All Together Now: Integration, Delegation and Management*

Laura Alfaro, HBS and NBER
Nick Bloom, Stanford and NBER
Paola Conconi, Université Libre de Bruxelles (ECARES), CEPR, and CESifo
Harald Fadinger, Mannheim and CEPR
Patrick Legros Université Libre de Bruxelles (ECARES), Northeastern and CEPR
Andrew F. Newman, Boston University and CEPR
Raffaella Sadun, HBS and NBER
John Van Reenen, MIT, CEP, NBER and CEPR

March 2017

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, management practices, real options.

*We are grateful for comments from Philippe Aghion, Jacques Crémer, Wouter Dessein, Luis Garicano, Bob Gibbons, Oliver Hart, Francine Lafontaine, Andrea Prat, Mike Powell, Veronica Rappoport, Birger Wernerfelt, and participants in the 2016 FOM Conference, the Fifth CEPR IMO Workshop, the MIT Empirical Management Conference, the 2017 ASSA (IOS Session), and seminars at UCLA, NUS, Oxford, Collegio Carlo Alberto, MIT, Mannheim, Nova SBE, PUC-Rio, Unversitat Autònoma de Barcelona, and the London School of Economics. Isabella Kanczuk provided outstanding research assistance.

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 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. 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. 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 becom-

[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).

ing 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 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 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 adapt inputs to his production needs. The supplier may have a comparative advantage in adaptation, 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

[2]In our model, integration is 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, 2013; Dessein, 2014).

a supplier or instead to keep complete control.[3]

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.

The positive relationship between delegation and integration is mediated through management. Hence, a second prediction of our model is that, 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 suppliers in "riskier" input industries, in which 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 fixed effects and controls, 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

[3]The model thus shares with Baker, Gibbons and Murphy (1999) the view that delegation is an informal means of allocating control to a supplier, in contrast to asset divestiture (non-integration), which is formal.

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 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 (2010), 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 (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 Hart and Holmström (2010) considers delegation and firm boundaries together, and none brings these elements together with management practices. Legros and Newman (2015) presents a "three-dimensional" model of firm organization, combining integration, delegation, and profit sharing schemes (rather than management practices).

Finally, our empirical strategy is closely related to the analysis in Holmström and Milgrom (1994) on the 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 discusses our empirical strategy. Section 4 describes the data and Section 5 presents the empirical results. Section 6 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 $i \in \{1, \ldots, n\}$. 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) makes 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 adaptation decisions.

The final good producer has "productivity" $A \geq 0$, 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 not only on technology, but also on management and organization. Total output is

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

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

2.1 Management and Organizational Design

Management practices are multi-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 has also a significant "human" dimension, 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.

To operationalize the model, we will assume 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, which for simplicity is independent of the organizational arrangement under which it is borne.[4] The capability of a supplier of input i is a_i, which is drawn from a distribution $G_i(a_i)$ with support $[0, \overline{a}]$. We assume that the random variables a_i are independently distributed. For each supplier i, the distribution G_i is common knowledge, but the value of a_i is realized only after the production process gets started, at which time it is revealed to the final good producer as well as the supplier.[5]

HQ designs the organization that maximizes the total surplus of the enterprise, including expected revenue, private adaptation costs, and costs of management.[6] She first chooses which input suppliers to integrate and what type of management practices to put in place

[4]Our results are unchanged if we assume small differences in private costs under delegation, centralization, and non-integration.

[5]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, 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. And third, the information *is* revealed for non-integrated 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. The last is perhaps closest to our empirical implementation of the model.

[6]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.

in the enterprise. Next, after observing their comparative advantage, she decides to which suppliers it will delegate the adaptation decisions; HQ retains control over adaptation for the remaining suppliers it owns. Suppliers that are non-integrated are effectively out of her jurisdiction, and thus retain control over adaptation.

Before supplier capabilities a_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 a_i realizations.[7] The cost function $c(M)$ is differentiable and strictly increasing with $c(0) = 0$.

Management practices facilitate adaptation and improve performance, but differentially depending on the organizational choice. The performance of supplier i with productivity a_i *within the enterprise*, that is, on behalf of the final good producer, is $\pi_i(M, a_i, o)$, where $o \in \{N, C, D\}$ denotes the organization that is chosen (*N*on-integration, *C*entralized integration, *D*elegated integration).

Firm Boundaries and Delegation

Simultaneous with the M decision, HQ chooses a subset $I \subseteq \{1, \ldots, n\}$ 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 and independence of adaption costs from organization, 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 guarantee that the suppliers adapt, so she has to buy generic forms of the inputs.[8] Nevertheless, since the management practices chosen by HQ may improve performance of generic inputs, non-integrated supplier i will contribute $\pi_i(M, a_i, N)$ to the enterprise surplus.

By contrast, under integration HQ has authority over the suppliers that are within the

[7] We have also considered a version of the model in which HQ can choose management M_i *after* observing the realization of a_i. As discussed in Section 5, this variant yields 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.

[8] 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. We ignore incentive contracts for non-integrated suppliers that are based on aggregate output, because they have very low power if n is large.

firm boundaries, and can ensure that they engage in adaptation. Once a_i is realized, HQ can choose to centralize and direct the adaptation process or to delegate it to the supplier.

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.

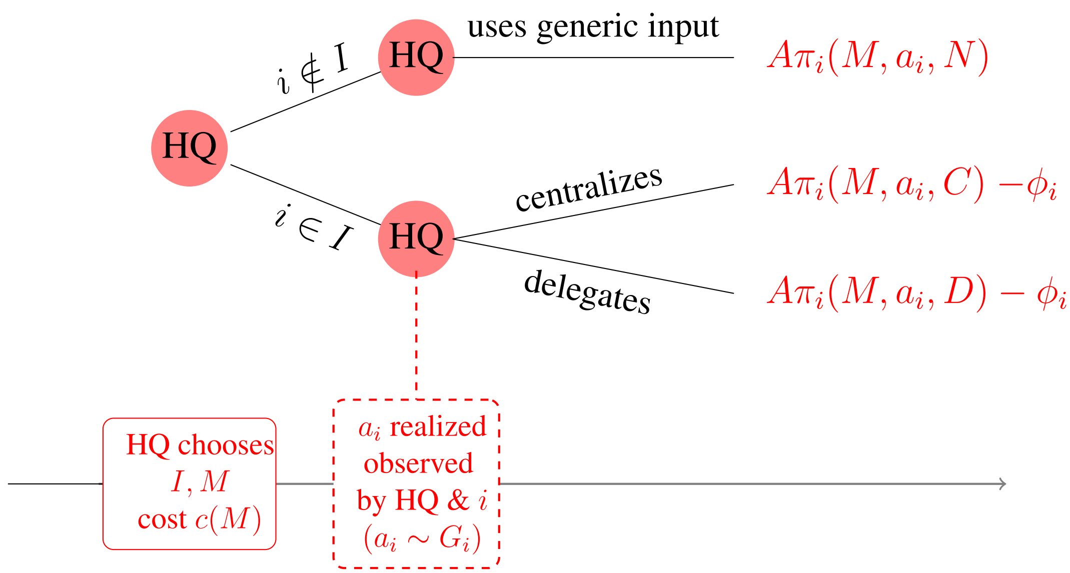


Figure 1: Timing

Operationalizing the Theory

In order for the model to generate predictions about the relationships among the organizational variables — integration, delegation, and management — one needs to make more specific assumptions about the properties of the function $\pi_i(M, a_i, o)$.

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. Moreover, the effect of management is likely to be more important under delegation than under centralization. In a parallel fashion, though the supplier's productivity is always going to affect his contribution, it will be least important when he is producing a generic input, and most important when he is controlling the adaptation process. Ordering the three organizational modes as $D \succ C \succ N$, we can then formalize our assumptions:

Assumption 1. *(i)* $\pi_i(M, a_i, o) \in [0, 1]$ *is increasing in* (M, a_i)*, concave in* M*, and differentiable in* (M, a_i).

(ii) For any i *and* a_i*,* $\pi_i(0, a_i, C) \geq \pi_i(0, a_i, N)$.

(iii) For any i*,* $\pi_i(M, a_i, o)$ *is supermodular in* (M, o)

(iv) For any i*,* $\pi_i(M, a_i, o)$ *is supermodular in* (a_i, o)

Assumption 1(ii) and (iii) ensure that $\pi_i(M, a_i, C) > \pi_i(M, a_i, N)$ for positive M: coupled with HQ's delegation behavior, integration will generate a larger contribution than non-integration because adaptation can be effectuated more readily, thanks to HQ's authority, within the firm boundaries than outside them. Of course, this gain has to be weighed against the loss ϕ_i borne by the supplier.

Note that Assumption 1 need not entail $\pi_i(M, a_i, D) \geq \pi_i(M, a_i, C)$. That would be implied by imposing $\pi_i(0, a_i, D) \geq \pi_i(0, a_i, C)$ in addition to Assumption 1 (ii), 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.[9] To avoid trivialities, however, we shall assume $\pi_i(0, 0, D) < \pi_i(0, 0, C)$ and $\pi_i(\overline{M}, \overline{a}, D) > \pi_i(\overline{M}, \overline{a}, C)$, which rule out the extreme decisions < always delegate> and <never delegate>.

Some direct evidence for part (iii) of this assumption is discussed in Appendix A-3; in fact, it appears that a stronger condition, log-supermodularity, is present in the data (data limitations do not allow direct assessment of part (iv)).

Delegation and Management

Consider an integrated supplier i with realization a_i. HQ prefers to delegate to i if the expected contribution is larger when the supplier decides than when HQ decides, that is when $\pi_i(M, a_i, D) \geq \pi_i(M, a_i, C)$.[10] Letting $a_i^*(M)$ be the (unique, following Assumption 1) solution to $\pi_i(M, a_i, D) = \pi_i(M, a_i, C)$, the probability that HQ delegates to i is

$$D_i(M) = 1 - G_i(a_i^*(M)), \tag{1}$$

[9] In a similar vein, Dessein, Garicano and Gertler (2010) show, 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.

[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; either way, the supplier is compensated ex-ante for the expected cost whenever he is integrated.

From Assumption 1, $a_i^*(M)$ is decreasing in M: by the implicit function theorem $\pi_i(M, a_i^*, D) - \pi_i(M, a_i^*, C) = 0$ implies that $\frac{da_i^*(M)}{dM} = -\frac{\partial_M \pi_M(M, a_i^*, D) - \partial_M \pi_i(M, a_i^*, C)}{\partial_a \pi_i(M, a_i^*, D) - \partial_a \pi_i(M, a_i^*, C)}$, which is negative since the numerator and denominator are positive by supermodularity in (M, o) and in (a, o). Thus, $D_i(M)$ is also an increasing function of M. As management quality increases, so does delegation.

Proposition 1. *The degree of delegation $D_i(M)$ increases with better management practices M.*

Integration, Delegation, and Management

Expected output from integrating supplier i is $Aq_i^I(M)$ where

$$\begin{aligned} q_i^I(M) &\equiv \mathbb{E}_i[\max\{\pi_M(M, a_i, D), \pi_i(M, a_i, C)\}] \\ &= \int_0^{a_i^*(M)} \pi_i(M, a_i, C) dG_i(a_i) + \int_{a_i^*(M)}^{\infty} \pi_i(M, a_i, D) dG_i(a_i). \end{aligned}$$

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 $\pi_M(M, a_i, D)$ and $\pi_i(M, a_i, C)$ are increasing in M. The monotonicity of the option value with respect to management plays a key role in the analysis.

The value under non-integration is,

$$q_i^N(M) \equiv \mathbb{E}_i[\pi_i(M, a_i, N)],$$

and Assumption 1 also implies that the marginal value of management under integration exceeds that under non-integration.

Lemma 1. *The marginal value of management under integration exceeds that under non-integration: $q_i^{I\prime}(M) > q_i^{N\prime}(M)$.*

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:

$$W(I, M; A) = \sum_{i \in I} \left(Aq_i^I(M) - \phi_i \right) + \sum_{i \notin I} Aq_i^N(M) - c(M),$$

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

$$\begin{aligned} W(I, M; A) = A \sum_{i \in I} (q_i^I(M) - q_i^N(M)) \\ + A \sum_{i=1}^{n} q_i^N(M) - \sum_{i \in I} \phi_i - c(M). \end{aligned} \tag{2}$$

Supermodularity in (I, M) depends only on the first term, $A \sum_{i \in I}(q_i^I(M) - q_i^N(M))$, 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, 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, I) follows from Assumption 1, which imply that integration output is larger than non-integration output, so that increases in A are more valuable under integration.

It follows that the solution $(I(A), M(A))$, is increasing in A.[11] Higher enterprise value not only results in better management, but in a (weakly) larger set of integrated suppliers. Details of the proof are in the Appendix.

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

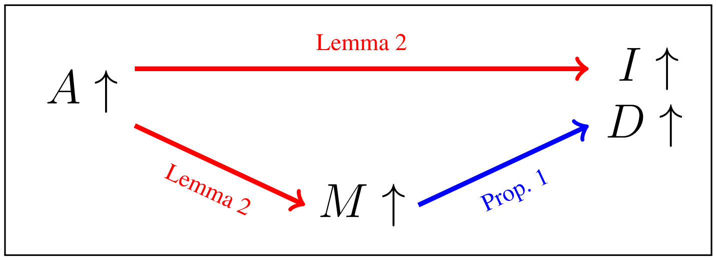
In Lemma 2, A determines the choices of management practices and integration. This implies that integration and management will covary. Recall that Proposition 1 establishes a direct link between management and the degree of delegation. Combining the two results, we obtain a positive covariation between integration and delegation.

Notice that A directly affects integration, while it only indirectly influences delegation, through its impact on management. Thus, if M were kept fixed, D would also be fixed, while I would still vary with A; hence D and I would be uncorrelated.

Proposition 2. *(i) There is a positive covariation between integration and delegation; (ii) If M is fixed, there is no covariation between integration and delegation.*

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

Figure 2



Unpacking Management

As discussed in Section 4.3, 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). Output functions are now $\pi_i(M_T, M_H, a_i, o)$, and supermodularity applies only to M_H. The cost $c(M_T, M_H)$ is submodular.

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.

Integration as a Real Option

The mechanism driving the co-variation in integration and delegation in Proposition 2 also implies that integration has an option value. In the theory of real options, increases in uncertainty tend to make options more attractive, because of the convexity they introduce by protecting the holder from downside risk. Carrying this intuition to the present context, we should expect that greater uncertainty may make integration more attractive.

In our model, the source of uncertainly is the capability of the supplier that is not realized until after the adaptation process gets started. Supplier capability is most important under delegation, but it also affects centralization and to a lesser extent non-integration. The effect of greater uncertainty about supplier capability on the incentive to integrate must take account of its effects on the *relative* risks under integration and non-integration.

Note that the benefit of integration $q_i^I(M) - q_i^N(M)$ can be written as

$$\mathbb{E}_i[\max\{\pi_i(M, a_i, C) - \pi_i(M, a_i, N), \pi_i(M, a_i, D) - \pi_i(M, a_i, N)\}];$$

supplier i is integrated if this exceeds the adaption cost ϕ_i. Then if $\max\{\pi_i(M, a_i, C) - \pi_i(M, a_i, N), \pi_i(M, a_i, D) - \pi_i(M, a_i, N)\}$ is a convex function of a_i, the expectation increases if the distribution G_i becomes riskier in the Rothschild-Stigliz order. But satisfying the convexity hypothesis may be a tall order, since there is no particular reason to expect $\pi_i(M, a_i, o)$ to be convex in a_i.

However, if we regard the non-integration output $\pi_i(M, a_i, N)$ as the fundamental random variable, and hypothesize that $\pi_i(M, a_i, C)$ and $\pi_i(M, a_i, D)$ are convex transforms of $\pi_i(M, a_i, N)$, (in the next section we shall display conditions under which this convexification hypothesis applies), then since the $\max$ operator is also convex, the classical real option logic applies to increases in the riskiness of $\pi_i(M, a_i, N)$.[12] Since HQ's management choice is common across all suppliers, it follows that if two different input industries differ only in riskiness, HQ is more likely to integrate a supplier from the riskier input industry.

Proposition 3. *If supplier contributions under integration are convex transforms of the contributions under non-integration, then the final good producer is more likely to integrate suppliers for which the distribution of a_i is riskier.*

3 Empirics

In this section we outline our empirical strategy. We first start with a description of how we approach measurement of the variables that appear in the main predictions of our model, and next we outline our empirical strategy. The following section discusses data.

3.1 From Theory to Measurement

Delegation

In contrast to the binary delegation outcome in the previous section, we shall be measuring delegation continuously, in terms of the number or fraction of a set list of tasks or activities

[12] In case $\pi_i(M, 0, o) = 0$, all o, convexification implies that the delegation and centralization contributions are more capability elastic than the non-integration contribution.

that a subordinate supplier actually controls. Suppose then that for each supplier i, HQ can delegate each of T separate tasks t, such as hiring engineers, purchasing capital equipment, or adding a new product. The supplier's capability on task t is $a_{i,t}$, drawn independently from the distribution G_i. His contribution is $\pi_i(M, a_{i,t}, o_t)$, where $o_t \in \{C, D\}$ if supplier i is integrated and $o_t = N$ if he is not integrated. Denote $a_i^*(M)$ the cutoff capability for which the contribution is the same under delegation and integration. From the analysis in the text, the probability of delegation on task t is $D_i(M) = 1 - G_i(a_i^*)$, and therefore delegation can be measured continuously as the realization of the binomial distribution Bin$(D_i(M), T)$ where T is the number of tasks. As M increases, the distribution Bin$(D_i(M), T)$ increases in the first order.[13] In this manner, the empirical content of Proposition 1 is that the number or fraction of tasks that are delegated is increasing in M.

Now, the contribution of a task is $q_{i,t}^I(M) = \mathbb{E}_i[\max\{\pi_i(M, a_{i,t}, C), \pi_i(M, a_{i,t}, D)\}]$, but since the distributions of $a_{i,t}$ are identical, the total contribution of supplier i is simply $q_i^I(M) = T \cdot \mathbb{E}_i[\max\{\pi_i(M, a_i, C), \pi_i(M, a_i, D)\}]$ (for the non-integrated supplier, the contribution is $q_i^N(M) = T \cdot \mathbb{E}_i \pi_i(M, a_i, C)$, where $a_i \sim G_i$). It is straightforward to verify that the results in Propositions (1) and (2) are preserved under this construction.

Integration

In our model, integration induces a partial order (set inclusion) on subsets I of $\{1, \ldots, n\}$. Empirically, we shall find it convenient to use a cardinal measure $\sum \rho_i \mathbf{1}_I(i)$ for some non-negative weights $\{\rho_i\}$ representing input requirements for the final good, and the indicator function $\mathbf{1}_I(i) = 1$ if $i \in I$, 0 otherwise. Clearly, if I increases to $I' \supset I$, then $\sum \rho_i \mathbf{1}_I(i) \geq \sum \rho_i \mathbf{1}_{I'}(i)$. (The inequality is in fact strict because no supplier with zero input requirement would be integrated given the positive cost.)

Supplier Riskiness

Observing the underlying capability of a supplier a_i is difficult, but one could proxy for it with the capability of non-integrated suppliers in the same industry. For instance, consider Cobb-Douglas contributions:

$$\pi(M, a_i, o) = M^{\mu(o)} a_i^{\alpha(o)},$$

[13] If we suppose that capabilities for different tasks are drawn from different distributions $G_{i,t}$, the cutoffs $a_{i,t}^*$ and the probabilities of delegation $D_{i,t}(M)$ vary with tasks, and the degree of delegation then follows a Poisson-binomial distribution with mean $\sum_{t \in T} D_{i,t}(M)$, which is also increasing in M.

with $\mu(o)$ and $\alpha(o)$ increasing in $o = N, C, D$. Suppose that we observe several draws of $a_i^{\alpha(N)}$ (or some positive multiple thereof) by sampling several non-integrated suppliers in the input industry i in order to construct an estimated capability distribution for the industry. Then, making the change of variable $y_i = a_i^{\alpha(o)}$, we have new contribution functions

$$\hat{\pi}_i(M, y_i, N) = M^{\mu(N)} y$$
$$\hat{\pi}_i(M, y_i, C) = M^{\mu(C)} y^{\alpha(C)/\alpha(N)}$$
$$\hat{\pi}_i(M, y_i, D) = M^{\mu(D)} y^{\alpha(D)/\alpha(N)}$$

Now $\hat{\pi}_i(M, y_i, C)$ and $\hat{\pi}_i(M, y_i, D)$ are convex transforms of $\hat{\pi}_i(M, y_i, N)$ (in fact are convex in y_i), and Proposition 3 applies to the transformed variable y_i. We should then observe a positive relationship between the riskiness of the sampled distribution of y_i and the propensity to integrate with an i supplier.

It is well known that if the distributions $G_i(y_i)$ 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.

3.2 Empirical Strategy

According to our model, exogenous productivity A should have a direct effect on vertical integration I and management M, but no direct effect on delegation choices D (see Figure 2 above). In econometric terms, the choices of delegation, integration, and management can be described by the following equations:

$$D = \beta_{D0} + \beta_{D1} M + \varepsilon_1, \quad (3)$$

$$I = \beta_{I0} + \beta_{I1} A + \varepsilon_2, \quad (4)$$

$$M = \beta_{M0} + \beta_{M1} A + \varepsilon_3, \quad (5)$$

with $Cov(\varepsilon_i, \varepsilon_j) = 0$ for $i \neq j$. Given that A is unobservable to us, our empirical strategy is to verify in the data the validity of the model's predictions concerning the endogenous relationships between the firm's organizational choices. Our model delivers two results about these relationships (Propositions 1 and 2). For the purpose of our empirical analysis, Proposition 1 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.

To assess the validity of this prediction, in our empirical analysis, we will run regression (3) above (first considering the overall quality of management and then comparing different types of management practices). According to our model, the estimates of β_{D1} should be positive and significant.

Proposition 2 leads to a second testable prediction:

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

To test the first part of this prediction, we will first run the following regression:

$$D = \beta_0 + \beta_1 I + u_1. \tag{6}$$

The β_1 coefficient should be positive and significant, because it picks up the positive correlation between the D and the omitted variable M (driven by the fact that M and I are both increasing in A).[14]

To assess the validity of the second part of prediction P.2, we will estimate

$$D = \alpha_0 + \alpha_1 I + \alpha_2 M + u_2. \tag{7}$$

If our theoretical model is correct, A should not have any direct effect on D, implying that I should not be included in (7). If this is the case, the estimated coefficient α_1 should not be significantly different from zero. Moreover, the effect of management on delegation should not depend on the degree of vertical integration, implying that the estimate of α_2 in regression (7) should be the same as the estimate of β_{D1} in regression (3).

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:

[14] According to our model, the estimated β_1 coefficient in regression (6) suffers from an omitted variable bias:

$$\beta_1 = \frac{Cov(D,I)}{Var(I)} = \frac{Cov(\beta_{D0} + \beta_{D1}M + \epsilon_1, I)}{Var(I)} = \beta_{D1}\frac{Cov(M,I)}{Var(I)} = \beta_{D1}\beta_{M1}\beta_{I1}\frac{Var(A)}{Var(I)}.$$

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

4 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.[15] 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.

4.1 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.[16] 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.[17]

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,

[15] 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.

[16] 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.

[17] 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.

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).[18]

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).[19]

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 $\textit{Vertical Integration}_f$, which measures the degree of vertical integration of firm f.[20] 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.[21]

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

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

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

[21] 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.

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.[22]

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 input-output coefficient for the sector pair ij, stating the dollars of output of sector i required to produce a dollar of j, and $I^f_i \in \{0, 1\}$ is an indicator variable that equals one if and only if firm f owns plants that are active in sector i. A firm 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

$$\text{Vertical Integration}_f = \sum_i IO^f_{ij}, \tag{8}$$

the sum of the IO coefficients for each industry in which the firm is active.[23] 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 activities, Fabricated Metal Structures (SIC 3441/BEA IO code 40.0400) and Sheet Metal Work (3444/40.0700).[24] The IO_{ij} coefficients for these sectors are:

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

[22] 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 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).

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

[24] 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.

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 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.[25]

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.

4.2 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.[26]

Plant managers were asked to divulge how much autonomy they have in making four key decisions:[27]

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

[25] 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.

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

[27] Additional information on the survey on delegation can be found in Appendix Table A-3.

dollars using purchasing power parity);

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 level, 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.[28]

4.3 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-4 lists these practices and gives a sense of how each was measured on a scale from 1 to 5.

[28]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. Our results are robust to controlling for the number of plants owned by a firm.

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).

The extension of our model presented in Section 2.1 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).

5 Empirical Results

5.1 Relationship between Delegation and Management

We first assess the validity of prediction P.1 concerning the endogenous relationship between management and delegation. According to our model, better management practices M should lead to more delegation (D).

We first regress the overall delegation index of firm f producing final good j and located in country c against the firm's management score:

$$\text{Delegation}_f = \alpha_0 + \alpha_1 \, \text{Management}_f + \alpha_2 \, \mathbf{X}_f + \delta_j + \delta_c + \epsilon_{f,j,c}, \tag{9}$$

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),[29] 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.

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). 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 1: Delegation and Management

	(1)	(2)	(3)
Management_f	0.126***	0.123***	0.111***
	(0.018)	(0.018)	(0.020)
$\log(\text{Employment}_f)$			0.005
			(0.017)
$\log(1+\text{Age}_f)$			0.031
			(0.020)
$\log(\text{\% Workforce with a College Degree}_f)$			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.

[29] The variables $Employment_f$, Age_f and *% Workforce with a College Degree*$_f$ have a fat right tail, so we take logs to reduce the skewness of the distribution.

In line with prediction P.1 of our model, the results of Table 1 confirm that better management practices lead to more delegation. Our findings are also consistent with the evidence in Bloom, Eifert, Mahajan, McKenzie, and Roberts (2013), which shows that an exogenous increase in management leads to more delegation.[30]

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.

Table 2: Delegation and Different Components of Management

Dependent variable is *Delegation*$_f$	(1)	(2)	(3)
Targets$_f$	0.092***	0.102***	0.096***
	(0.035)	(0.035)	(0.035)
Incentives$_f$	0.118***	0.122***	0.115***
	(0.035)	(0.035)	(0.035)
Operations & Monitoring$_f$	0.001	-0.018	-0.021
	(0.032)	(0.033)	(0.033)
log(Employment$_f$)			-0.060
			(0.040)
log(1+ Age$_f$)			0.031
			(0.020)
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.

In line with prediction P.1, the results reported in Table 2 show that delegation is positive correlated with the management practices that best capture M_H in our theoretical model

[30] 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.

(*Targets*$_f$ and *Incentives*$_f$). By contrast, the coefficient of the variable capturing the more technological component of management (*Operations & Monitoring*$_f$), is not statistically significant.[31]

5.2 Relationship between Integration, Delegation, and Management

We next assess the validity of the second prediction of our model, by regressing the delegation index against the vertical integration index:

$$\text{Delegation}_f = \beta_0 + \beta_1 \text{ Vertical Integration}_f + \beta_2 \mathbf{X}_f + \delta_j + \delta_c + \epsilon_{f,j,c}, \qquad (10)$$

where *Vertical Integration*$_f$ is the vertical integration index of firm f. As discussed in Section 3, our model suggests that the estimated coefficient β_1 should be positive and significant, but only if the vector $\mathbf{X}_f$ does not include the firm's management practices. If instead we control for management, β_1 should not be significantly different from zero.

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.

[31] We have also run specifications in which we included separately management practices covering operations and monitoring. The coefficients of these variables were insignificant.

The results are reported in Table 3. In line with prediction P.2 of our model, 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. Notice also that the estimated coefficient for *Management*$_f$ in column (6) of Table 3 (0.109) is almost identical to the corresponding coefficient in column (3) of Table 1 (0.111). As discussed in Section 3, this is also consistent with our theory, according to which vertical integration should have no direct effect on delegation choices.

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 7). 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.

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 2.1, 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.[32]

[32] 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. 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).

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

	(1)	(2)	(3)	(4)	(5)
Vertical Integration$_f$	0.388**	0.323*	0.272	0.284	0.249
	(0.189)	(0.190)	(0.190)	(0.193)	(0.193)
Operations & Monitoring$_f$		0.083***			-0.022
		(0.024)			(0.033)
Targets$_f$			0.135***		0.094***
			(0.025)		(0.035)
Incentives$_f$				0.154***	0.113***
				(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)	(0.040)
log(1+Age$_f$)	0.032	0.030	0.029	0.029	0.029
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
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	0.217	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.

5.3 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 prediction P.3 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 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 capability 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 independent 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 capability of input suppliers approximately follows a log-normal distribution, we can assess the validity of the prediction by running the following specification:

$$\text{Integration}_{f,i} = \gamma_0 + \gamma_1 \text{ CV Productivity}_{i,c} + \gamma_2 \text{ Mean Productivity}_{i,c} + \gamma_3 \text{ IO}_{ij} + D_f + D_i + \epsilon_{f,j,i,c} \quad (11)$$

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 independent 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.[33] We estimate (11) 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 consider the top 100 inputs (based on IO coefficients) necessary to produce the firm's output

[33] D_i captures characteristics of input industries that can affect integration decisions, e.g., the degree of contractibility. Country fixed effects are absorbed by the firm fixed effects, since each firm is associated to the location of its headquarters.

(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$_{i,j}$	0.04499***	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 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 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-5 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-6). The results are also robust to using the full WorldBase sample to study firms' integration decisions (see Table A-7).

5.4 Discussion

Sections 5.1-5.3 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-6). 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.

6 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.[34] 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.

[34] 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.

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.[35] 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.

References

Acemoglu, D., P. Aghion, R. Griffith, and F. Zilibotti (2010). "Vertical Integration and Technology: Theory and Evidence," *Journal of European Economic Association*, 8, 1-45.

Acemoglu, D., P. Aghion, C. Lelarge, J. Van Reenen, and F. Zilibotti (2007). "Technology, Information and the Decentralization of the Firm," *Quarterly Journal of Economics* 122, 1759-1799.

Acemoglu, D., S. Johnson, and T. Mitton (2009). "Determinants of Vertical Integration: Financial Development and Contracting Costs," *Journal of Finance* 63, 1251-1290.

Aghion, P., M. Dewatripont, and P. Rey (2002). "On Partial Contracting," *European Economic Review* 46, 745-753.

Aghion, P. and J. Tirole (1995). "Some Implications of Growth for Organizational Form and Ownership Structure," *European Economic Review* 39, 440-455.

_______(1997). "Real and Formal Authority in Organizations," *Journal of Political Economy* 105, 1-29.

Alfaro, L., P. Antràs, D. Chor, and P. Conconi (2015). "Internalizing Global Value Chains: A Firm-Level Analysis," NBER Working Paper 21582.

Alfaro, L., and A. Charlton (2009). "Intra-Industry Foreign Direct Investment," *American Economic Review* 99, 2096-2119.

Alfaro, L., A. Charlton, and F. Kanczuk (2009). "Plant-Size Distribution and Cross-Country Income Differences," In *NBER International Seminar on Macroeconomics 2008*, edited by J. A. Frankel and C. Pissarides. Cambridge, MA: National Bureau of Economic Research.

[35] 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.

Alfaro, P. Conconi, H. Fadinger, A. Newman (2016). "Do Prices Determine Vertical Integration?", *Review of Economic Studies* 83, 1-35.

Alonso, R., W. Dessein, and N. Matouschek (2008). "When does Coordination require Centralization?" *American Economic Review* 98, 145-179.

Antràs, P., and D. Chor (2013). "Organizing the Global Value Chain," *Econometrica* 81, 2127-2204.

Baker, G. R. Gibbons and K. Murphy (1999). "Informal Authority in Organizations," *Journal of Law Economics and Organization* 15, 56-73.

Baker, G., and T. Hubbard (2003). "Make Versus Buy in Trucking: Asset Ownership, Job Design and Information," *American Economic Review* 93, 551-572.

Bloom, N., B. Eifert, A. Mahajan, D. McKenzie, and J. Roberts (2013). "Does Management Matter? Evidence from India," *Quarterly Journal of Economics* 128, 1-51.

Bloom, N., L. Garicano, R. Sadun, and J. Van Reenen (2014). "The Distinct Effects of Information Technology and Communication Technology on Firm Organization,? *Management Science* 60, 2859-2885.

Bloom, N., R. Sadun, and J. Van Reenen (2010). "Does Product Market Competition Lead Firms to Decentralize?," *American Economic Review* 100, 434-438.

_______(2012). "The Organization of Firms Across Countries," *Quarterly Journal of Economics* 127, 1663-1705.

_______(2016). "Management as a Technology?," NBER Working Paper No. 22327.

Bloom, N., and J. Van Reenen (2007). "Measuring and Explaining Management Practices Across Firms and Countries," *Quarterly Journal of Economics* 122, 1351-1408.

Bolton, P. and M. Whinston (1993). "Incomplete Contracts, Vertical Integration, and Supply Assurance," *Review of Economic Studies 60*, 121-148.

Carlton, D. W. (1979). "Vertical Integration in Competitive Markets Under Uncertainty," *Journal of Industrial Economics*, 27, 189-209.

Coase, R. H. (1937). "The Nature of the Firm,"*Economica* 4, 386-405.

Conconi, P., P. Legros, and A. F. Newman (2012). "Trade Liberalization and Organizational Change," *Journal of International Economics* 86, 197-208.

Dessein, W. (2002). "Authority and Communication in Organizations," *Review of Economic Studies* 69, 811-838.

Dessein, W. (2014). "Incomplete Contracts and Firm Boundaries: New Directions" *Journal of Law Economics and Organizations* 30.

Dessein W., L. Garicano, and R.H. Gertner (2010), "Organizing for Synergies," *American Economic Journal: Microeconomics* 2, 77–114.

Fajgelbaum, P., G. M. Grossman, G., and E. Helpman (2015), “A Linder Hypothesis for Foreign Direct Investment,” *Review of Economic Studies* 82, 83-121.

Fan, J. P. H., and L. H. Lang (2000). “The Measurement of Relatedness: An Application to Corporate Diversification,” *Journal of Business* 73, 629-660.

Forbes, S. and M. Lederman (2010). “Does Vertical Integration Affect Firm Performance? Evidence from the Airline Industry,” *Rand Journal of Economics* 41, 765-790.

Friebel, G., and M. Raith (2010). “Resource Allocation and Organizational Form,” *American Economic Journal: Microeconomics* 2, 1-33.

Garicano, L. (2000). “Hierarchies and the Organization of Knowledge in Production,” *Journal of Political Economy* 108, 874-904.

Gates, D. (2013). “Boeing 787’s Problems Blamed on Outsourcing, Lack of Oversight,” *Seattle Times*, February 2, 2013.

Geanakoplos, J., and P. Milgrom (1991).“A Theory of Hierarchies Based on Limited Managerial Attention,” *Journal of the Japanese and International Economies* 5, 205-225.

Gibbons, R., and J. Roberts (2013). *The Handbook of Organizational Economics*, Princeton: Princeton University Press.

Grossman S. J., and O. D. Hart (1986). “The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration,” *Journal of Political Economy* 94, 691-719.

Grossman, G. M., and E. Helpman (2002), “Integration Versus Outsourcing In Industry Equilibrium,” *Quarterly Journal of Economics* 117, 85-120.

Guadalupe, M., and J. Wulf (2010). “The Flattening Firm and Product Market Competition: The Effect of Trade Liberalization,” *American Economic Journal: Applied Economics* 4, 105-127.

Hart, O. D., and B. R. Holmström (2010). “A Theory of Firm Scope,” *Quarterly Journal of Economics* 125, 483-513.

Hart, O. D., and J. H. Moore (1990). “Property Rights and the Nature of the Firm,” *Journal of Political Economy* 98, 1119-1158.

Hart, O. D., and J. H. Moore (2005). “On the Design of Hierarchies: Coordination versus Specialization,” *Journal of Political Economy* 113, 675-702.

Holmström, B. and P. Milgrom (1991). “Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design,” *Journal of Law, Economics and Organization* 7, 24-52.

Holmström, B., and J. Tirole (1991). “Transfer Pricing and Organizational Form.” *Journal of Law, Economics, and Organization* 7 (2), 201-28.

Hortaçsu, A., and C. Syverson (2007). “Cementing Relationships: Vertical Integration, Foreclosure, Productivity and Prices,” *Journal of Political Economy* 115, 250-301.

Joskow, P. (1987). “Contract Duration and Relationship-Specific Investments: Empirical Evidence from Coal Markets,” *American Economic Review* 77, 168-185.

Legros, P., and A. F. Newman (2008). “Competing for Ownership,” *Journal of the European Economic Association* 6, 1279-1308.

_______(2013). “A Price Theory of Vertical and Lateral Integration,” *Quarterly Journal of Economics* 128, 725-770.

_______(2015). “Integration, Delegation and Management,” mimeo

Levy, H. (1973). “Stochastic Dominance Among Log-Normal Prospects,” *International Economic Review* 14(3): 601-14.

Marin, D., and T. Verdier (2008). “Power Inside the Firm and the Market: A General Equilibrium Approach,” *Journal of the European Economic Association* 6, 752-788.

McDonald, R., and S. Kotha (2015). “Boeing 787: Manufacturing a Dream,” Harvard Business School Case 615-048.

McLaren, J. (2000). “Globalization and Vertical Structure,” *American Economic Review* 90, 1239-1254.

Milgrom, P., and J. Roberts (1990). “The Economics of Modern Manufacturing: Technology, Strategy and Organization," *American Economic Review*, 80: 511-528.

Powell, M. (2015). “An Influence-Cost Model of Organizational Practices and Firm Boundaries,”*Journal of Law, Economics, and Organization*, 31, i104-i140.

Rantakari, H. (2013), “Organizational Design and Environmental Volatility,” *Journal of Law, Economics, and Organization*, 29, 569-607

Roberts, J. (2007). *The Modern Firm: Organizational Design for Performance and Growth*, Oxford University Press.

Van den Steen, E. J. (2010) “Interpersonal Authority in a Theory of the Firm.” *American Economic Review* 100, : 466?490.

Williamson, O. (1975). *Markets and Hierarchies: Analysis and Antitrust Implications*, Free Press.

Woodruff, C. (2002). “Non-contractible Investments and Vertical Integration in the Mexican Footwear Industry,” *International Journal of Industrial Organization* 20, 1197-1224.

Woodward, J. (1958) *Management and Technology*. Cambridge: Cambridge University Press.

Zhao, Y., and X. Xu (2013). “Build-to-Performance: The Boeing 787 Dreamliner: A Case on Development Outsourcing and Supply Chain Management.”

Appendix

A-1 Proofs

Lemma 1 Direct computation yields

$$q_i^{I\prime}(M) = \int_0^{a_i^*(M)} \partial_M \pi_i(M, a_i, C) dG_i(a_i) + \int_{a_i^*(M)}^{\infty} \partial_M \pi_i(M, a_i, D) dG_i(a_i)$$
$$> \int_0^{\infty} \partial_M \pi_i(M, a_i, C) dG_i(a_i) > \int_0^{\infty} \partial_M \pi_i(M, a_i, N) dG_i(a_i) = q_i^{N\prime}(M).$$

The inequalities are direct consequences of Assumption 1 —differentiability and supermodularity of $\pi_i(M, a_i, o)$ in (M, o).

Lemma 2 From Topkis's monotonicity theorem, it is enough to prove that $W(I, M, A)$ is supermodular in (I, M) 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 $\{1, \ldots, n\}$; $\mathcal{P}_n$ 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 verify that the term $A \sum_I (q_i^I(M) - q_i^N(M)$ in expression (2) is supermodular. Let I, I' be arbitrary elements of $\mathcal{P}_n$ and $M, M' \in [0, \overline{M}]$. We show

$$A \sum_{I \cup I'} [q_i^I(M \vee M') - q_i^N(M \vee M')] + A \sum_{I \cap I'} [q_i^I(M \wedge M') - q_i^N(M \wedge M')]$$
$$\geq A \sum_I [q_i^I(M) - q_i^N(M)] + A \sum_{I'} [q_i^I(M') - q_i^N(M')]. \quad (12)$$

Consider the case $M' \geq M$. Since $A \geq 0$, (12) reduces to

$$\sum_{I \cup I'} [q_i^I(M') - q_i^N(M')] - \sum_{I'} [q_i^I(M') - q_i^N(M')]$$
$$\geq \sum_I [q_i^I(M) - q^N(M)] - \sum_{I \cap I'} [q_i^I(M) - q_i^N(M)].$$

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

$$\sum_{I \setminus (I \cap I')} [q_i^I(M') - q_i^N(M')] \geq \sum_{I \setminus (I \cap I')} [q_i^I(M) - q_i^N(M)], \tag{13}$$

Since the sets I and I' are arbitrary, (13) is true if and only if $q_i^I(M') - q_i^I(M) \geq q_i^I(M') - q_i^N(M)$, which follows from $q_i^{I'}(M) > q_i^{N'}(M)$ as established in Lemma 1.

If $I = I'$ or $M = M'$, then (13) holds with equality; otherwise, it holds strictly. The case $M > M'$ is similar, with the inequality in (13) 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 $q_i^I(M)$ and $q_i^N(M)$, and therefore their sums, are strictly increasing in M.

Strict Increasing Differences in (I,A). We need to show that for any $I' \subset I$, $W_A(I, M, A) = \sum_I q_i^I(M) + \sum_{I^C} q_i^N(M) > W_A(I', M, A) = \sum_{I'} q_i^I(M) + \sum_{I'^C} q_i^N(M)$. But $W_A(I, M, A) - W_A(I', M, A) = \sum_{I \setminus I'} [q_i^I(M) - q_i^N(M)] > 0$, since $q_i^I(M) > q_i^N(M)$ 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: 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

Table A-4: 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 1(ii)

Assumption 1(ii) in our theoretical model posits the supermodularity of the supplier contribution in management and organization, which in particular implies the marginal productivity of management should increase with 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 Assumption 1(ii), among others.

We can also assess the validity of Assumption 1(ii) 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 management elasticity of firm performance is not only positive, implying supermodularity (since management and performance are positive), but also increasing in delegation, suggesting someting stronger, namely log-supermodularity of management and delegation.

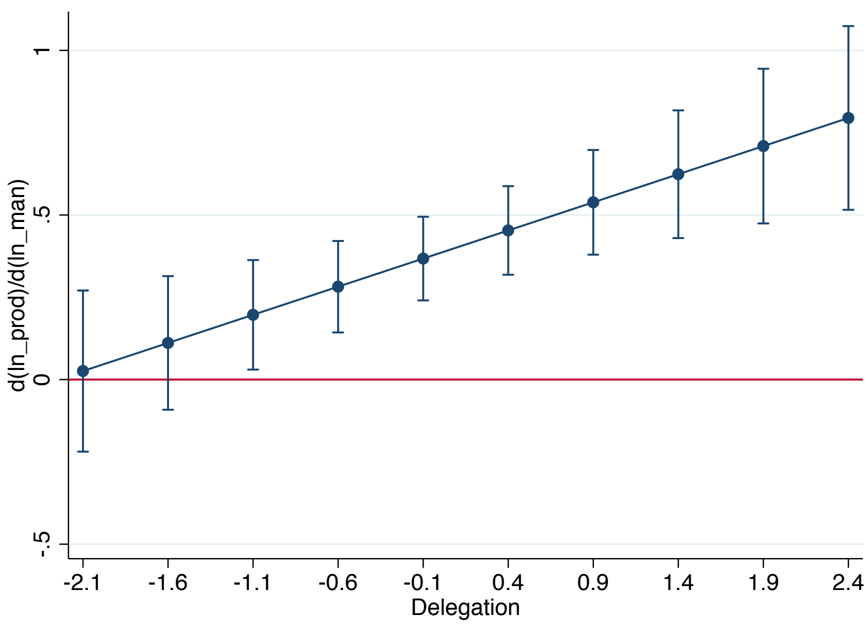


Figure A-1: Log-supermodularity of productivity in management and delegation

A-4 Additional Robustness Checks

Table A-5: 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 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 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 (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 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 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-7: Option Value of Integration (WorldBase Sample)

	(1)	(2)	(3)	(4)
CV Productivity$_{i,c}$	0.00032**	0.00031**	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$_f$)		0.00354***	0.00401***	
		(0.00025)	(0.00026)	
log(1+Age$_f$)		0.00088***	0.00007	
		(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 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 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.