that we will bring to the data:

P.3 If suppliers' productivity follows a log-normal distribution, controlling for mean productivity, final good producers should be more likely to integrate suppliers with a larger coefficient of variation of productivity.

3 Dataset and Variables

To assess the validity of our model's predictions, we construct a unique dataset combining firm-level information on vertical integration, delegation, and management practices.[14] Our matched sample includes 2,661 firms in 20 countries. 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.

In what follows, we describe the data and methodology used to construct each of the organizational variables.

3.1 Data on Vertical Integration

To measure vertical integration, we follow Alfaro, Conconi, Fadinger and Newman (2016), combining information on firms' production activities from Dun & Bradstreet's WorldBase with input-output data.

WorldBase is a database covering public and private companies in more than 200 countries and territories.[15] The unit of observation is the establishment/plant. With a full sample, plants belonging to the same firm can be linked via information on domestic and global parents using the DUNS numbers.[16]

The WorldBase dataset has been used extensively in the literature (e.g. Alfaro and Charlton, 2009; Acemoglu, Johnson and Mitton, 2009; Fajgelbaum, Grossman and Helpman, 2015; Alfaro, Antràs, Chor, and Conconi, 2015; Alfaro, Conconi, Fadinger, and Newman 2016). One of the advantages of WorldBase compared to other international datasets is that it is compiled from a large number of sources (e.g. partner firms, telephone directory records, websites, self-registration).[17]

[14] The data is constructed using plant-level data. As discussed below, to construct the vertical integration index, we use information on all plants belonging to the same firm. The measures on delegation and management practices are usually constructed based on surveys on one plant per firm.

[15] WorldBase is the core database with which D&B populates its commercial data products, including Who Owns Whom™, Risk Management Solutions™, Sales & Marketing Solutions™, and Supply Management Solutions™. These products 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. For more information see: http://www.dnb.com/us/about/db_database/dnbinfoquality.html.

[16] D&B uses the United States Government Department of Commerce, Office of Management and Budget, Standard Industrial Classification Manual 1987 edition to classify business establishments. The Data Universal Numbering System — the D&B DUNS Number — introduced in 1963 to identify businesses numerically for data-processing purposes, supports the linking of plants and firms across countries and tracking of plants' histories including name changes.

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

Our main sample is based on the 2005 WorldBase dataset. 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 as many as five secondary industries.

2. Ownership information: information about the firms' family members (number of family members, domestic parent and global parent).[18]

3. Location information: country, state, city, and street address of each plant.

4. Additional information: sales, employment, age.

We carry out the analysis at the firm level, using DUNS numbers to link plants that have the same ultimate owner.

To measure the extent of vertical integration for a given firm, we combine information on plant activities and ownership structure from WorldBase with input-output data to construct the index *Vertical Integration*$_f$, which measures the degree of vertical integration of firm f.[19] Given 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 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.[20]

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.[21]

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other data sources.

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

[19] See Fan and Lang (2000) and Alfaro, Conconi, Fadinger, and Newman (2016).

[20] 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.

[21] While the BEA employs six-digit input-output industry codes, WorldBase uses the SIC industry classification. The BEA website provides a concordance guide, but it is not a one-to-one key. For codes for which the match

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_{ij}^f. Here, $IO_{ij}^f \equiv IO_{ij} * I_i^f$, where IO_{ij} is the input-output coefficient for the sector pair ij, stating the dollars of output of sector i required to produce a dollar of j, and $I_i^f \in \{0, 1\}$ is an indicator variable that equals one if and only if firm f owns plants that are active in sector i. A firm that produces i as well as j will be assumed to supply itself with all the i it needs to produce j; thus, the higher IO_{ij} for an i-producing plant owned by the firm, the more integrated the vertical integration measure.

The firm's integration index is

$$\text{Vertical Integration}_f = \sum_i IO_{ij}^f, \tag{3}$$

the sum of the IO coefficients for each industry in which the firm is active.[22] 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 shipbuilder that has two secondary manufacturing activities, Fabricated Metal Structures (SIC 3441/BEA IO code 40.0400) and Sheet Metal Work (3444/40.0700).[23] 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

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).

[22] Our results are robust to using an alternative measure of vertical integration, based on all the firm's activities rather than its primary activity.

[23] 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.

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 V_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.[24]

To study within-firm integration decisions, we also construct the variable $\textit{Integration}_{f,i}$. This is an indicator variable equal to 1 if firm f with primary output j integrates input i within its boundaries. To keep the analysis tractable, we limit the sample to firms that integrate an 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, 2015).

It is important to stress that any potential misclassification of integrated versus non-integrated inputs would give rise to measurement error in the explanatory (P.2) or dependent variable in our regressions (P.3). To the extent that this is classical measurement error, it would make our coefficient estimates less precise, making it harder to find empirical support for the model's predictions. In robustness checks we show that our results are robust to restricting the analysis to single establishment firms, for which the methodology is less likely to give rise to measurement error.

3.2 Data on Delegation

Our measure of delegation is from Bloom, Sadun and Van Reenen (2012; there called "decentralization.") The measure was obtained through in-depth interviews with plant managers conducted by a team of MBA, MSc and BA students from top universities overseen by the authors. The sample covers close to 8000 medium-sized manufacturing firms in 20 countries.[25]

Plant managers were asked four questions regarding the degree of autonomy they have in making some key decisions:

> Budgeting: How much capital investment the plant manager could undertake without prior authorization of central headquarters (HQ) (in national currency converted into dollars using purchasing power parity);

[24] Many industries, including Ship Building and Repairing, have positive IO_{jj} coefficients: some "ships" 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.

[25] The sample excludes plants where the CEO and the plant manager were the same person (only 4.9% of the interviews).

Hiring: Whether the plant manager can hire a new full-time permanent shop floor employee without the agreement of HQ;

New products: where decisions on the introduction of new products are taken at the plant, at the HQ level, or both;

Sales and marketing: How much of sales and marketing is carried out at the plant level (rather than at the HQ).

The answers to the last three questions are scaled from a score of 1 (defined as all decisions taken at the corporate headquarters) to a score of 5 (defined as complete power to the plant manager). We convert the scores from the four decentralization questions to z-scores by normalizing each one to mean 0 and standard deviation 1.

Our main measure of delegation is an average across four z-scored measures of plant manager autonomy on hiring, capital expenditure, marketing, and product innovations. In every country, the sampling frame for the organization survey was all firms with a manufacturing primary industry code with between 100 and 5,000 employees on average, medium sized firms, over the most recent three years of data (typically 2002 to 2004).

Based on this information, we construct the variable $Delegation_f$, the delegation index of firm f. This is the unweighted average across all four z-scores of firm f. If we have information for only one plant per firm, the firm's delegation index is given by the plant's score. If we have information on more than one plant per firm, we average the scores of all plants.[26]

3.3 Data on Management Practices

To measure management practices, we use the methodology developed in Bloom and Van Reenen (2007) and extended in Bloom, Sadun and Van Reenen (2016). The authors use an interview-based evaluation tool that defines and scores from 1 ("worst practice") to 5 ("best practice") eighteen basic management practices. Appendix Table A-3 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, $Management_f$, 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).

[26]Given that the data on delegation were collected in different waves, in our regressions we will include fixed effects for the year in which the firm was surveyed.

The extension of our model presented in Section 2.3 suggests that some management practices should be more closely related to integration and delegation decisions. To asses the role of different aspects of management, we construct the following variables:

Operations & Monitoring$_f$ (based on the first eight survey questions) covers a firm's operations (e.g. introduction of lean manufacturing techniques, documentation of processes improvements) and its monitoring practices (e.g. tracking the performance of individuals through regular appraisals and job plans).

Targets$_f$ (based on the following five survey questions) covers practices related to different aspects of a firm's targets (e.g. their type, realism, transparency and consistency).

Incentives$_f$ (based on the last five survey questions) covers practices concerning promotion criteria (e.g. purely tenure-based or linked to individual performance), pay and bonuses, and fixing or firing bad performers.

The variable *Operations & Monitoring*$_f$ captures more "technical" practices (M_T in the theoretical model), while *Targets*$_f$ and *Incentives*$_f$ capture more "human" practices, closely related to the management of personnel (M_H in the model).

4 Empirical Results

4.1 Relationship between Delegation and Management

To verify prediction P.1, we regress the overall delegation index of firm f producing final good j and located in country c against the firm's management score:

$$\text{Delegation}_f = \alpha_0 + \alpha_1 \text{ Management}_f + \alpha_2 \mathbf{X}_f + \delta_j + \delta_c + \epsilon_{f,j,c}. \tag{4}$$

where the vector $\mathbf{X}_f$ includes firm-level controls (employment, age, and the fraction of the workforce with a college degree, all in logs), and δ_j and δ_c are output industry and country fixed effects. Given that the variables *Delegation*$_f$ and *Management*$_f$ are constructed from survey data, we also include a series of "noise controls" for the interview process (e.g. the time of day, day of the week, characteristics of the interviewee, identity of the interviewer) to reduce some of the random measurement error. According to prediction P.1, the coefficient α_1 should be positive and significant.

Table 1: Delegation and Management

	(1)	(2)	(3)
Management$_f$	0.126***	0.123***	0.111***
	(0.018)	(0.018)	(0.020)
log(Employment$_f$)			0.005
			(0.017)
log(1+ Age$_f$)			0.031
			(0.020)
log(% Workforce with a College Degree$_f$)			0.042***
			(0.015)
Country FE	yes	yes	yes
Output industry FE	no	yes	yes
Noise control	yes	yes	yes
R-squared	0.201	0.214	0.215
N	3,444	3,444	3,444

Notes: The dependent variable, *Delegation*$_f$, is the overall autonomy index of firm f. *Management*$_f$ is the normalized to z-score capturing the quality of the firm's management practices. *Employment*$_f$ measures the firm's employment, *Age*$_f$ is the number of years since its establishment, *% Workforce with a College Degree*$_f$ is the percentage of the employees with a bachelor's degree or higher. Standard errors clustered at the firm level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

The results are reported in Table 1. We first include as the only controls the firms' management score, country fixed effects and noise controls (column 1). We then add fixed effects for the firm's output industry (column 2) and additional firm controls (column 3). In line with prediction P.1, the estimated coefficient of *Management*$_f$ is always positive and significant at the 1 percent level. In terms of magnitudes, a one-standard-deviation increase in management increases delegation by 0.12 standard deviations.

Table 2: Delegation and Different Components of Management

	(1)	(2)	(3)
Targets$_f$	0.092***	0.103***	0.097***
	(0.035)	(0.035)	(0.035)
Incentives$_f$	0.080***	0.082***	0.077***
	(0.023)	(0.024)	(0.024)
Operations & Monitoring$_f$	0.000	-0.018	-0.021
	(0.032)	(0.033)	(0.033)
log(Employment$_f$)			-0.06
			(0.04)
log(1+ Age$_f$)			0.031
			(0.02)
log(% Workforce with a College Degree$_f$)			0.040***
			(0.015)
Country FE	yes	yes	yes
Output industry FE	no	yes	yes
Noise control	yes	yes	yes
R-squared	0,202	0,216	0,218
N	3,444	3,444	3,444

Notes: The dependent variable, *Delegation*$_f$, is the overall autonomy index of firm f. *Targets*$_f$, *Incentives*$_f$, and *Operations & Monitoring*$_f$ are the three components of a firm's management practices. *Employment*$_f$ measures the firm's employment, *Age*$_f$ is the number of years since its establishment, *% Workforce with a College Degree*$_f$ is the percentage of the employees with a bachelor's degree or higher. Standard errors clustered at the firm level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

We next distinguish different components of management, to verify whether the results of Table 1 are driven by those practices related to the management of personnel. In line with prediction P.1, Table 2 shows that delegation is positive correlated with *Targets*$_f$, *Incentives*$_f$, the management practices that best capture M_H in our theoretical model. By contrast, the coefficient of *Operations & Monitoring*$_f$, capturing the more technological component of management, is not statistically significant.[27]

Recall that, in our model, what drives the choice of M is A, the exogenous productivity of the enterprise (e.g. entrepreneurial ability, product coolness). A higher M then leads to

[27] We also tried specifications in which we included separate variables for management practices covering operations and monitoring. The coefficients of these variables were also insignificant.

more delegation following Assumption 2. Given that A is unobservable, we are verifying the endogenous relationship between management and delegation.[28]

4.2 Relationship between Integration, Delegation, and Management

To verify prediction P.2, we regress the delegation index against the vertical integration index:

$$\text{Delegation}_f = \beta_0 + \beta_1 \text{ Vertical Integration}_f + \beta_2 \mathbf{X}_f + \delta_j + \delta_c + \epsilon_{f,j,c}, \tag{5}$$

where *Vertical Integration*$_f$ is the vertical integration index of firm f. According to prediction P.2, the estimated coefficient β_1 should be positive and significant — unless $\mathbf{X}_f$ includes proxies for M in the model, in which case β_1 should not be significant.

The results are reported in Table 3. The estimated coefficient of *Vertical Integration*$_f$ is positive and significant in columns (1)-(3), and becomes insignificant in columns (4)-(5), in which we control for the firm's management practices. In terms of economic magnitudes, a one-unit increase in vertical integration is associated with an around 0.43 standard-deviation-increase in delegation.

These findings are in line with prediction P.2 of our theoretical model.[29] As mentioned before, we have experimented with a variant of our model in which management practices are chosen after HQ observes the ability of integrated suppliers (see footnote 6). In this setting, there would no longer be a one-to-one relationship between HQ's exogenous productivity and his choices of management practices. This variant of the model could explain the positive correlation between delegation and integration, but not the fact that this vanishes when management practices are controlled for.

[28] Consistent with our findings, the evidence in Bloom, Eifert, Mahajan, McKenzie, and Roberts (2013) shows that an *exogenous* increase in management leads to more delegation. They carried out a randomized control trial to improve management practices in a group of large Indian manufacturing plants. There was a large significant impact of improved management on increasing decentralization of decision making within firms. Moreover, also consistent with our model, better managed firms tended to expand both by adding plants and also integrating with suppliers.

[29] If integration is empirically driven by factors uncorrelated with productivity, then since $D_|I|$ depends on the level of integration as well as on management, there could still be correlation between delegation and integration even after controlling for management. Our results suggest that such drivers are weak in our data.

Table 3: Delegation, Vertical Integration, and Management

	(1)	(2)	(3)	(4)	(5)	(6)
Vertical integration$_f$	0.427**	0.431**	0.388**	0.161	0.140	0.255
	(0.188)	(0.186)	(0.189)	(0.193)	(0.188)	(0.191)
Management$_f$				0.163***	0.161***	0.109***
				(0.016)	(0.017)	(0.019)
log(Employment$_f$)			-0.067*			-0.061
			(0.040)			(0.040)
log(1+Age$_f$)			0.032			0.029
			(0.020)			(0.020)
log(% Workforce with a College Degree$_f$)			0.058***			0.042***
			(0.015)			(0.015)
Country FE	yes	yes	yes	yes	yes	yes
Output industry FE		yes	yes		yes	yes
Noise controls	yes	yes	yes	yes	yes	yes
R-squared	0.191	0.205	0.209	0.152	0.169	0.217
N	3,444	3,444	3,444	3,444	3,444	3,444

Notes: The dependent variable, *Delegation*$_f$, is the overall autonomy index of firm f. *Vertical integration*$_f$ is the vertical integration index of firm f. *Management*$_f$ is the normalized z-score capturing the quality of the firm's management practices. *Employment*$_f$ measures the firm's employment, *Age*$_f$ is the number of years since its establishment, *% Workforce with a College Degree*$_f$ is the percentage of the employees with a bachelor's degree or higher. Standard errors clustered at the firm level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

In Table 4, we verify that the results above are driven by the "human" components of management practices. According to the model's extension presented in Section 2.3, controlling for M_T should preserve co-variation of integration and delegation, while controlling for M_H would eliminate it. In column (1), we first reproduce column (3) of Table 3, which shows the positive relationship between delegation and vertical integration. In column (2), we control for *Operations & Monitoring*$_f$, the more "technical" component of a firm's management practices. As expected, the coefficient of *Vertical integration*$_f$ remains positive and significant. In columns (3) and (4), we include instead *Targets*$_f$ and *Incentives*$_f$, the two components more closely related to the management of a firm's human resources. In line with prediction P.2, the coefficient of *Vertical integration*$_{f,j,c}$ becomes insignificant. The same is true in column (5), in which we control for the three components together.[30]

[30]One may be concerned that the coefficient on vertical integration loses significance once we include controls for management due to multicollinearity between the control variables. However, the variance inflation factor for vertical integration is 1.3, well below the level of 10 above which multicollinearity may become an issue.

Table 4: Delegation, Vertical Integration, and Different Components of Management

	(1)	(2)	(3)	(4)	(5)
Vertical Integration$_f$	0.388**	0.323*	0.272	0.285	0.249
	(0.189)	(0.190)	(0.190)	(0.193)	(0.193)
Operations & Monitoring$_f$		0.083***			0.022
		(0.024)			(0.033)
Targets$_f$			0.126***		0.088***
			(0.023)		(0.033)
Incentives$_f$				0.156***	0.114***
				(0.028)	(0.035)
log(Employment$_f$)	-0.067*	-0.063	-0.062	-0.063	-0.062
	(0.040)	(0.040)	(0.040)	(0.040)	(0.04)
log(1+Age$_f$)	0.032	0.030	0.029	0.030	0.029
	(0.020)	(0.020)	(0.020)	(0.020)	(0.02)
log(% Workforce with a College Degree$_f$)	0.058***	0.051***	0.045***	0.043***	0.040***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Country FE	yes	yes	yes	yes	yes
Output industry FE	yes	yes	yes	yes	yes
Noise controls	yes	yes	yes	yes	yes
R-squared	0.209	0.211	0.216	0.216	0.218
N	3,444	3,444	3,444	3,444	3,444

Notes: The dependent variable, *Delegation*$_f$, is the overall autonomy index of firm f. *Vertical integration*$_f$ is the vertical integration index of firm f. *Targets*$_f$, *Incentives*$_f$, and *Operation & Monitoring*$_f$ are the three components of a firm's management practices. *Employment*$_f$ measures the firm's employment, *Age*$_f$ is the number of years since its establishment, *% Workforce with a College Degree*$_f$ is the percentage of the employees with a bachelor's degree or higher. Standard errors clustered at the firm level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

4.3 Option Value of Integration

In our model, ex-ante uncertainty about suppliers' productivity 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 productivity realizations and delegation decisions.

According to prediction P.3 of our model, final good producers should be more likely to integrate inputs when the productivity of suppliers in the upstream sector is more uncertain.

Similarly, the different components of managements are also all separately identifiable with the maximum of the variance inflation factors being 2.8 for *Targets*$_f$ when simultaneously including all three components of management in the regression (column (5).

To test this prediction, we regress the probability that firm f producing final product j and located in country c integrates input i on the coefficient of variation of the productivity of i suppliers in that country (*CV Productivity*$_{i,c}$), controlling for the average of labor productivity of suppliers in the input market (*Mean Productivity*$_{i,c}$). To construct these variables, we use information on labor productivity of firms with primary sector i in country c. In some specifications, we impose a minimum number of suppliers (50) in each country-sector to construct these variables. We also control for the importance of input i in the production of final good j, captured by the IO coefficient and firm-level controls, such as log firm employment and log(1+ Age_f).

Given that the distribution of productivity of input suppliers approximately follows a log-normal distribution, we can assess the validity of the prediction by running the following specification:

$$\text{Integration}_{f,i} = \gamma_0 + \gamma_1 \text{ CV Productivity}_{i,c} + \gamma_2 \text{ Mean Productivity}_{i,c} + \gamma_3 \text{ IO}_{ij} + D_f + D_i + \epsilon_{f,j,i,c} \quad (6)$$

Recall that the dependent variable, *Integration*$_{f,i}$, is a 0-1 indicator for whether firm f located in country c with primary output j has integrated input i within its boundaries. The key explanatory variable is *CV Productivity*$_{i,c}$, the coefficient of variation of labor productivity of the suppliers in input industry i located in country c. *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. D_i and D_f denote input industry and firm fixed effects.[31] We estimate (6) as a linear probability model, with standard errors clustered at the input industry i level.

This specification allows us to study the integration decisions of individual firms, and how they are affected by uncertainty in the productivity of supplier firms. 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 we measure) cannot have a causal impact on integration, and so is not present in the regression. According to prediction P.3, the estimated coefficient γ_1 should be positive and significant.

The results are reported in Table 5. We include all firms in the matched sample and con-

[31] Country fixed effects are absorbed by the firm fixed effects, since each firm is associated to the location of its headquarters.

sider the top 100 inputs (based on IO coefficients) necessary to produce the firm's output (identified by its reported primary SIC code). In all specifications, the estimated coefficient for *CV Productivity*$_{i,c}$ is positive and significant, in line with prediction P.3. This result suggests that, due to the uncertainty in the productivity of suppliers, there is an option value of integrating them.

Table 5: Option Value of Integration

	(1)	(2)	(3)	(4)
CV Productivity$_{i,c}$	0.00103***	0.00082***	0.00052***	0.00046***
	(0.00014)	(0.00011)	(0.00010)	(0.00010)
Mean Productivity$_{i,c}$	-0.00000***	-0.00000***	-0.00000**	-0.00000**
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
IO$_{i,j}$	0.04532***	0.00897	0.03044**	0.15003***
	(0.01413)	(0.01434)	(0.01442)	(0.01805)
log(Employment$_f$)		0.00901***	0.00963***	
		(0.00046)	(0.00048)	
log(1+ Age$_f$)		0.00191***	0.00080***	
		(0.00030)	(0.00029)	
log(% Workforce with a College Degree$_f$)		0.00027	-0.00083***	
		(0.00019)	(0.00025)	
Input sector FE	yes	yes	yes	yes
Country FE	no	no	yes	no
Firm FE	no	no	no	yes
R-squared	0.025	0.056	0.061	0.112
Observations	251,992	251,992	251,992	251,992

Notes: The dependent variable is *Integration*$_{f,i}$, a dummy variable equal to 1 if firm f located in country c with primary output j integrates input i. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the 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 total 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 respectively.

We have carried out a series of robustness checks to verify the validity of prediction P.3. In particular, the results of Table 5 continue to hold when we restrict the analysis to manufacturing inputs (see Table A-4 in the Appendix) and 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). The results are also robust to using the full WorldBase sample to study firms' integration decisions (see Table A-6).

4.4 Discussion

Sections 4.1-4.3 establish the following regularities:

1. Firms that delegate more also use better management practices, specifically those associated with providing targets and incentives to their personnel.

2. Firms that delegate more tend to be more vertically integrated; however, this correlation is explained entirely by their use of management practices.

3. Firms are more likely to integrate "riskier" inputs, i.e. industries in which supplier productivity is more dispersed.

These results are consistent with a model in which integration enhances efficiency by improving adaptation or other non-contractable investments and creates a real option for HQ to retain control or delegate according to comparative advantage, and in which management efficacy depends on the authority structure under which it is exercised, ranging from most valuable under delegation to least valuable under non-integration.

Of course, there could be other explanations for some of these findings. For instance, 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. Notice that the positive correlation between delegation and integration is robust to controlling for firm size (column 3 of Table 3). Still, for a given size, vertical integration could increase headquarters' overload by raising the complexity of the firm, leading to more delegation. However, it is less clear how these theories could account for the vanishing correlation between delegation and integration when management practices are controlled for (columns 4-6 of Table 3). If anything, they would view delegation and management as substitutes, to the extent that good management reduces headquarters' overload; we would then expect the correlation between delegation and integration

to get stronger when controlling for management practices. By the same logic, management and delegation should covary negatively, rather than positively (Table 1). Finally, theories of limited managerial attention do not address how input risk could provide a positive incentive to integrate (Table 5).

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 sector (column 4). More importantly, supply assurance theories have nothing to say about the interplay between integration, delegation, and management-practice decisions and thus cannot explain our first two empirical regularities.

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, "one-dimensional" organizational models 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. It seems they ought to covary positively.

Yet they are conceptually distinct. 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.[32] 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

[32]The law treats delegation and non-integration differently as well. 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.

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 allows us to consider other dimensions of the organization, in particular management practices. The exercise leads to new insights about the value of management in different organizational contexts. For example, in light of our model, the data suggest that performance is likely to be most responsive to high quality management when there are high degrees of delegation within widely integrated firms.[33] More broadly, 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.

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[33] In the Dreamliner case mentioned in the Introduction, part of Boeing's strategy for regaining oversight of small-component supplier relations, which was crucial for resolving their quality and delay issues, involved extending the degree of integration by acquiring from their partners major assets such as factories in which the key components were assembled.

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Appendix

A-1 Proofs

Lemma 1 Direct computation yields

$$q_i'(M) = \delta'(M) \int_{y \geq \frac{\sigma(M)\overline{\pi}_i}{\delta(M)}} y dG_i(y) + \sigma'(M)\overline{\pi}_i G_i\left(\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\right).$$

Note that $\int_{y \geq x} y dG_i(y) \geq x(1 - G_i(x))$. Thus,

$$\begin{aligned} q_i'(M) &\geq \delta'(M)\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\left(1 - G_i\left(\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\right)\right) + \sigma'(M)\overline{\pi}_i G_i\left(\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\right) \\ &= \frac{\delta'(M)}{\delta(M)}\frac{\sigma(M)}{\sigma'(M)}\sigma'(M)\overline{\pi}_i\left(1 - G_i\left(\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\right)\right) + \sigma'(M)\overline{\pi}_i G_i\left(\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\right). \end{aligned}$$

Since $\frac{\delta'(M)}{\delta(M)}\frac{\sigma(M)}{\sigma'(M)} > 1$ by Assumption 2,

$$\begin{aligned} q_i'(M) &\geq \sigma'(M)\overline{\pi}_i\left(1 - G_i\left(\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\right)\right) + \sigma'(M)\overline{\pi}_i G_i\left(\frac{\sigma(M)\overline{\pi}_i}{\delta(M)}\right) \\ &= \sigma'(M)\overline{\pi}_i \\ &> \nu'(M)\underline{\pi}_i. \end{aligned}$$

The first inequality is strict if $M > M_i$, the last inequality is just Assumption 1(a) and $\overline{\pi}_i \geq \underline{\pi}_i$.

Lemma 2 From Topkis's monotonicity theorem, it is enough to prove that $W(I, M, A)$ is supermodular in (I, M), that is

$$W(I \vee I', M \vee M', A) + W(I \wedge I', M \wedge M', A) \geq W(I, M, A) + W(I', M', A)$$

and has increasing differences in $(A, (I, M))$ (in fact we will show strict increasing differences). Here I, I' are elements of $\mathcal{P}(N)$, the set of all subsets of $N = \{1, \cdots, n\}$; $\mathcal{P}(N)$ forms a complete lattice under the set inclusion order. $M, M' \in [0, \overline{M}]$ are levels of management practice. $A \in \mathbb{R}_+$ is the exogenous productivity parameter, assumed to vary across final-good producers. We use as a short-hand notation $\sum_I$ instead of $\sum_{i \in I}$, and I^c for the complement of I in N.

Supermodularity. From the discussion in the text, it is enough to check that the term $A\sum_I(q_i(M) - \nu(M)\underline{\pi}_i)$ in expression (2) is supermodular. Let I, I' be arbitrary elements of

$\mathcal{P}(N)$ and $M, M' \in [0, \overline{M}]$. We show

$$\begin{aligned} A\sum_{I\cup I'}[q_i(M \vee M') - \nu(M \vee M')\underline{\pi}_i] + A\sum_{I\cap I'}[q_i(M \wedge M') - \nu(M \wedge M')\underline{\pi}_i] \\ \geq A\sum_{I}[q_i(M) - \nu(M)\underline{\pi}_i] + A\sum_{I'}[q_i(M') - \nu(M')\underline{\pi}_i]. \end{aligned} \tag{7}$$

Consider the case $M' \geq M$. Since $A \geq 0$, (7) reduces to

$$\begin{aligned} &\sum_{I\cup I'}[q_i(M') - \nu(M')\underline{\pi}_i] - \sum_{I'}[q_i(M') - \nu(M')\underline{\pi}_i] \\ &\geq \sum_{I}[q_i(M) - \nu(M)\underline{\pi}_i] - \sum_{I\cap I'}[q_i(M) - \nu(M)\underline{\pi}_i]), \end{aligned}$$

or, since $(I \cup I') \setminus I' \equiv I \setminus (I \cap I')$,

$$\sum_{I\setminus(I\cap I')}[q_i(M') - \nu(M')\underline{\pi}_i] \geq \sum_{I\setminus(I\cap I')}[q_i(M) - \nu(M)\underline{\pi}_i], \tag{8}$$

Since the sets I and I' are arbitrary, (8) is true if and only if $q_i(M') - q_i(M) \geq \nu(M')\underline{\pi}_i - \nu(M)\underline{\pi}_i$, which follows from $q_i'(M) > \nu'(M)\underline{\pi}_i$ as established in Lemma 1.

If $I = I'$ or $M = M'$, then (8) holds with equality; otherwise, it holds strictly. The case $M > M'$ is similar, with the inequality in (8) reversed and the domain of summation equal to $I' \setminus (I \cap I')$.

Strict Increasing Differences in (M,A). $W_A(I, M, A)$ is strictly increasing in M because both $q_i(M)$ and $\nu(M)\underline{\pi}_i$, and therefore their sums, are strictly increasing in M.

Strict Increasing Differences in (I,A). We need to show that for any $I' \subset I$, $W_A(I, M, A) = \sum_I q_i(M) + \sum_{I^C} \nu(M)\underline{\pi}_i > W_A(I', M, A) = \sum_{I'} q_i(M) + \sum_{I'^C} \nu(M)\underline{\pi}_i$. But $W_A(I, M, A) - W_A(I', M, A) = \sum_{I\setminus I'}[q_i(M) - \nu(M)\underline{\pi}_i] > 0$, since $q_i(M) \geq \sigma(M)\overline{\pi}_i > \nu(M)\underline{\pi}_i$ by Assumption 1.

Supermodularity and strict increasing-difference conditions of $W(I, M, A)$ imply that the solution $(I(A), M(A))$ to the problem $\max_{(I,M)} W(I, M, A)$, is increasing in A, strictly so for $M(A)$ and potentially weakly for $I(A)$ (since the set of suppliers is finite). 

A-2 Descriptive Statistics

Table A-1: Descriptive Statistics of Matched Sample

	Mean	Median	Standard deviation	N. observations	N. firms
Delegation$_f$	0.13	0.07	0.99	3,444	2,661
Vertical Integration$_f$	0.10	0.08	0.08	3,444	2,661
Management$_f$	0.000	0.004	1	3,444	2,661
Targets$_f$	0.093	0.0978	0.721	3,444	2,661
Incentives$_f$	0.000	0.008	1	3,444	2,661
Operations & Monitoring$_f$	0.128	0.210	0.763	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
% Workers with College Degree$_f$	15.20	10.00	16.34	3,225	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

Table A-3: 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 Evidence on Assumption 2

Assumption 2 in our theoretical model posits the log-supermodularity of supplier productivity in management and delegation, which is equivalent to the management elasticity of supplier performance increasing in delegation. Tables 1 and 2 provide indirect evidence for this assumption: delegation and management positively covary, in line with prediction P.1, which relies on the assumption.

We can also assess the validity of Assumption 2 more directly. In particular, we regress firm-level log-productivity (measured as sales, with log employement and log capital as controls) on log of $Management_f$, $Delegation_f$, and the interaction between the two. As Figure A-1 shows, our estimates indicate that the empirical management elasticity of firm performance is increasing in delegation.

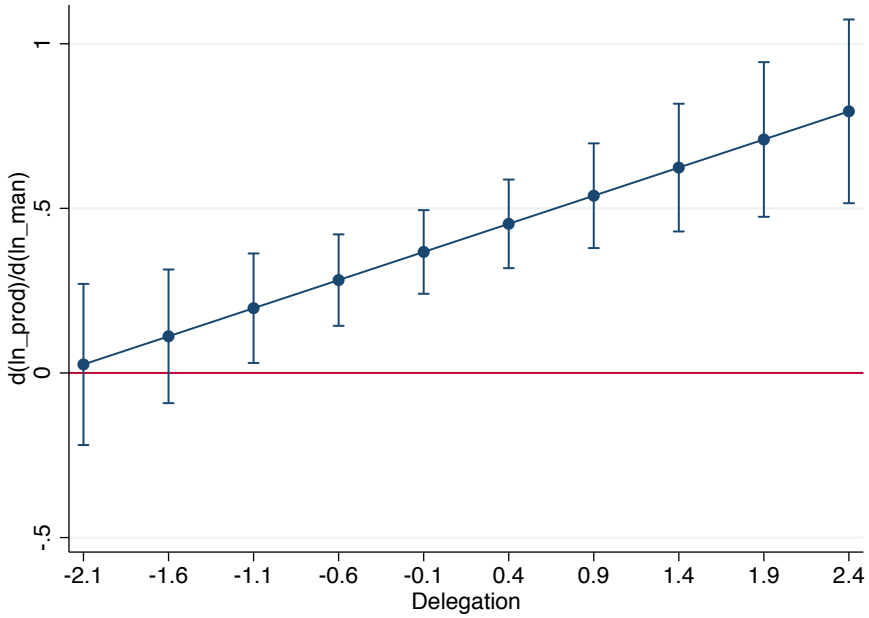


Figure A-1: Log-supermodularity of productivity in management and delegation

A-4 Additional Robustness Checks

Table A-4: Option Value of Integration (Manufacturing Inputs)

	(1)	(2)	(3)	(4)
CV Productivity$_{i,c}$	0.00166***	0.00108***	0.00077***	0.00072***
	(0.00044)	(0.00024)	(0.00012)	(0.00013)
Mean Productivity$_{i,c}$	-0.00000***	-0.00000	-0.00000	-0.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
IO$_{i,j}$	0.23054***	0.22734***	0.23195***	0.17031***
	(0.03157)	(0.02980)	(0.02980)	(0.03686)
log(Employment$_f$)		0.01716***	0.01708***	
		(0.00133)	(0.00134)	
log(1+ Age$_f$)		0.00215*	0.00081	
		(0.00112)	(0.00116)	
log(% Workforce with a College Degree$_f$)		-0.00086	-0.00275***	
		(0.00066)	(0.00071)	
Input sector FE	yes	yes	yes	yes
Country FE	no	no	yes	no
Firm FE	no	no	no	yes
R-squared	0.039	0.082	0.087	0.158
Observations	31,854	31,854	31,854	31,773

Notes: The dependent variable is *Integration*$_{f,i}$, a dummy variable equal to 1 if firm f located in country c with primary output j integrates input i. The set of inputs is restricted to manufacturing (SIC code between 2000 and 3999). The variable *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the 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 total 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 respectively.

Table A-5: Option Value of Integration (50+ Suppliers per Input Sector)

	(1)	(2)	(3)	(4)
CV Productivity$_{i,c}$	0.00082***	0.00064***	0.00043***	0.00040***
	(0.00014)	(0.00011)	(0.00010)	(0.00011)
Mean Productivity$_{i,c}$	-0.00000**	-0.00000**	-0.00000**	-0.00000*
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
IO$_{i,j}$	0.05837***	0.00207	0.01748	0.22775***
	(0.02004)	(0.02074)	(0.02092)	(0.02895)
log(Employment$_f$)		0.01032***	0.01087***	
		(0.00054)	(0.00057)	
log(1+Age$_f$)		0.00174***	0.00090**	
		(0.00037)	(0.00036)	
log(% Workforce with a College Degree$_f$)		0.00025	-0.00090***	
		(0.00025)	(0.00033)	
Input sector FE	yes	yes	yes	yes
Country FE	no	no	yes	no
Firm FE	no	no	no	yes
R-squared	0.027	0.062	0.067	0.119
Observations	180,132	180,132	180,132	180,132

Notes: The dependent variable is *Integration*$_{f,i}$, a dummy variable equal to 1 if firm f located in country c with primary output j integrates input i. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the 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 total 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 respectively.

Table A-6: Option Value of Integration (WorldBase Sample)

	(1)	(2)	(3)	(4)
CV Productivity$_{i,c}$	0.00033**	0.00032**	0.00035**	0.00034**
	(0.00013)	(0.00013)	(0.00014)	(0.00014)
Mean Productivity$_{i,c}$	-0.00000	-0.00000	-0.00000	-0.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
IO$_{i,j}$ 0.15893***	0.15714***	0.15649***	0.21493***	
	(0.01307)	(0.01307)	(0.01313)	(0.01562)
log(Employment$_f$)		0.00347***	0.00394***	
		(0.00025)	(0.00026)	
log(1+Age$_f$)		0.00088***	0.00018	
		(0.00019)	(0.00016)	
Input sector FE	yes	yes	yes	yes
Country FE	no	no	yes	no
Firm FE	no	no	no	yes
R-squared	0.040	0.041	0.041	0.040
Observations	6,565,938	6,565,938	6,565,938	6,565,938

Notes: The dependent variable is *Integration*$_{f,i}$, a dummy variable equal to 1 if firm f located in country c with primary output j integrates input i. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the 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 total 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 respectively.