# Come Together: Firm Boundaries and Delegation*

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May 2018

**Abstract**

Little is known theoretically, and even less empirically, about the relationship between firm boundaries and the allocation of decision rights within firms. We develop a model in which firms choose which suppliers to integrate and whether to delegate decisions to integrated suppliers. We test the predictions of the model using a novel dataset that combines measures of vertical integration and delegation for a large set of firms from many countries and industries. In line with the model's predictions, we obtain three main results: (i) integration and delegation co-vary positively; (ii) producers are more likely to integrate suppliers in input sectors with greater productivity variation (as the option value of integration is greater); and (iii) producers are more likely to integrate suppliers of more important inputs and to delegate decisions to them.

*Keywords*: Vertical integration, delegation, real options, supply assurance.

*An earlier version of this paper was circulated under the title "All Together Now: Integration, Delegation, and Management." We are grateful for comments from Philippe Aghion, Ricardo Alonso, Jacques Crémer, Wouter Dessein, Luis Garicano, Bob Gibbons, Oliver Hart, Francine Lafontaine, Rocco Macchiavello, Jawwad Noor, Andrea Prat, Mike Powell, Veronica Rappoport, Birger Wernerfelt, and participants in the FOM Conference, the Fifth CEPR IMO Workshop, the MIT Empirical Management Conference, ASSA (IOS Session), the Organizational Economics Workshop at Berkeley, EEA-ESEM, and seminars at UCLA, NUS, Oxford, Collegio Carlo Alberto, MIT, Mannheim, Nova SBE, PUC-Rio, Unversitat Autònoma de Barcelona, LSE, King's College London, Southampton, and HSE Moscow. The authors gratefully acknowledge financial support from the FNRS (Conconi), the DFG - CRC TR224 (Fadinger), and the European Research Council under the European Union's Seventh Framework Programme - ERC Grant Agreement N. 339950 (Legros).

# 1 Introduction

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

Notwithstanding these intellectual divides, decisions over integration and delegation are clearly interdependent. Outside the firm boundaries, suppliers retain control over those production decisions that cannot be guided by contract. Inside the boundaries, top management not only has authority to dictate decisions, but can also choose whether and to whom to delegate those decisions, often in response to information that arrives during the course of production. Management can also decide to intervene and take control of the production decisions of integrated suppliers, which is not an option if the suppliers are outside the firm boundaries. Failure to align these two elements of organizational design correctly can be disastrous: Boeing's infamous Dreamliner fiasco is a stark illustration of the consequences of underestimating these interdependencies.[1]

Although some studies have emphasized the conceptual difference between integration and delegation (Baker, Gibbons and Murphy, 1999; Hart and Holmström, 2010), there has been little theoretical work to operationalize these differences. And, to the best of our knowledge, there is no systematic empirical work along those lines. More broadly, as evidence mounts that organization matters for the performance of whole industries and aggregate

[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 Boeing 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 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." This gave rise to problems in design and compatibility and, according to company engineers, it 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 discussion of the Dreamliner case, see McDonald and Kotha (2015).

economies as well as individual firms (e.g., Hortaçsu and Syverson, 2007; Alfaro, Charlton, and Kanczuk, 2009; Forbes and Lederman, 2010; Bloom, Sadun and Van Reenen, 2012, 2016), it is becoming ever more imperative to understand the functioning of organizations as a whole rather than just their parts.

In this paper, we bring integration and delegation together, both theoretically and empirically. Building on earlier work by Legros and Newman (2013), we develop a theoretical model that allows us to jointly study these "twin organizational" design decisions. We then assess the evidence in light of the model, assembling a new dataset that contains information on vertical integration[2] (based on Alfaro, Conconi, Fadinger and Newman, 2016), and delegation (based on Bloom, Sadun and Van Reenen, 2012) for a sample with thousands of firms covering multiple countries and industries.

In our model, firm boundaries and the internal allocation of control are endogenous, the result of optimizing behavior by a headquarters (HQ) producing a final good. HQ has an exogenous "productivity," interpretable as a measure of entrepreneurial ability, product demand, or firm value. Production of the final good can use "generic" or "adapted" inputs. Inputs (e.g., the seats in an airplane, or a section of its fuselage) are more valuable if they are adapted to the final product (e.g., planes intended for sale to different carriers need different seats, which in turn vary by class of service; fuselage parts must be mutually adjusted with utmost precision in order to assemble a functioning aircraft). The nature and means of such investments are often difficult to specify contractually, because they are complicated to fully describe and often obscure until late in the course of production. Generic inputs rely only on the supplier's direction to produce, while adapted ones require coordinated investments by both HQ and the supplier. The supplier has low variable stakes in the enterprise profit, but bears the private costs of investments. If the transaction is at arms length, HQ has neither contracts nor authority to see the investments through, so only the generic version of the input is feasible. By contrast, if the supplier is integrated, HQ can exercise authority to elicit adaptation investments from the supplier.[3]

HQ first chooses which of its suppliers to integrate. She is ex-ante uncertain about the capability of suppliers to adapt inputs to her production needs and only learns this after she

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

[3]Indeed, part of Boeing's remedial reorganization for the Dreamliner was to acquire some of its suppliers (e.g. Vought, the supplier of rear fuselage assemblies) to have more direct control on the production of its inputs (Tang and Zimmerman, 2009).

has made the integration decision. At that point, she can decide which of the integrated suppliers she will centralize, retaining control over their production decisions, and to which of them she will delegate decision making. For non-integrated suppliers, by contrast, there is little question of delegation: the supplier retains control as part of his bundle of ownership rights. But his capability still plays a role, determining the value of the delivered generic input.

Because the rights of ownership acquired by the HQ under integration include the authority to delegate or centralize the adaptation process, integration has an option value. The model predicts that HQ will choose to delegate decisions to integrated suppliers when they are highly capable, and centralize otherwise. As a result, integration provides a form of supply assurance: with non-integration, low capability suppliers deliver low-value generic inputs; by allowing for the possibility of centralization, integration guarantees HQ at least a moderate level of input value, no matter the supplier's capability. Integration does come at a cost, however, because of the adaptation investments.

Since non-contractibility prevents HQ from internalizing the supplier's costs once the relationship begins, when she retains control, she always chooses the maximum possible adaptation investments for him, regardless of her own productivity or his capability. The result is the oft-cited "rigidity" of centralized decision making. But with delegation, there is an incentive problem, since HQ and the supplier have imperfectly aligned interests, leading to imperfectly coordinated decisions. Higher productivity attenuates this incentive problem, as the private costs of coordination weigh less heavily relative to the benefits in decision makers' calculations. The rigidity of centralization and the "flexibility" of the incentive response under delegation jointly imply that delegation will increase with the productivity of the HQ.

A more productive HQ also has stronger incentives to integrate suppliers. As HQ's productivity increases, integration becomes relatively more productive than non-integration (both because adapted inputs are more valuable than generic ones, and because of the incentive response of delegation) and the costs of integration decline (because centralization becomes less likely). For a more productive HQ, the efficiency gains of integration are thus more likely to offset the costs, in line with the "value theory" of integration developed in Legros and Newman (2013) and Alfaro, Conconi, Fadinger and Newman (2016).

Both the propensity to integrate suppliers within the firm boundaries and the propensity to delegate decisions to integrated suppliers should thus increase in the productivity of the HQ, which yields our first testable prediction: *integration and delegation should co-vary positively*, or equivalently integration and centralization should move in opposite directions. This result underscores a fundamental conceptual distinction between delegation and non-integration. Delegation is a non-contractible act of relinquishing control that can in principle be revoked at will by managerial fiat. Non-integration, by contrast, is the result of a formal sale of assets (Baker, Gibbons, and Murphy, 1999). "One-dimensional" organizational models that focus on the allocation of control have a hard time distinguishing between complete non-integration and complete delegation: both would seem to put decisions as far removed from the "center" as possible. From the perspective of such models, it would seem that integration and delegation ought to covary negatively. Contrary to this presumption, our model predicts a positive covariation between integration and delegation.[4]

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

Finally, the value theory logic predicts that *integration and delegation should depend on the technological importance of the inputs*: suppliers that contribute more to enterprise value are more likely to be integrated. Among the integrated suppliers, more decisions will be delegated to those which provide more important inputs.

We show that the predictions of the theoretical model are remarkably consistent with the features of the novel dataset we have put together, which allows us to measure the extent of delegation within firms as well as the degree of vertical integration. Data on delegation come from the survey of Bloom, Sadun, Van Reenen (2012), who have interviewed plant managers on the degree of autonomy granted to them by central headquarters. To measure vertical integration, we use WorldBase, a plant-level dataset covering millions of firms in many countries, which allows to link plants belonging to the same firm via a common-ownership identifier. Using the methodology employed in Alfaro, Conconi, Fadinger and Newman (2016), we combine information on reported production activities with detailed input-output data to measure the share of inputs used in the production of a firm's final good that can be produced in house. Our matched sample consists of 2,661 firms, corresponding to 3,444 plants, operating in 574 industries and 20 countries.

We find that plant-level delegation is robustly positively correlated with our measure of firm-level vertical integration. Our estimates imply that moving vertical integration from the 10th to the 90th percentile is associated with an increase in delegation by around 0.13 standard deviations. These results hold up in our baseline regressions and in a series of

[4]This result also holds true more broadly, including settings that allow for richer financial contracting possibilities, renegotiation, and strategic interaction among suppliers (see Legros and Newman, 2015).

robustness checks (e.g., including different sets of fixed effects and controls, using different samples of firms).

To test the option-value prediction, we compute the coefficient of variation of labor productivity of independent suppliers in each upstream-industry-country pair using information from millions of plants in WorldBase. A higher coefficient of variation captures a more risky productivity distribution of suppliers in an input industry, which according to our model should increase the option value of integrating a supplier in that industry. In line with this prediction, we find that the probability to vertically integrate a given input varies positively and robustly with the riskiness of the productivity distribution of suppliers. A one-standard-deviation increase in the coefficient of variation of suppliers' labor productivity increases the probability to vertically integrate a given input by around 39 percent. This finding is extremely robust and holds for different sets of fixed effects and samples.

Our empirical results also confirm the role of the technological importance of the inputs for integration and delegation choices. Using input-output coefficient to proxy for the importance of each input, we find that final good producers are indeed more likely to integrate suppliers of more important inputs, and to delegate more decisions to these suppliers.

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

Our work is related to two main streams of literature, which focus on each of the organizational choices we bring together in this paper. First, we build on the vast literature on firm boundaries. Theoretical studies have looked at inter alia the technological/contractual determinants of vertical integration (e.g., Coase, 1937; Grossman and Hart, 1986; Hart and Moore, 1990; Holmström and Milgrom, 1991; Hart and Holmström, 2010). The view of integration in our model is similar to that of Williamson (1975), and puts it in the "ex-post non-contractible" branch of incomplete-contracts economics (e.g., the 2002 version of Hart and Holmström, 2010; Aghion, Dewatripont and Rey, 2002; Legros and Newman, 2008, 2013; Dessein, 2014). Another strand has focused on market determinants (e.g., McLaren, 2000; Grossman and Helpman, 2002; Legros and Newman, 2008; Conconi, Legros and Newman, 2012). In this vein, Legros and Newman (2013, 2017) develop a "value theory" of firm boundaries, closely related to the model presented here, that emphasizes how product value helps determine the propensity for firms to vertically or laterally integrate. Empirical studies have tried to shed light on these determinants using firm-level data within specific industries (e.g., Joskow, 1987; Woodruff, 2002; Baker and Hubbard, 2003; Hortaçsu and Syverson, 2007), countries (e.g., Acemoglu, Aghion, Griffith and Zilibotti, 2010), or across countries (e.g., Acemoglu, Johnson and Mitton, 2009; Alfaro and Charlton, 2009; Alfaro, Conconi, Fadinger and Newman, 2016). Recent contributions study integration decisions along value chains (Antràs and Chor, 2013; Alfaro, Antràs, Chor, and Conconi, 2017).

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

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

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

# 2 The Model

## 2.1 Production

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

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

where the contribution $\pi_{ij}v_i$ of supplier $i$ depends on the technologically determined importance of the input $\pi_{ij}$ for producing good $j$, as well as the value $v_i$ generated by the supplier. This value will depend partly on whether the input is adapted to HQ's specific needs, the result of an uncertain process that depends on the capabilities of the supplier and HQ as well as on investments and production decisions that are determined by the organizational environment, as discussed below. For now we will consider the relationship between HQ and a typical supplier and suppress the index notation.

Inputs can either be *generic* or *adapted*. If the input is generic, the value generated by the supplier is $v = y$, where $y \geq 0$ is his "capability," a random variable with distribution $F(y)$ and $\mathbb{E}y \leq 1$ ($\mathbb{E}$ is the expectation operator). A generic input therefore contributes value $A\pi y$ to the enterprise.

For an input to be adapted, the supplier must first make a fixed investment at private cost $\phi$. For example, he may go through lengthy meetings and plant visits to learn about specific features of the final good, take training courses that instill the final good producer's brand or reputation, or simply move to the HQ's premises. After the investment, the adaptation process itself involves actions, such as design and process modifications in response to problems, that are performed by the supplier ($s \in [0,1]$) and by HQ ($h \in [0,1]$). These need to be coordinated for adaptation to be successful. To model the coordination problem, we follow Legros-Newman (2013), and suppose that adaptation succeeds (yields a return) with probability $p(s,h) = 1 - (s-h)^2$, and fails (yields zero) otherwise. HQ and the supplier have opposing preferences about how to carry out adaptation and find it costly to accommodate the other's approach (this could be due to differences in background, technologies, or "vision," possibly arising from the fact that they are in different industries). Specifically, HQ has private cost $(1-h)^2$, while the supplier has private cost $cs^2$ ($c > 0$). Hence, HQ prefers the decision to be close to $h = 1$, while the supplier likes the adaptation decision to be close to $s = 0$. Typically, we would expect $c$ to be small, as HQ's practices or brand identity would matter more than that of a small component of her product.

The value of the adapted input depends on who decides which actions to perform. HQ has a capability that we normalize to 1, thereby weakly exceeding, on average, the capability of the supplier. If HQ chooses the action $s$ as well as $h$, the expected contribution from the adapted input is $A\pi p(s,h)$. However, if the supplier chooses $s$, the expected value is $A\pi y p(s,h)$, reflecting his capability $y$.[5] Summarizing, let $\mathbb{D}$ (for delegation) be the indicator

[5] We do not consider the case in which the supplier is permitted to choose $h$; this could be supposed to be technologically infeasible, but it can also be shown that HQ would never choose to delegate the $h$ decision to $S$ under the payoff and contractibility assumptions we make.

function taking value 1 if the supplier chooses $s$ for the enterprise, and value 0 if HQ does; let $\mathbb{I}$ be the indicator whether the initial fixed investment is made. Then the expected supplier contribution is

$$\mathbb{E}v = \mathbb{I}p(s,h)(\mathbb{D}y + 1 - \mathbb{D}) + (1 - \mathbb{I})y.$$

## 2.2 Contracting and Timing

We assume that contracting is limited to fixed monetary payments and transfers of ownership. In particular, payments contingent on adaptation decisions or outcomes are not possible (e.g., because they are not observable or, if they are, they are not verifiable by third parties). Moreover, only aggregate output, and not the (relatively small) contribution of individual suppliers, is contractible, so that profit shares would provide no meaningful incentives. Neither the fixed investment, nor the adaptation decisions are contractible. Nor is the identity of the decision maker (hence the delegation decision) contractible .

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

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

Contracting occurs between HQ and all of the suppliers $S_i$ simultaneously. First, HQ chooses the firm boundaries, by deciding which suppliers to integrate (the transfer can be interpreted as the asset purchase price in this case). Crucially, when making this choice, she does not yet know what their capabilities are, only the distributions $F_i(y)$. She can then invoke the authority garnered from ownership to force all integrated suppliers to make the initial adaptation investment, but she has no such authority over the non-integrated ones. After learning the capability of the suppliers, HQ can decide to which of the integrated ones she delegates the adaptation process.[6]

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

1. Contracting: integration decision and monetary transfer.

[6] Leaning about the capability of non-integrated suppliers may be possible, but is also useless, given that HQ cannot force the initial adaptation investment on them.

2. Adaptation investment choice at supplier cost $\phi$.

3. Supplier capability $y$ observed by HQ and $S$.

4. Delegation decision if the supplier is integrated.

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

6. Output realized.

## 2.3 Ownership Structures

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

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

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

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

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

$$v^C(A, \pi) = A\pi. \tag{3}$$

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

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

Notice that the function $v^D(A, \pi, y)$ is supermodular, increasing, and strictly convex in $A$, $\pi$ and $y$, as well as zero if any of its arguments is zero.

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

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

From (3) and (4), $y^*(A\pi)$ is the unique positive solution to $A\pi(y^2 - y) = 1$. It is (i) greater than 1 (HQ's capability) and (ii) decreasing in $A$.[7] The reason for property (i) is that delegation suffers from an incentive distortion, since HQ and the supplier make their decisions independently, while centralization suffers relatively little (in this model, not at all) from incentive distortions. In order to compensate for the incentive loss, it takes a supplier capability strictly higher than HQ's to convince her to delegate. Property (ii) results from the relative rigidity of centralization: the decision there is the same regardless of $A$ (or $\pi$), whereas with delegation, decisions improve with firm value because of the incentive response (in this case HQ's). Thus, the value of delegation is more elastic with respect to $A$ than is the value of centralization, implying that an HQ with a higher $A$ is more willing to delegate.

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

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

Anticipating the measure of delegation in our empirical analysis, which is continuous rather than binary, suppose there are many tasks $t \in \{1, \ldots, T\}$ that need to be performed in order to adapt the input. The lemma can be generalized as follows. On each task the capability of the supplier is a random variable $y + \epsilon_t$, where $y$ has distribution $F$ and $\epsilon_t$ are i.i.d., with distribution $G(\epsilon)$ and mean zero, while HQ has capability 1 on all tasks and can separately delegate or retain control over each task. Each task contributes equally and additively to the overall supplier value, and costs of decision on each task are weighted by $1/T$. Then, the capability $x_t \equiv y + \epsilon_t$ has distribution given by the convolution $C(x_t) = \int_0^\infty G(x_t - y) f(y) dy$, and we know from the previous analysis that the probability of delegation on task $t$ is $1 - C(y^*(A\pi))$, increasing in $A$. The *degree of delegation* is the number or the fraction of tasks that are delegated. It is a binomial random variable with parameters $(1 - C(y^*(A\pi)), T)$, stochastically increasing in $A$. Hence, as $A$ increases, the expected degree of delegation

[7] The second property is true for any function $v^D(A, \pi, y)$ which is convex in $A$ and increasing in $A, y$.

increases (details in the Appendix).

## Firm Boundary Choices

At the contracting stage, HQ determines whether to integrate each supplier $S$. The total surplus of an integrated relationship is (returning now to the single-task-per-input version of the model)

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

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

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

The left-hand side is the option value of integration, which is increasing in $A\pi$. While the value of both ownership structures increase with $A\pi$, integration increases faster than non-integration because of the incentive response under delegation.[8] Meanwhile, since $y^*(A\pi)$ is decreasing, the integration cost on the right-hand side decreases in $A\pi$. It follows that the propensity to integrate a supplier is increasing in the productivity $A$ and in the technological importance $\pi$:

**Lemma 2.** *(i) If an HQ in industry $j$ with productivity $A$ integrates a supplier in industry $i$ then an HQ in industry $j$ with productivity $A' > A$ will also integrate a supplier in industry $i$. (ii) holding $F$, $c$, and $\phi$ fixed across input industries, if an HQ in industry $j$ integrates a supplier from industry $i$, she also integrates suppliers from industries $k$ for whom $\pi_{kj} > \pi_{ij}$.*

A corollary of result (i) is that the set of integrated suppliers will increase (in the set inclusion order) as $A$ increases. That is, if an HQ with productivity $A$ integrates a set $I(A) \subset$

[8] To see this, keep things simple by supposing $\pi$ is fixed at 1, and consider marginal increases in $A$. Non-integration value increases by $\partial_A V^N = \mathbb{E}y \leq 1$. The marginal increase in the integration return $\mathbb{E}\max[v^C(A,\pi), v^D(A,\pi,y)]$ is $F(y^*(A)) + (1-F(y^*(A)))\mathbb{E}|_{y\geq y^*(A)}[\partial_A v^D(A,1,y)]$. Supermodularity of $v^D$ ensures $\partial_A v^D(A,1,y)$ is increasing in $y$, so it is sufficient that $\partial_A v^D(A,1,y^*(A)) > 1$ for the conditional expectation, thus the marginal increase in integration revenue, to exceed 1 and therefore $\partial_A V^N$. But this last condition follows from the definition of $y^*(A)$, convexity in $A$, and $v^D(0,1,y) = 0$.

$\{1, 2, \ldots, n\}$, then, all else equal, an HQ with productivity $A' > A$ integrates a superset $I(A') \supseteq I(A)$. We call the union $\{\text{HQ}\} \cup I$ a *firm*.

In the empirical analysis, the degree of vertical integration for a firm present in industry $j$ is the sum $VI(A) \equiv \sum_{i \in I(A)} \pi_{ij}$. Lemma 2 (i) implies that the degree of vertical integration is an increasing function of $A$. Since the degree of delegation is also an increasing function of $A$, firms with a more productive HQ have stronger incentives both to integrate suppliers and to delegate the adaptation process to them. We can thus state our first main result:

**Proposition 1.** *The degree of delegation and the degree of vertical integration covary positively across firms.*

Thus result generalizes straightforwardly to the case of multiple tasks (see the Appendix for details).

## 2.4 Option Value of Integration

In our model, integration creates an option value. Namely, if the supplier turns out to be of low capability (low $y$), the producer is able to ensure at least a minimal level of input contribution by directing the production process herself. Such an option is not available under non-integration wherein the producer is entirely reliant on the supplier's capabilities.

Following intuition from real option theory, this observation suggests that riskiness of suppliers will influence integration decisions. Consider a family of distributions $\{F(y; \sigma);\ \sigma \in [\underline{\sigma}, \overline{\sigma}]\}$, $0 < \underline{\sigma} < \overline{\sigma} < \infty$, where higher $\sigma$ indicates greater Rothschild-Stiglitz riskiness, and let $\mathbb{E}_\sigma$ denote the expectation operator when the distribution of $y$ is $F(y; \sigma)$.

The option value $R(A\pi; \sigma) \equiv \mathbb{E}_\sigma \max[v^C(A, \pi), v^D(A, \pi, y)] - A\pi\mathbb{E}_\sigma y$ is increasing in the risk $\sigma$, since the integrand of the first term is convex in $y$, while by definition the second term is independent of risk. It follows that whenever $\partial_\sigma F(y^*(A\pi); \sigma)$ is non positive, the likelihood that the integration condition (7) is satisfied increases with $\sigma$, since the cost of integration is falling along with its growing value. Since $\mathbb{E}_\sigma y \leq 1 < y^*(A\pi)$, this will be the case for all single-crossing symmetric unimodal families of distributions (e.g., uniform, triangular, normal, symmetric beta). For other families, cost also declines over some ranges of $\sigma$, and even when it does not, integration increases with risk as long as the cost parameter $c$ is small enough.[9]

We can then state our second main result:

[9] Specifically, a sufficient condition when $\partial_\sigma F(y^*(A\pi); \sigma)$ is positive is that $c < \frac{\partial_\sigma R(A\pi;\sigma)}{\partial_\sigma F(y^*(A\pi);\sigma)}$, which always holds for some interval of positive costs $(0, \overline{c})$, since $\partial_\sigma R(A\pi; \sigma)$ and $1/\partial_\sigma F(y^*(A\pi); \sigma)$ (and therefore their product) are uniformly bounded away from 0 on $[\underline{\sigma}, \overline{\sigma}]$. For lognormal families with common means (where the

**Proposition 2.** *For single-crossing, symmetric, unimodal capability distributions or small supplier cost parameters, if a supplier is integrated at risk $\sigma$, he will also be integrated at risk $\sigma' > \sigma$.*

Our model thus suggests that an increase in risk in input industries should increase the incentives of final good producers to integrate suppliers in those industries. In our empirical analysis we will proxy the distribution of $y$ by the empirical distribution of labor productivity of suppliers who are not integrated.[10] We will use the coefficient of variation of this distribution in each input industry to capture the degree of uncertainty in the ability of suppliers.[11]

## 2.5 Testable Predictions

We conclude this section by summarizing the key predictions of our model that we bring to the data. The first testable prediction follows directly from Propositions 1 and 2:

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

P.2: Final good producers should have a higher propensity to integrate inputs when the capability of suppliers in the input industry is more uncertain.

According to our model, delegation and integration decisions should also vary across suppliers, depending on the technological importance of their inputs. A corollary of Lemma 1 is that HQ should have stronger incentives to delegate decisions to suppliers of more important inputs, i.e. with larger $\pi_{ij}$. The reason for this is that the cutoff value $y^*(A\pi_{ij})$ is decreasing in $\pi_{ij}$; then larger $\pi_{ij}$ implies more delegation, just as larger $A$ does. Similarly, Lemma 2 (ii) implies that HQ should be more likely to integrate suppliers of more important inputs.

Our model thus delivers two additional predictions that we can bring to the data:

P.3: Final good producers should delegate more tasks to suppliers of more important inputs.

P.4: Final good producers should be more likely to integrate suppliers of more important inputs.

index $\sigma$ is interpretable as the standard deviation of $\ln y$; see Levy (1973)), for instance, there appears to be very little variation, even when it is positive, in the probability of integration over a wide range of $\sigma$ values consistent with our data, implying that the small-cost condition is easily satisfied. Details available upon request.

[10] In the case of integrated suppliers, observed labor productivity will not only reflect their ability, but also the productivity of HQ ($A$) and her organizational choice to delegate or centralize productive decisions.

[11] The effect of changes in the mean is ambiguous. Even if the distribution increases in the first order sense, so that the integration cost on the right hand side of (7) decreases, the change in option value on the left hand side is ambiguous because both $\mathbb{E}\max[v^C(A,\pi,y), v^D(A,\pi,y)]$ and $A\pi\mathbb{E}y$ increase.

# 3 Dataset and Variables

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

## 3.1 Datasets

### World Management Survey

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

The WMS survey was conducted by telephone without telling the managers they were being scored on organizational or management practices. This enabled scoring to be based on the interviewer's evaluation of the firm's actual organizational practices, rather than their aspirations, the manager's perceptions or the interviewer's impressions. Second, the interviewers were not informed of the firm's financial information or performance in advance of the interview. This was achieved by selecting medium sized manufacturing firms and by providing only firm names and contact details to the interviewers (but no financial details). The survey tool is thus "double blind" – managers do not know they are being scored and interviewers do not know the performance of the firm. Third, each interviewer ran 85 interviews on average, allowing for removal of interviewer fixed effects from all empirical specifications. This helps to address concerns over inconsistent interpretation of responses. Fourth, information on the interview process itself (duration, day-of-the-week), on the manager (seniority, job tenure and location), and on the interviewer (for removing analyst fixed effects and subjective reliability score) was collected. These survey metrics are used as "noise controls" to help reduce residual variation.

The sampling frame was drawn from each country to be representative of medium sized manufacturing firms. The main wave of interviews was run in the summer of 2006, followed by smaller waves in 2009 and 2010.[12]

The WMS dataset contains around 10,000 plants in 20 countries. As discussed in detail in Section 3.3 below, we use the survey to construct our delegation measure, as well as

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

additional plant-level controls included in our regressions.

**WorldBase**

The other dataset used in our empirical analysis is the WorldBase by Dun & Bradstreet, which provides coverage of public and private firms for more than 24 million plants in more than 200 countries and territories.[13]

The WorldBase dataset has been used extensively in the literature (e.g. Alfaro and Charlton, 2009; Acemoglu, Johnson and Mitton, 2009; Alfaro, Conconi, Fadinger, and Newman 2016; Alfaro, Antràs, Chor, and Conconi, 2017).[14] The unit of observation in the dataset is the establishment/plant (namely a single physical location where industrial operations or services are performed or business is conducted). Each establishment in WorldBase is identified by a unique nine-digit sequence called Data Universal Numbering System (DUNS) number. WorldBase also provides information about the year of establishment and the location of each plant, its basic performance (employment, sales, etc.), as well as its primary and secondary production activities, classified based on the U.S. Standard Industrial Classification (SIC) Manual (1987 edition).

WorldBase allows us to trace ownership linkages between establishments. In particular, for non-single establishment firms, we can use DUNS numbers to link all plants that have the same domestic of global parent. D&B defines a parent as a corporation that owns more than 50 percent of another corporation. In our baseline regressions, we link all plants that have the same domestic parent, as in Alfaro, Conconi, Fadinger, and Newman 2016.[15]

In our analysis, we use the 2005 WorldBase dataset. When focusing on the 20 countries that are also included in the WMS, this dataset contains 1,028,939 domestic ultimates. As discussed below, we combine this dataset with information from Input-Output tables to construct firm-level measures of vertical integration. We use the additional information provided by WorldBase to construct auxiliary firm-level controls (e.g., employment, age).

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

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

[15] A "Domestic Ultimate" is a subsidiary within the global family tree which is the highest ranking member within a specific country and is identified by a "domuduns" code. A "Global Ultimate" is the top most responsible entity within the global family tree and is identified by "gluduns" code. The two codes only differ in the case of multinationals firms.

## 3.2 Matched Sample

Combining WorldBase and the WMS, we construct a matched sample, which includes 2,661 firms in 20 countries, operating in 574 sectors (primary SIC codes of the firm), corresponding to 3,444 plants.[16] For the US and Canada we linked plants interviewed in the WMS to plants in WorldBase using a common plant identifier (the DUNS number). For the remaining countries, we did not have a common plant identifier available, so we used a string matching algorithm to link plants in WMS to plants in WorldBase using location information and company names. We then manually checked the results of the matching process. Finally, we used ownership information from Worldbase to assign any matched plant to a firm via the domestic parent.

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

## 3.3 Main Variables

### Delegation

In the WMS, plant managers were asked four questions on delegation from the central headquarters to the local plant manager.[17] First, they were asked how much capital investment they could undertake without prior authorization from the corporate headquarters. This is a continuous variable enumerated in national currency that is converted into dollars using PPPs. Plant managers had then to state the degree of autonomy they had in three other dimensions: (a) the introduction of a new product, (b) sales and marketing decisions, and (c) hiring a new full-time permanent shop floor employee. These more qualitative variables were scaled from a score of 1 (defined as all decisions taken at the corporate headquarters), to a score of 5 (defined as complete autonomy granted to the plant manager). Since the scaling may vary across questions, we have standardized the scores from the four autonomy questions to z-scores, by normalizing each question to mean zero and standard deviation one. The variable $Delegation_{f,p}$ is the average across the four z-scores for plant $p$ belonging to firm $f$.

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

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

**Vertical Integration**

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

As mentioned above, the unit of observation in WorldBase is the establishment/plant, a single physical location at which business is conducted or industrial operations are performed. For each establishment, we use different categories of data recorded in WorldBase:

1. Industry information: the 4-digit SIC code of the primary industry in which each establishment operates, and the SIC codes of up to five secondary industries.
2. Ownership information: information about the firms' family members (number of family members, domestic parent and global parent).[18]
3. Location information: country of each plant.
4. Additional information: sales, employment, age.

We combine information on plant activities and ownership structure from WorldBase with input-output data to construct a firm-level vertical integration index. The methodology used to construct this measure is based on Fan and Lang (2000) and has been used in several empirical studies on firm boundaries (e.g. Acemoglu, Johnson and Mitton, 2009; Alfaro, Conconi, Fadinger, and Newman, 2016; Alfaro, Antràs, Chor, and Conconi, 2017). Given the difficulty of finding highly disaggregated input-output matrices for all the countries in our dataset, we follow Acemoglu, Johnson and Mitton (2009) and Alfaro and Charlton (2009) in using the U.S. input-output tables to provide a standardized measure of input requirements for each output sector. U.S. input-output (IO) tables should be informative about input flows across industries to the extent that these are determined by technology.[19]

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.[20]

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

[19] The assumption that the U.S. IO structure carries over to other countries introduces some measurement error in the construction of the vertical integration index defined below, which can bias our empirical analysis against finding a significant relationship between delegation and integration. Moreover, using U.S. IO tables to construct vertical integration indices for other countries mitigates the possibility that the IO structure is endogenous.

[20] We use the Use of Commodities by Industries after Redefinitions 1992 (Producers' Prices) tables. While the BEA employs six-digit input-output industry codes, WorldBase uses the SIC industry classification. We convert

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

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

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

which is the sum of the IO coefficients for each input industry in which firm $f$ is active. This index measure the fraction of inputs used in the production of a firm?s final good that can be produced in house.[21] 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 reports two secondary activities, Fabricated Metal Structures (SIC 3441) and Sheet Metal Work (SIC 3444). The $IO_{ij}$ coefficients for these sectors are:

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

The 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

the IO table to the 4-digit SIC 1987 classification, using the concordance guide provided by the BEA. For codes for which the match is not one-to-one, we have randomized between possible matches. The multiple matching problem, however, is not particularly relevant when looking at plants operating in the manufacturing sector (for which the key is almost one-to-one).

[21] Alternatively, we could normalize input-output coefficients by the total sector-specific intermediate share to make them sum to unity for each sector. Since we include output-sector fixed effects in our empirical specifications, such sector-specific normalization is absorbed by the fixed effects.

in which it owns a plant (or reports a secondary activity). The $IO_{ij}$ coefficient for fabricated metal structures to ships is 0.0281, indicating that 2.8 cents worth of metal structures are required to produce a dollar's worth of ships. The firm is treated as self-sufficient in the listed inputs but not any others, so its vertical integration index *Vertical integration*$_f$ is the sum of these coefficients, 0.0294: about 2.9 cents worth of the inputs required to make a dollar of primary output can be produced within the firm.[22]

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

To test predictions 3 and 4, we use the variable $IO_{ij}$, the input-output coefficient (direct requirement coefficient) at the 4-digit SIC level for the sector pair $ij$ taken from the US input-output tables.

**Riskiness of Input Industries**

To assess the validity of the second prediction of our model, we need to verify how uncertainty in the productivity of suppliers in an input industry affects a firm's integration choices. To identify the relevant inputs, we again use the input-output data from the BEA. For every firm $f$ producing good $j$ located in country $c$, we focus on the top 100 inputs $i$ as ranked by the IO coefficients $IO_{ij}$.

It is well known that if distributions are lognormal with a common mean, greater risk in the Rothschild-Stiglitz sense is equivalent to a higher coefficient of variation (Levy, 1973). Given that the distribution of productivity of input suppliers approximately follows a lognormal distribution, we can make use of this observation in the empirical analysis by constructing the variables *CV Productivity*$_{i,c}$, the coefficient of variation (standard deviation/mean) of productivity of suppliers in input industry $i$ located in country $c$, and *Mean Productivity*$_{i,c}$, the arithmetic average of suppliers' productivity. We construct these variables using information on the labor productivity of all independent (i.e., non-integrated) firms.[23] We consider

[22] 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. As a result, firms will be measured as at least somewhat vertically integrated. To control for this, in the empirical analysis, we will include output industry fixed effects.

[23] As mentioned before, in the case of an integrated supplier, his observed labor productivity will not only reflect his ability ($y_i$), but will also how productive HQ is ($A$) and whether or not she delegates the adaptation decision

all suppliers present in the 20 countries considered by the WMS using the full WorldBase dataset (around 15 million independent firms) with primary sector $i$ located in country $c$.

In some robustness checks, we restrict the analysis to input industries in which we have at least 50 independent suppliers in industry $i$ country $c$ to construct *CV Productivity*$_{i,c}$ or construct the uncertainty measure after winsorizing labor productivity at the 5th and 95th percentile.

Testing our model's predictions requires measures that capture the difficulty to assess the quality of suppliers in an input industry $i$, which is fixed but ex-ante unknown (rather than measures capturing stochastic supplier's quality, which is fully observable but keeps changing over time). The advantage of using the measure *CV Productivity*$_{i,c}$ is that it can be constructed at the SIC 4 level for all the 20 countries in our sample. We also experiment with two alternative measures capturing cross-sectional variation in firm performance within SIC 4 industries. These variables are taken from Bloom, Floetotto, Jaimovich, Saporta, and Terry (2018) and are only available at the SIC4 level for the United States and for manufacturing inputs. The first is *SD Stock Returns*$_i$, which is the cross-sectional standard-deviation of the mean annual return for each firm within each input industry. The second is *SD Output Growth*$_i$, which is the cross-sectional standard-deviation of real sales growth in each input industry.[24]

### Additional Controls

Using information from WorldBase, we construct auxiliary firm-level controls. These include *Employment*$_f$, the total number of employees of the firm, and *Age*$_f$, the number of years since its establishment. *Labor Productivity*$_f$, which measures sales per worker of the parent firm.

The auxiliary plant-level controls drawn from the WMS data include the number of employees of the plant (*Employment*$_p$), and the education of the workforce, defined as the percentage of a plant's employees who have a bachelor's degree or higher (*% Workforce with College Degree*$_p$). In some specifications, we also control for a plant's adoption of basic management practices, using the methodology developed in Bloom and Van Reenen (2007) and extended in Bloom, Sadun and Van Reenen (2016). Figure A-2 in the Appendix lists these practices and gives a sense of how each was measured on a scale from 1 to 5. Our

to the supplier (see footnote 10). Transfer pricing incentives may also distort the measure of labor productivity for integrated suppliers. Nevertheless, we have verified that our results are robust to including integrated suppliers in the construction of the measure *CV Productivity*$_{i,c}$.

[24] The data for these variables are available on-line at `http://www.stanford.edu/~nbloom/RUBC.zip`. We use data for 2005, the same year as our WorldBase dataset.

overall measure of the quality of a firm's management practices, $Management_p$, is simply the average of the 18 individual management dimensions, after each has been normalized to a z-score (with a mean of zero and a standard-deviation of one).[25]

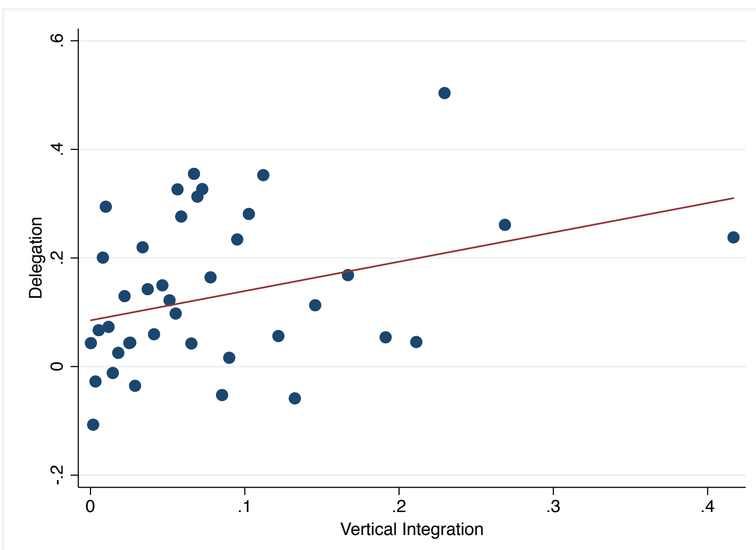
# 4 Empirical Results

## 4.1 Delegation Choices

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

A first look at the data suggests that more vertically integrated firms tend indeed to delegate more decisions to their plant managers (see binned scatterplot of Figure 1).[26]

Figure 1: Delegation and Vertical Integration




[25] In some specifications, we have also used the individual components of the plant's management practices: $Operations_p$, which measures the adoption of lean management practices; $Monitoring_p$, which measures the adoption of practices related to performance monitoring and review; $Targets_p$, which measures the adoption of practices related to targets setting and review; and $Incentives_p$, which measures the adoption of practices related to the management of human capital, including monetary and non-monetary incentives.

[26] Figure 1 is created by grouping *Vertical Integration* into 40 equal-sized bins, computing the mean of the *Vertical Integration* and *Delegation* variables within each bin, then creating a scatterplot of these data points.

To more systematically assess the first prediction of our model, we estimate the following:

$$\text{Delegation}_{f,p,i,j,c} = \beta_1 \text{ Vertical Integration}_{f,j,c} + \beta_2 \mathbf{X}_p + \beta_3 \mathbf{X}_f + \delta_i + \delta_j + \delta_c + \epsilon_{f,p,i,j,c}. \quad (9)$$

The dependent variable is the degree of autonomy granted to plant $p$ (with primary activity $i$, located in country $c$) by the parent firm $f$ (with primary activity $j$, located in country $c$). The main control of interest is *Vertical Integration*$_{f,i,c}$, the vertical integration index of firm $f$. According to the first prediction of our theoretical model, the estimated coefficient $\beta_1$ should be positive and significant. $\mathbf{X}_p$ and $\mathbf{X}_f$ are vectors of plant- and of firm-level controls, while $\delta_i$, $\delta_j$ and $\delta_c$ are input-sector, output-sector (at the 3-digit SIC level), and country fixed effects.[27] We include input-sector (output-sector) fixed effects to control for the average amount of delegation to a given input industry (by a given output industry).[28] We cluster standard errors at the firm level.

The results of estimating (9) are reported in columns 1-3 of Table 1. Column 0 presents the results of the most parsimonious specification, in which we simply regress *Delegation*$_{f,p,i,j,c}$ against our key control of interest, *Vertical Integration*$_{f,j,c}$, without including any other controls. In line with prediction P.1 of our model, the estimated coefficient of *Vertical Integration*$_f$ is positive and significant (at the five-percent level). In column 1 we add country and input-industry fixed effects. Again, the estimated coefficient of interest is positive and significant (at the one-percent level). This result continues to hold when we further include output-industry fixed effects (column 2), and control for the size and age of the parent firm, as well as the size and level of education of the plant's workforce (column 3).[29]

In terms of quantitative implications, the point estimates reported in column 2 of Table 1 indicate that, as we move from the 10th percentile to the 90th percentile of *Vertical Integration*$_f$, delegation increases by around 0.13 standard deviations.[30]

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

[28] For the vast majority of firms, we observe delegation for a single plant, so we cannot include firm fixed effects.

[29] The variables *% Workforce with College Degree*$_p$ and *Employment*$_p$ are missing for a few plants. To avoid dropping observations, in the specifications in which we include these variables, we replace missing values with -99 and use a dummy variable to control for these instances.

[30] The 10th percentile of *Vertical Integration*$_f$ is 0.006 and the 90th percentile is 0.198, thus (0.198-0.006)*0.691=0.132.

# Table 1

## Delegation Choices

| | (0) | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|
| Vertical Integration$_f$ | 0.540** | 0.794*** | 0.691*** | 0.554** | 0.754*** | 0.628** | 0.473* |
| | (0.220) | (0.244) | (0.250) | (0.249) | (0.245) | (0.254) | (0.253) |
| log(Employment$_f$) | | | | -0.086** | | | -0.100** |
| | | | | (0.042) | | | (0.044) |
| log(Age$_f$) | | | | 0.035* | | | 0.048** |
| | | | | (0.021) | | | (0.022) |
| log(Employment$_p$) | | | | 0.111*** | | | 0.113*** |
| | | | | (0.023) | | | (0.023) |
| log(% Workforce with College Degree$_p$) | | | | 0.055*** | | | 0.056*** |
| | | | | (0.016) | | | (0.017) |
| IO$_{ij}$ | | | | | 0.862** | 0.852* | 0.949** |
| | | | | | (0.372) | (0.449) | (0.444) |
| Country FE | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | No | Yes | Yes | No | Yes | Yes |
| Input FE | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Noise controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 3,444 | 3,444 | 3,444 | 3,444 | 3,179 | 3,179 | 3,179 |

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

It should be stressed that the positive coefficient of *Vertical Integration*$_f$ should not be interpreted in a causal sense, i.e., more integration leading to more delegation. Rather, our model suggests that integration and delegation choices are endogenously correlated, because firms that have a more productive HQ (higher $A$) have stronger incentives to integrate suppliers and delegate production decisions to them.[31]

To verify how the technological importance of an input affects delegation choices, we further include in regression (9) the input-output coefficient $IO_{ij}$. The results are reported in columns 4-6 of Table 1. Across all specifications, the coefficient of $IO_{ij}$ is positive and highly significant. This confirms prediction P.3, according to which final good producers should be more likely to delegate decisions to suppliers of more important inputs.[32] In terms of magnitude, based on the estimates reported in column 5, increasing the input-output coefficient by one standard deviation increases delegation by around 0.05 standard deviations.[33] Notice that the coefficient of *Vertical Integration*$_f$ remains positive and significant, confirming that more integrated firms give more autonomy to their suppliers, in line with prediction P.1.[34]

Concerning the auxiliary controls in Table 1, we find that firms delegate more when their plant is larger and has a more educated workforce, a result that continues to hold in all the robustness checks we have carried out on the delegation results. The coefficients of the firm-level variables *log(Employment*$_f$*)* and *log(Age)*$_f$ are significative (negative and positive, respectively) in Table 1, but their sign and significance is not always robust.

We have carried out a series of additional robustness checks to verify the validity of predictions P.1 and P.3. The results are reported in the Appendix. First, the coefficients of our key variables of interest, *Vertical Integration*$_f$ and $IO_{ij}$, remain positive and significant when we use more disaggregated industry fixed effects (defined at the SIC4 level instead of SIC3) to control for the primary activities of the plant and its parent firm (see Table A-3).[35]

Second, the results of Table 1 are robust to restricting the analysis to the 10 largest countries in our sample, i.e. those that have the highest number of firms (see Table A-4).

Third, the results of Table 1 continue to hold when controlling for labor productivity of

[31] If we had a good proxy for the exogeneous ability of the HQ, we could include it as a control when estimating (9). Based on our theory, the correlation between delegation and vertical integration should then become insignificant. As discussed at the end of this section, in some of the robustness checks, we control for labor productivity of the parent firm. However, this is a not a good proxy for $A$, among other reasons because it is contaminated by $y$, the realized capability of suppliers.

[32] Following the same specifications as in columns 1-3, we have clustered standard errors at the firm level. Results are practically identical if we cluster at the industry-pair level (the level of variation of the IO coefficient).

[33] The standard deviation of $IO_{ij}$ is 0.05, so 0.852*0.055=0.047.

[34] As expected given the positive correlation between $IO_{ij}$ and *Vertical Integration*$_f$, the magnitude of the coefficient of the overall vertical integration index drops slightly when we control for the input-output coefficient.

[35] The main drawback is that we lose some observations, which are absorbed by the fixed effects.

the parent firm (see A-5). Notice that the coefficients of *Vertical Integration*$_f$ and *IO*$_{ij}$ remain positive and significant. The coefficient of *Productivity*$_f$ is positive but not significant. Recall that, according to our model, the reason why delegation and vertical integration should be correlated is that both should be increasing in $A$, which captures exogenous characteristics of the HQ that increase the profitability of the enterprise (e.g., product appeal, entrepreneurial ability of the CEO). The results of Table A-5 suggest that nominal labor productivity of the parent firm is a poor proxy for $A$, the underlying productivity of the HQ. Our model suggests that one reason for this is that the measure of labor productivity of the firm also reflects $y$, the realized capability of suppliers.

Finally, one may be concerned about measurement error in the vertical integration index. In an influential study, Atalay, Hortaçsu, and Syverson (2014) find little evidence of intra-firm shipments between related plants within the United States. This suggests that using Fan and Lang (2000)'s methodology to construct *Vertical Integration*$_f$ may lead us to mis-classify some inputs as being integrated, when the firm is actually sourcing them from the market. Random measurement error in the vertical integration index should work against us, by attenuating the coefficient $\beta_1$, making it harder to find support for prediction P.1. Nevertheless, we have verified that the positive relationship between delegation and vertical integration holds even when we restrict the analysis to single-plant firms (see Table A-6).[36] For these firms, measurement error in the vertical integration index should be less of a concern, since it is unlikely that a parent would not use the inputs produced in its own establishment.

## 4.2 Integration Choices

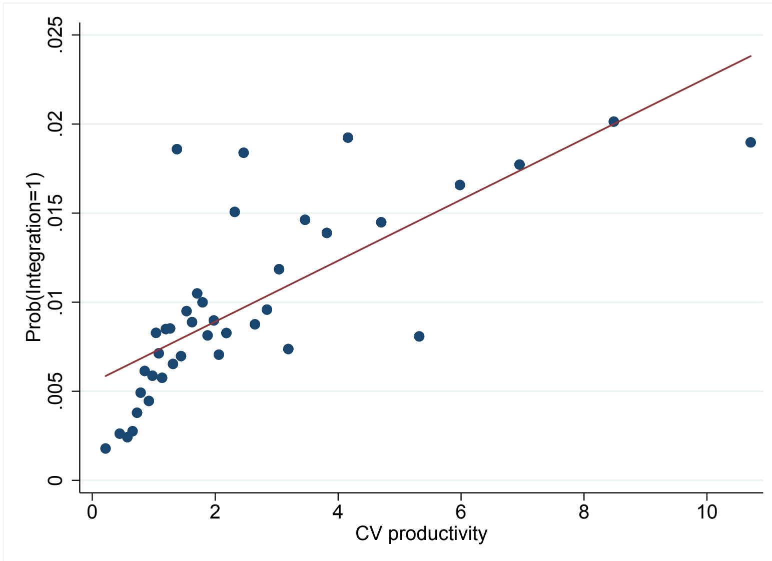
In our model, ex-ante uncertainty about suppliers' capability creates an option value of integration, because HQ can decide whether and to which suppliers to delegate decisions. In this section, we focus on integration choices, which occur before capability realizations and delegation decisions.

According to prediction P.2 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. A first look at the data suggests that the likelihood that a producer integrates a particular input

[36] In these regressions, we do not include *IO*$_{ij}$: in the small sample of single-plant firms, the correlation between *IO*$_{ij}$ and *Vertical Integration*$_f$ is 0.4523 (instead of 0.2522 in our main sample), so there is little variation in the importance of integrated inputs, once we control for *Vertical Integration*$_f$ and industry fixed effects. Notice also that we can only include one set of industry fixed effects (given that the primary SIC code of the parent firm coincides with the primary SIC code of the plant) and one employment variable (given that the number of employees of the plant and the firm are the same).

increases with the uncertainty in suppliers' productivity in the input industry (see Figure 2).[37]

Figure 2: Integration Probability and Riskiness of Input Industry




To more systematically assess the validity of the second prediction of our model, we estimate the following linear probability model:

$$\text{Integration}_{f,j,i,c} = \gamma_1 \text{ CV Productivity}_{i,c} + \gamma_2 \text{ Mean Productivity}_{i,c} + \gamma_3 \mathbf{X}_f + \delta_i + \delta_f + \epsilon_{f,j,c,i}. \quad (10)$$

The dependent variable is *Integration*$_{f,j,i,c}$, which is equal to 1 if firm $f$ (with primary activity in sector $j$ and located in country $c$) integrates input $i$ within its boundaries. The key control of interest is *CV Productivity*$_{i,c}$, which captures the degree of uncertainty in the capability of suppliers faced by the firm ex-ante, before deciding whether or not to integrate a particular input. As explained in Section 3.3, this variable is constructed using information on the labor productivity of all independent firms with primary sector $i$ in country $c$. We control for *Mean Productivity*$_{i,c}$, the mean of suppliers' productivity in each country-input-sector; given the approximate lognormality of productivity distributions, this ensures that *CV Productivity*$_{i,c}$ orders distributions by risk in the Rothschild-Stiglitz sense. $\mathbf{X}_f$ is a vector of firm-level controls, while $\delta_i$ denotes input-industry fixed effects at the 4-digit SIC level. In the most demanding specifications, we include firm fixed effects ($\delta_f$), which allow us to account for the role of unobservable firm characteristics. In alternative specifications, we replace firm

[37]Figure 2 is created by grouping *CV productivity* into 40 equal-sized bins, computing the mean of the *CV productivity* and *Delegation* variables within each bin, then creating a scatterplot of these data points.

fixed effects with output-sector and country fixed effects ($\delta_j$ and $\delta_c$). We cluster standard errors at the input-industry $i$ level, since the main variable of interest varies at the input-industry-country level.

According to prediction P.2 of our model, the estimated coefficient of *CV Productivity*$_{i,c}$ should be positive and significant. Greater uncertainty in suppliers' productivity implies that by integrating an input, 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 integration more likely. Notice that, it is the possibility of delegation that generates the option value of integration. However, ex-post (realized) delegation (which is what our survey data measures) cannot have a causal impact on integration, and thus is not included in our regressions.

The baseline results are reported in columns 1-4 of Table 2. We include the 2,661 firms in the matched sample and consider the top 100 inputs (based on the IO coefficients) necessary to produce the firm's output (see also Alfaro, Antràs, Chor, and Conconi, 2017).[38] We first specification includes only our key control of interest, *CV Productivity*$_{i,c}$ (column 0). We then further add country and input fixed effects (column 1), output fixed effects (column 2), and additional firm-level controls (column 3).[39] In the last specification, we include firm fixed effects, exploiting only within-firm variation across inputs to identify how the riskiness of suppliers affects integration choices (column 4).[40]

In all specifications, the estimated coefficient for *CV Productivity*$_{i,c}$ is positive and highly significant. This finding is consistent with prediction P.2 of our model, according to which higher uncertainty in the productivity of suppliers should increase the option value of integration. As for the economic magnitude of the effect, based on the specification in column 2, a one-standard-deviation increase in *CV Productivity*$_{i,c}$ increases the probability of integrating with a supplier by around 0.27 percentage points, which corresponds to a 27 percent increase compared to the baseline probability of one percent.[41] Concerning the auxiliary controls, we find that the propensity to integrate inputs is higher in firms that are larger and have a less educated workforce.

[38]The unit of observation in these regressions is the firm-input level. Notice that number of observations is 249,471, which is less than 2,661 firms * 100 inputs = 266,100. This is because there are not enough firms by country-sector to construct *CV Productivity*$_{i,c}$ for each country-sector pair.

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

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

[41]The standard deviation of *CV Productivity*$_{i,c}$ is 4.685. Thus, 0.267=0.00057*4.685*100.

# Table 2

## Integration Choices

| | (0) | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|---|
| CV Productivity$_{i,c}$ | 0.00076*** | 0.00062*** | 0.00057*** | 0.00057*** | 0.00056*** | 0.00062*** | 0.00057*** | 0.00056*** | 0.00056*** |
| | (0.00017) | (0.00015) | (0.00014) | (0.00014) | (0.00015) | (0.00015) | (0.00014) | (0.00014) | (0.00015) |
| log(Employment$_f$) | | | | 0.00671*** | | | | 0.00672*** | |
| | | | | (0.00040) | | | | (0.00040) | |
| log(1+ Age$_f$) | | | | -0.00007 | | | | -0.00009 | |
| | | | | (0.00028) | | | | (0.00028) | |
| IO$_{ij}$ | | | | | | 0.07702*** | 0.12626*** | 0.12829*** | 0.13752*** |
| | | | | | | (0.01188) | (0.01495) | (0.01485) | (0.01592) |
| Country FE | No | Yes | Yes | Yes | - | Yes | Yes | Yes | - |
| Input FE | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | No | Yes | Yes | - | No | Yes | Yes | - |
| Firm FE | No | No | No | No | Yes | No | No | No | Yes |
| N | 249,471 | 249,471 | 249,471 | 249,471 | 249,471 | 249,471 | 249,471 | 249,471 | 249,471 |

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

To assess the validity of prediction P.4 of our model, in columns 5-8 of Table 2 we re-estimate the linear probability model (10) including the input-output coefficient as a covariate. Across all specifications, $IO_{ij}$ is positive and significant, confirming that final good producers are more likely to produce in house more important inputs. In particular, according to the specification in column 6, moving the input-output coefficient by one standard deviation increases the probability to vertically integrate the supplier of this input by 0.44 percentage points – a 44 percent increase compared to the baseline probability of one percentage point.[42] The coefficient of $\textit{CV Productivity}_{i,c}$ remains positive and significant, in line with the prediction P.2 of our model.

We have carried out a series of additional robustness checks to verify the validity of predictions P.2 and P.4. The results are reported in the Appendix. First, we have verified that the results of Table 2 continue to hold if we construct the uncertainty measure after winsorizing labor productivity at the 5th and 95th percentile (see Table A-7).

Second, we have restricted the analysis to input industries in which there are at least 50 suppliers in each input industry-country, for which $\textit{CV Productivity}_{i,c}$ can be measured more precisely. The results confirm that producers are more likely to integrate suppliers when they face more uncertainty about their capability and when they produce more important inputs (see Table A-8).

Third, we have verified that the results of Table 2 are robust to using different samples of firms and countries. The coefficients of our key variables of interest, $\textit{CV Productivity}_{i,c}$ and $IO_{ij}$, remain positive and significant if we restrict the analysis to the 10 largest countries in our sample (see Table A-9), and when we use the larger WorldBase sample (see Table A-10).[43]

Fourth, as mentioned before, the results of Atalay, Hortaçsu, and Syverson (2014) suggest that using the methodology of Fan and Lang (2000) may lead us to mistakenly classify some inputs as being sourced from plants owned by the parent, whereas they are actually bought on the market. In the regressions of Table 2, this would imply a measurement error in the dependent variable $\textit{Integration}_{f,j,i,c}$. In turn, this should make our coefficient estimates less precise, making it harder to find support for our model's predictions. The coefficient for *CV*

[42] The standard deviation of $IO_{ij}$ is 0.035. Thus, 0.126*0.035*100=0.441.

[43] In this robustness check, we include in our analysis all parent firms in the WorldBase dataset that i) have a primary SIC code in manufacturing (between SIC 2000 and 3999), ii) have integrated at least one input different from their primary SIC code, iii) are located in the same 20 countries as the firms in the matched sample, and iv) have at least 20 employees. This gives us 67,106 parent firms. When running regression (10) on this sample, we cannot include the variable $\textit{log(\% Workforce with College Degree}_p\textit{)}$, which comes from the World Management Survey and is thus only available for firms in the matched sample.

*Productivity*$_{i,c}$ is always positive and highly significant. Nevertheless, we have verified that the results continue to hold when we restrict the analysis to all single-establishment firms in WorldBase, for which measurement error in the dependent variable should be less of a concern (see Table A-11).

Fifth, one may be concerned that the results on the role of input risk may be driven by omitted variables correlated with *CV Productivity*$_{i,c}$. Table A-12 shows that the results of Table 2 are robust to including additional controls that vary at the input industry-country level. We have also included input industry-country sector fixed effects, exploiting cross-firm variation to identify the role of input risk. In particular, we have used information about the quality of a firm's management practices. We would expect the option value of integration to be larger for firms with better management practices, to the extent that these practices make it easier to enforce adaptation of production decisions and monitor suppliers under centralization. Indeed, the results of Table A-13 show that the coefficient of the interaction between *CV Productivity*$_{i,c}$ and *Management*$_f$ is positive and significant. Crucially, this result is robust to including input sector-country fixed effects to account for omitted variable concerns (see columns 5 and 10).

Finally, we have experimented with alternative measures of uncertainty in the ability of input suppliers: the cross-sectional standard-deviation of stock market returns and the cross-sectional standard-deviation of real sales growth; as described in Section 3.3, these measures are only available for the United States. In Table A-14, we verify that our results are robust to focusing on US firms in our matched sample, for which we can use the three uncertainty measures (*CV Productivity*$_i$, *SD Stock Returns*$_i$ and *SD Output Growth*$_i$). Notice that the number of observations is much smaller than in our benchmark regressions (less than 4,000 observations when using *SD Output Growth*$_i$, compared to almost 250,000 observations in Table 2). Also, given that the uncertainty measures vary at the input industry level (rather than at the input industry-country level), we cannot include input and country fixed effects. Notwithstanding these limitations, the results of Table A-14 confirm our model's predictions about integration choices: final good producers are more likely to integrate inputs when the capability of suppliers in the upstream sector is more uncertain (the coefficients of the three uncertainty measures are always positive and significant); and final good producers are more likely to produce in house more important inputs (the coefficient of the variable *IO*$_{ij}$ is aways positive and significant).[44]

[44] The results are unaffected if we include the firm-level controls: the coefficients of our main variables of interest remain positive and significant; of the firm controls, only *Employment*$_f$ has a significant (positive) coefficient.

## 4.3 Alternative Mechanisms

Our empirical analysis establishes the following regularities:

1. Firms that delegate more tend to be more vertically integrated.
2. Firms are more likely to integrate "riskier" inputs, i.e., industries in which supplier productivity is more dispersed.
3. Final good producers are more likely to delegate decisions to integrated suppliers of more important inputs.
4. Final good producers are more likely to integrate suppliers of more important inputs.

These results are consistent with the predictions of our theoretical model, in which integration enhances efficiency and creates a real option for HQ to retain control or delegate according to comparative advantage. Below we discuss other possible explanations for our findings.

The covariation of delegation and integration might be rationalized by models in which headquarter's attention is a scarce corporate resource (e.g., Geanakoplos and Milgrom, 1991; Aghion and Tirole, 1995). If vertical integration increases the scope of decisions in a firm, HQ may simply need to cede control to lower-level managers.

We believe that theories of limited managerial capacity do not provide a rationale for our empirical findings. There are three reasons for this. First, the positive correlation between delegation and integration is robust to controlling for the size of the firm as captured by its total number of employees.

Second, these theories would view delegation and management as substitutes, to the extent that good management reduces headquarters' overload. To address this, we have included in regression (9) controls for the quality of a plant's management practices. The results reported in Table 3 suggest that delegation and management are complements rather than substitutes: the better the plant's management practices the higher is the degree of autonomy given to plant-level managers.[45] Also, if good management reduces headquarters' overload, the partial correlation between delegation and vertical integration should become larger once we control for the quality of management. Instead, we find that the coefficient of $\textit{Vertical Integration}_f$ becomes *smaller* when we control for management.[46]

[45] We have also tried substituting the variable $\textit{Management}_p$ with its four components (see footnote 25 for their definition). In these specifications, we find that only the management practices related to providing targets and incentives to personnel ($\textit{Targets}_p$, and $\textit{Incentives}_p$) are significantly correlated with the degree of autonomy granted to the plant manager.

[46] The coefficients of $\textit{Vertical Integration}_f$ reported in columns 1 and 2 (3 and 4) are statistically different from each other at the 5% level (10% level).

The third reason for skepticism is that theories of limited managerial capacity have little to say about the other empirical regularities, particularly how the riskiness and technological importance of the inputs affect integration choices.

Table 3

Delegation Choices, Controlling for Management

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Vertical Integration$_f$ | 0.517** | 0.504** | 0.473* | 0.441* |
| | (0.249) | (0.249) | (0.253) | (0.253) |
| log(Employment$_f$) | -0.086** | -0.076* | -0.100** | -0.089** |
| | (0.042) | (0.042) | (0.044) | (0.045) |
| log(Age$_f$) | 0.035* | 0.033 | 0.048** | 0.046** |
| | (0.021) | (0.021) | (0.022) | (0.022) |
| log(Employment$_p$) | 0.111*** | 0.086*** | 0.113*** | 0.089*** * |
| | (0.023) | (0.023) | (0.023) | (0.024) |
| log(% Workforce with College Degree$_p$) | 0.055*** | 0.042*** | 0.056*** | 0.044** |
| | (0.016) | (0.016) | (0.017) | (0.017) |
| Management$_p$ | | 0.087*** | | 0.083*** |
| | | (0.021) | | (0.022) |
| IO$_{ij}$ | | | 0.949** | 0.940** |
| | | | (0.444) | (0.444) |
| Country FE | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | Yes |
| Input FE | Yes | Yes | Yes | Yes |
| Noise controls | Yes | Yes | Yes | Yes |
| N | 3,444 | 3,444 | 3,179 | 3,179 |

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

We have described our model as exhibiting a kind of "supply assurance" motive for integration: the ability to centralize control under integration affords the HQ at least a moderate level of input value, even if her supplier turns out to be quite inept. Note that it is *interim* uncertainty (after production begins, but before the input is produced) that is hedged here, and it predicts our empirical finding that input risk increases integration propensities. But that result might be explained by other, "ex-post," forms of supply assurance (e.g., Carlton, 1979; Bolton and Whinston, 1993; Baker, Gibbons, and Murphy, 2002). In these models, firms also integrate in order to guarantee a stable supply of inputs. But the assurance motive for integration is driven by uncertainty resolved after input production (e.g., product demand), possibly augmented by the supplier's hold-up behavior. 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 ex-post assurance motives 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 (see Table A-8), albeit with somewhat diminished magnitude (the difference in the coefficients is significant at the 5% level). This is also true in the specification in which we include firm fixed effects, which account for demand for inputs by other firms in the same country-output sector (column 4), while output industry fixed effects in other columns control for product market uncertainty.

Thus, while ex-post supply assurance models may go part way toward explaining the response of integration to uncertainty, there remains considerable scope for interim assurance to motivate integration. Of course, a more fundamental difference between our model and the ex-post assurance theories is that they have little to say about our empirical findings concerning delegation levels and their interplay with firm boundaries.

# 5 Conclusion

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

Yet non-integration and delegation are conceptually distinct. Non-integration is formal, delegation informal.[47] And if there are many types of decisions that must be made, non-

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

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

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

We hope the exercise is an encouraging illustration of what can be learned by bringing together disparate elements of organizational design, as well as datasets rich enough to measure them, within a single framework. Our analysis emphasizes the importance of understanding the conceptual distinction between integration and centralization, as well as their interrelatedness. For example, the empirical literature on delegation studies the degree of autonomy granted to integrated plants/suppliers. Our theoretical model and empirical results suggest that integrated suppliers are more likely to operate in riskier industries, to produce more important inputs, and to have more productive HQs. These selection effects can bias the conclusions of empirical studies on delegation, which abstract from prior integration choices.

Some of our empirical results also raise new questions about the interactions of integration and delegation with other aspects of organization. For example, we find that firms in which central headquarters give more autonomy to their subordinates tend to adopt better management practices. Moreover, the propensity to integrate in the face of greater supply uncertainty is enhanced by better management practices. It would be interesting to explore the mechanisms behind these apparent complementarities between management and the aspects of organizational design we have considered here, both theoretically and empirically. More broadly, an understanding of how choices of management practices depend on the organizational environment, and how these decisions affect firm performance, is an important avenue for future research.

intervention in many matters, in particular who will make various business decisions.

# 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 (2017). "Internalizing Global Value Chains: A Firm-Level Analysis," forthcoming, *Journal of Political Economy*.

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.

Alfaro, L., 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.

Atalay, E., A. Hortaçsu, and C. Syverson (2014), "Vertical Integration and Input Flows," *American Economic Review* 104, 1120-1148.

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

_______(2002). "Relational Contracts and the Theory of the Firm,? *Quarterly Journal of Economics*, 117 (1), 39-84.

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., M. Floetotto, N. Jaimovich, I. Saporta, and S. Terry (2018). "Really Uncertain Business Cycles," forthcoming, *Econometrica*.

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.

Certo, S.C. and S.T. Certo (2012). *Modern Management* 12th ed. Prentice Hall.

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.

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.

———(2017). “Demand-Driven Integration and Divorcement Policy,” *International Journal of Industrial Organization,* 53, 306-325.

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.

Tang, C.S., J. D. Zimmerman, and J. Nelson (2009). “Managing New Product Development and Supply Chain Risks: The Boeing 787 Case,” *Supply Chain Forum: An International Journal*, 10 (2), 74-86.

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 Multiple Tasks Extension

Without loss of generality, set $\pi = 1$. As stated in the text, suppose that adaptation involves a fixed set $T$ of steps or tasks $t$, and that the overall value of the input is the average of the values of each task. The capability of supplier $S$ on each task is $y + \epsilon_t$, where the $\epsilon_t$ are i.i.d. across $t$ and independent of $y$, with distribution $G(\epsilon)$, density $g(\epsilon)$, and $\mathbb{E}\epsilon = 0$. The $\epsilon_t$ as well as the single draw of $y$ are realized and observed before task assignment. We think of the distribution of task-specific capability $G$ as independent of input $i$, while the overall capability $F$ depends on $i$ as before. HQ always has capability 1.

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

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

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

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

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

$$v_t(A, y+\epsilon_t) = \begin{cases} A, & \text{if } y+\epsilon_t \leq y^*(A) \\ v^D(A, 1, y+\epsilon_t), & \text{if } y+\epsilon_t > y^*(A). \end{cases}$$

Under non-integration the adaptation tasks do not enter, since there is no adaptation; in particular, non-integration's value is still governed by the random variable $y$, $V^N$ remains $A\mathbb{E}y$. We can then reformulate our main results as follows:

**Proposition 3.** *In the tasks model, the propensity to integrate increases with $A$ and its option value increases in the riskiness of $F(y)$.*

*Proof.* Using the change of variable $x_t = y + \epsilon_t$, there is integration if:

$$\frac{1}{T}\sum_t \mathbb{E}v_t(A, x_t) - V^N > C(y^*(A))c + \phi. \tag{11}$$

**Integration increases with $A$.** As in the baseline model, $C(y^*(A))$ is a decreasing function of $A$. Therefore, it is enough to show that the left hand side is an increasing function of $A$, a sufficient condition being that each term $\mathbb{E}v_t(A, x_t) - V^N$ is increasing in $A$; since $\partial_A V^N = \mathbb{E}y \leq 1$, it is enough that $\partial_A \mathbb{E}v^D(A, x_t)$ exceed 1. Since $\mathbb{E}v_t(A, x_t) = AC(y^*(A)) + \int_{y^*(A)}^{\infty} v^D(A, 1, x_t)dC(x_t)$, the same argument as in footnote 8, using convexity and zero-at-zero of $v^D$in $A$, and supermodularity in $(A, x_t)$, yields the result.

**Option value increases with riskiness.** Each term in the option value sum $\frac{1}{T}\sum_t \mathbb{E}v_t(A, x_t) - V^N$ can be written $\int_{-\infty}^{\infty} g(\epsilon_t)\left[\int_0^{\infty} \max\{A, v^D(A, 1, y + \epsilon_t)\}f(y)dy\right] d\epsilon_t - V^N$. For each fixed $\epsilon_t$, our argument in section 2.4 ensures that the integral in brackets, is increasing in the riskiness of $y$, while $V^N$ remains constant. It then follows that the expectation with respect to $\epsilon_t$ of this integral, hence the left hand side of (11), is also increasing in the riskiness of $y$. 

For the propensity to integrate to increase with risk, the challenges are similar to those in the baseline model to ensure that the cost of integration $C(y^*(A))c$ does not increase too quickly. Note though that now a simpler sufficient condition can be invoked for Proposition 2: the distribution of the noise $G(\epsilon_t)$ has a decreasing density. Indeed, in this case $G(x - y)$ is concave in $y$, and therefore riskier $F(y)$ distributions reduce the probability of centralization $C(y^*(A)) = \int_0^{\infty} G(y^*(A) - y)dF(y)$.

## A-2 Descriptive Statistics

Table A-1

Descriptive Statistics of Matched Sample

| | Mean | Median | Standard deviation | N. observations | N. firms |
|---|---|---|---|---|---|
| Delegation$_p$ | 0.13 | 0.07 | 0.99 | 3,444 | 2,661 |
| Employment$_p$ | 254.11 | 150.00 | 367.23 | 3,387 | 2,661 |
| % Workers with College Degree$_p$ | 15.20 | 10.00 | 16.34 | 3,225 | 2,661 |
| Management$_p$ | 3.05 | 3.06 | 0.65 | 3,444 | 2,661 |
| Age$_f$ | 40.08 | 30.00 | 35.02 | 3,444 | 2,661 |
| Vertical Integration$_f$ | 0.10 | 0.08 | 0.08 | 3,444 | 2,661 |
| Integration$_{f,i}$ | 0.01 | 0.00 | 0.10 | 249,479 | 2,661 |
| CV Productivity$_{i,c}$ | 2.88 | 1.78 | 4.69 | 249,479 | 2,661 |
| IO$_{i,j}$ | 0.04 | 0.04 | 0.036 | 249,479 | 2,661 |

*Notes:* The table reports descriptive statistics of all the variables used in our main regressions on delegation and integration choices (see Tables 1- 3 in the body of the paper). *Delegation*$_p$, is the overall autonomy index of plant $p$. *Employment*$_p$ measures the plant's employment. *% Workforce with College Degree*$_p$ is the percentage of the plant's employees with a bachelor's degree or higher. *Management*$_p$ is the normalized z-score capturing the quality of the plant's management practices. *Employment*$_f$ measures the number of employees of firm $f$. *Age*$_f$ is the number of years since the firm was established. *Vertical integration*$_f$ is the vertical integration index of firm $f$. *Integration*$_{f,i}$ is a dummy equal to 1 if firm $f$ integrates input $i$ within its boundaries. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the independent suppliers in input industry $i$ located in country $c$. *IO*$_{i,j}$ is the IO coefficient capturing the importance of input $i$ in the production of good $j$.

## 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 |

*Notes:* The table reports the number of observations by country for our matched sample of firms.

## Figure A-1: Survey on Delegation

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

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

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

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

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

Notes: (a) Ignore form-filling

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

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

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

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

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

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

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

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

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

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

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

## Figure A-2: Management Practices

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

## A-3 Robustness Checks

Table A-3

Delegation Choices (4-digits SIC Industry FE)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Vertical Integration$_f$ | 0.725*** | 0.792** | 0.665** | 0.768*** | 0.821*** | 0.689** |
| | (0.277) | (0.314) | (0.313) | (0.275) | (0.314) | (0.313) |
| log(Employment$_f$) | | | -0.105** | | | -0.096* |
| | | | (0.053) | | | (0.053) |
| log(Age$_f$) | | | 0.037 | | | 0.040 |
| | | | (0.026) | | | (0.026) |
| log(Employment$_p$) | | | 0.116*** | | | 0.123*** |
| | | | (0.028) | | | (0.028) |
| log(% Workforce with College Degree$_p$) | | | 0.060*** | | | 0.061*** |
| | | | (0.020) | | | (0.020) |
| IO$_{ij}$ | | | | 0.898** | 1.185* | 1.369** |
| | | | | (0.457) | (0.696) | (0.685) |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | Yes | Yes | Yes |
| Input FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Noise controls | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 3,444 | 3,257 | 3,257 | 3,179 | 3,179 | 3,179 |

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

## Table A-4

Delegation Choices (Largest 10 Countries)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Vertical Integration$_f$ | 0.867*** | 0.653** | 0.527* | 0.776*** | 0.514* | 0.363 |
| | (0.287) | (0.305) | (0.305) | (0.286) | (0.306) | (0.306) |
| log(Employment$_f$) | | | -0.049 | | | -0.052 |
| | | | (0.056) | | | (0.058) |
| log(Age$_f$) | | | 0.028 | | | 0.047* |
| | | | (0.024) | | | (0.024) |
| log(Employment$_p$) | | | 0.115*** | | | 0.115*** |
| | | | (0.028) | | | (0.029) |
| log(% Workforce with College Degree$_p$) | | | 0.054*** | | | 0.055*** |
| | | | (0.018) | | | (0.019) |
| IO$_{ij}$ | | | | 1.358*** | 1.722*** | 1.778*** |
| | | | | (0.454) | (0.560) | (0.548) |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | Yes | Yes | Yes |
| Input FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Noise controls | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 2,512 | 2,512 | 2,512 | 2,369 | 2,369 | 2,369 |

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

## Table A-5

Delegation Choices (Controlling for Labor Productivity of the Parent Firm)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Vertical Integration$_f$ | 0.554** | 0.556** | 0.473* | 0.462* |
| | (0.249) | (0.251) | (0.253) | (0.256) |
| log(Employment$_f$) | -0.086** | -0.086** | -0.100** | -0.100** |
| | (0.042) | (0.042) | (0.044) | (0.044) |
| log(Age$_f$) | 0.035* | 0.034 | 0.048** | 0.047** |
| | (0.021) | (0.021) | (0.022) | (0.022) |
| log(Productivity$_f$) | | 0.004 | | 0.008 |
| | | (0.014) | | (0.015) |
| log(Employment$_p$) | 0.111*** | 0.111*** | 0.113*** | 0.112*** |
| | (0.023) | (0.023) | (0.023) | (0.023) |
| log(% Workforce with College Degree$_p$) | 0.055*** | 0.054*** | 0.056*** | 0.055*** |
| | (0.016) | (0.016) | (0.017) | (0.017) |
| IO$_{ij}$ | | | 0.949** | 0.949** |
| | | | (0.444) | (0.444) |
| Country FE | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | Yes |
| Input FE | Yes | Yes | Yes | Yes |
| Noise controls | Yes | Yes | Yes | Yes |
| N | 3,444 | 3,444 | 3,179 | 3,179 |

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

## Table A-6

### Delegation and Vertical Integration (Single-plant Firms)

| | (1) | (2) |
|---|---|---|
| Vertical Integration$_f$ | 1.010** | 1.016** |
| | (0.447) | (0.445) |
| log(Employment$_f$) | | -0.099 |
| | | (0.066) |
| log(Age$_f$) | | 0.000 |
| | | (0.036) |
| log(% Workforce with College Degree$_p$) | | 0.068*** |
| | | (0.025) |
| Country FE | Yes | Yes |
| Output FE | Yes | Yes |
| Noise controls | Yes | Yes |
| N | 1,480 | 1,480 |

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

## Table A-7

### Integration Choices (Winsorizing Suppliers' Productivity)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| CV Productivity$_{i,c}$ | 0.00266** | 0.00283** | 0.00298** | 0.00293** | 0.00274** | 0.00289** | 0.00304*** | 0.00297** |
| | (0.00118) | (0.00116) | (0.00116) | (0.00115) | (0.00118) | (0.00116) | (0.00116) | (0.00115) |
| log(Employment$_f$) | | | 0.00682*** | | | | 0.00683*** | |
| | | | (0.00040) | | | | (0.00040) | |
| log(1+ Age$_f$) | | | -0.00009 | | | | -0.00012 | |
| | | | (0.00029) | | | | (0.00029) | |
| IO$_{ij}$ | | | | | 0.08019*** | 0.13419*** | 0.13679*** | 0.14607*** |
| | | | | | (0.01222) | (0.01554) | (0.01542) | (0.01657) |
| Country FE | Yes | Yes | Yes | - | Yes | Yes | Yes | - |
| Input FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | - | No | Yes | Yes | - |
| Firm FE | No | No | No | Yes | No | No | No | Yes |
| N | 242,923 | 242,923 | 242,923 | 242,923 | 242,923 | 242,923 | 242,923 | 242,923 |

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

## Table A-8

Integration Choices (50+ Suppliers per Input Sector)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| CV Productivity$_{i,c}$ | 0.00050*** | 0.00046*** | 0.00045*** | 0.00044*** | 0.00050*** | 0.00046*** | 0.00045*** | 0.00044*** |
| | (0.00013) | (0.00012) | (0.00012) | (0.00013) | (0.00013) | (0.00012) | (0.00012) | (0.00013) |
| log(Employment$_f$) | | | 0.00812*** | | | | 0.00813*** | |
| | | | (0.00049) | | | | (0.00049) | |
| log(1+ Age$_f$) | | | -0.00016 | | | | -0.00019 | |
| | | | (0.00036) | | | | (0.00036) | |
| IO$_{ij}$ | | | | | 0.09569*** | 0.19432*** | 0.19715*** | 0.21395*** |
| | | | | | (0.01698) | (0.02344) | (0.02321) | (0.02621) |
| Country FE | Yes | Yes | Yes | - | Yes | Yes | Yes | - |
| Input FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | - | No | Yes | Yes | - |
| Firm FE | No | No | No | Yes | No | No | No | Yes |
| N | 176,347 | 176,347 | 176,347 | 176,347 | 176,347 | 176,347 | 176,347 | 176,347 |

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

## Table A-9

### Integration Choices (Largest 10 Countries)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| CV Productivity$_{i,c}$ | 0.00053*** | 0.00050*** | 0.00049*** | 0.00049*** | 0.00053*** | 0.00049*** | 0.00049*** | 0.00049*** |
| | (0.00013) | (0.00013) | (0.00013) | (0.00013) | (0.00013) | (0.00013) | (0.00013) | (0.00013) |
| log(Employment$_f$) | | | 0.00524*** | | | | 0.00524*** | |
| | | | (0.00036) | | | | (0.00036) | |
| log(1+ Age$_f$) | | | 0.00053* | | | | 0.00053* | |
| | | | (0.00031) | | | | (0.00031) | |
| log(% Workforce with College Degree$_p$) | | | 0.00026 | | | | 0.00024 | |
| | | | (0.00020) | | | | (0.00020) | |
| IO$_{ij}$ | | | | | 0.06011*** | 0.14177*** | 0.14198*** | 0.15384*** |
| | | | | | (0.01472) | (0.01987) | (0.01976) | (0.02135) |
| Country FE | Yes | Yes | Yes | - | Yes | Yes | Yes | - |
| Input FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | - | No | Yes | Yes | - |
| Firm FE | No | No | No | Yes | No | No | No | Yes |
| N | 171,729 | 171,729 | 171,729 | 171,729 | 171,729 | 171,729 | 171,729 | 171,729 |

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

## Table A-10

Integration Choices (WorldBase Sample)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| CV Productivity$_{i,c}$ | 0.00075*** | 0.00075*** | 0.00075*** | 0.00075*** | 0.00075*** | 0.00074*** | 0.00074*** | 0.00074*** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| log(Employment$_f$) | | | 0.00145*** | | | | 0.00144*** | |
| | | | (0.00013) | | | | (0.00013) | |
| log(1+ Age$_f$) | | | 0.00018 | | | | 0.00017 | |
| | | | (0.00011) | | | | (0.00011) | |
| IO$_{ij}$ | | | | | 0.14985*** | 0.17906*** | 0.17888*** | 0.20304*** |
| | | | | | (0.01342) | (0.01447) | (0.01446) | (0.01611) |
| Country FE | Yes | Yes | Yes | - | Yes | Yes | Yes | - |
| Input FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | - | No | Yes | Yes | - |
| Firm FE | No | No | No | Yes | No | No | No | Yes |
| N | 6,644,884 | 6,644,884 | 6,644,884 | 6,644,884 | 6,644,884 | 6,644,884 | 6,644,884 | 6,644,884 |

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

# Table A-11

Integration Choices (WorldBase Sample, Single-Plant Firms)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| CV Productivity$_{i,c}$ | 0.00070*** | 0.00070*** | 0.00070*** | 0.00070*** | 0.00070*** | 0.00069*** | 0.00069*** | 0.00069*** |
| | (0.00010) | (0.00010) | (0.00010) | (0.00010) | (0.00009) | (0.00009) | (0.00009) | (0.00009) |
| log(Employment$_f$) | | | 0.00011 | | | | 0.00010 | |
| | | | (0.00010) | | | | (0.00010) | |
| log(1+ Age$_f$) | | | 0.00015 | | | | 0.00014 | |
| | | | (0.00012) | | | | (0.00012) | |
| IO$_{ij}$ | | | | | 0.14390*** | 0.17148*** | 0.17147*** | 0.19426*** |
| | | | | | (0.01365) | (0.01475) | (0.01475) | (0.01646) |
| Country FE | Yes | Yes | Yes | - | Yes | Yes | Yes | - |
| Input FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | - | No | Yes | Yes | - |
| Firm FE | No | No | No | Yes | No | No | No | Yes |
| N | 6,027,632 | 6,027,632 | 6,027,632 | 6,027,632 | 6,027,632 | 6,027,632 | 6,027,632 | 6,027,632 |

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

# Table A-12

## Integration Choices (Additional Controls)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| CV Productivity$_{i,c}$ | 0.00062*** | 0.00057*** | 0.00056*** | 0.00056*** | 0.00062*** | 0.00057*** | 0.00056*** | 0.00056*** |
| | (0.00015) | (0.00014) | (0.00014) | (0.00015) | (0.00015) | (0.00014) | (0.00014) | (0.00015) |
| Mean Firm Employment$_{i,c}$ | -0.00010 | -0.00008 | -0.00016 | 0.00010 | -0.00009 | -0.00006 | -0.00014 | 0.00014 |
| | (0.00035) | (0.00034) | (0.00032) | (0.00033) | (0.00035) | (0.00034) | (0.00033) | (0.00034) |
| Mean Firm Sales$_{i,c}$ | 0.00028 | 0.00050 | 0.00028 | 0.00020 | 0.00024 | 0.00048 | 0.00026 | 0.00016 |
| | (0.00099) | (0.00092) | (0.00087) | (0.00090) | (0.00100) | (0.00094) | (0.00088) | (0.00091) |
| log(Employment$_f$) | | | 0.00671*** | | | | 0.00672*** | |
| | | | (0.00040) | | | | (0.00040) | |
| log(1+ Age$_f$) | | | -0.00007 | | | | -0.00009 | |
| | | | (0.00028) | | | | (0.00028) | |
| IO$_{ij}$ | | | | | 0.07701*** | 0.12625*** | 0.12828*** | 0.13752*** |
| | | | | | (0.01188) | (0.01495) | (0.01485) | (0.01592) |
| Country FE | Yes | Yes | Yes | - | Yes | Yes | Yes | - |
| Input FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Output FE | No | Yes | Yes | - | No | Yes | Yes | - |
| Firm FE | No | No | No | Yes | No | No | No | Yes |
| N | 249,471 | 249,471 | 249471 | 249,471 | 249,471 | 249,471 | 249,471 | 249,471 |

*Notes:* The dependent variable is *Integration*$_{f,j,i,c}$, a dummy equal to 1 if firm $f$ (producing final product $j$ and located in country $c$) integrates input $i$ within its boundaries. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the independent suppliers in input industry $i$ located in country $c$. *Mean Firm Employment*$_{i,c}$ and *Mean Firm Sales*$_{i,c}$ are average employment and sales for firms producing good $i$and in country $c$. *Employment*$_f$ measures firm employment, and *Age*$_f$ is the number of years since the firm's establishment. *IO*$_{i,j}$ is the IO coefficient capturing the importance of input $i$ in the production of good $j$. All regressions include *Mean Productivity*$_{i,c}$ as a control. Standard errors clustered at the input level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

# Table A-13

## Integration Choices (Interactions with Management)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| CV Productivity$_{i,c}$ | 0.00034*** | 0.00026** | 0.00034*** | 0.00028** | | 0.00033*** | 0.00026** | 0.00034*** | 0.00028** | |
| | (0.00013) | (0.00011) | (0.00012) | (0.00011) | | (0.00013) | (0.00011) | (0.00012) | (0.00011) | |
| CV Productivity$_{i,c}$ $\times$ Management$_f$ | 0.00042*** | 0.00034*** | 0.00021*** | 0.00024*** | 0.00029*** | 0.00042*** | 0.00035*** | 0.00021*** | 0.00024*** | 0.00029*** |
| | (0.00006) | (0.00006) | (0.00006) | (0.00007) | (0.00008) | (0.00006) | (0.00006) | (0.00006) | (0.00007) | (0.00008) |
| Management$_f$ | -0.00010*** | -0.00009*** | -0.00004*** | | | -0.00010*** | -0.00009*** | -0.00004*** | | |
| | (0.00001) | (0.00001) | (0.00001) | | | (0.00001) | (0.00001) | (0.00001) | | |
| log(Employment$_f$) | | | 0.00640*** | | | | | 0.00641*** | | |
| | | | (0.00037) | | | | | (0.00037) | | |
| log(1+ Age$_f$) | | | 0.00003 | | | | | 0.00001 | | |
| | | | (0.00028) | | | | | (0.00028) | | |
| IO$_{ij}$ | | | | | | 0.07437*** | 0.12550*** | 0.12781*** | 0.13765*** | 0.14862*** |
| | | | | | | (0.01177) | (0.01492) | (0.01483) | (0.01592) | (0.01671) |
| Country FE | Yes | Yes | Yes | - | - | Yes | Yes | Yes | - | - |
| Input FE | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | No |
| Output FE | No | Yes | Yes | - | - | No | Yes | Yes | - | - |
| Firm FE | No | No | No | Yes | Yes | No | No | No | Yes | Yes |
| Input-Country FE | No | No | No | No | Yes | No | No | No | No | Yes |
| N | 249,471 | 249,471 | 249,471 | 249,471 | 247,922 | 249,471 | 249,471 | 249,471 | 249,471 | 247,922 |

*Notes:* The dependent variable is *Integration*$_{f,j,i,c}$, a dummy equal to 1 if firm $f$ (producing final product $j$ and located in country $c$) integrates input $i$ within its boundaries. *CV Productivity*$_{i,c}$ is the coefficient of variation of labor productivity of the independent suppliers in input industry $i$ located in country $c$. *Mean Firm Employment*$_{i,c}$ and *Mean Firm Sales*$_{i,c}$ are average employment and sales for firms producing good $i$and in country $c$. *Employment*$_f$ measures firm employment, and *Age*$_f$ is the number of years since the firm's establishment. *IO*$_{i,j}$ is the IO coefficient capturing the importance of input $i$ in the production of good $j$. All regressions include *Mean Productivity*$_{i,c}$ as a control. Standard errors clustered at the input level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

## Table A-14

Integration Choices (Alternative Uncertainty Measures, United States)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| CV Productivity$_i$ | 0.00040** | 0.00039** | | | | |
| | (0.00017) | (0.00016) | | | | |
| SD Stock Returns$_i$ | | | 0.69947** | 0.69402** | | |
| | | | (0.27097) | (0.29573) | | |
| SD Output Growth$_i$ | | | | | 0.15959* | 0.15638* |
| | | | | | (0.08377) | (0.08427) |
| IO$_{ij}$ | | 0.30568*** | | 0.17544** | | 0.30305*** |
| | | (0.08314) | | (0.08791) | | (0.08529) |
| Output | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 6,720 | 6,717 | 3,901 | 3,892 | 6,720 | 6,717 |

*Notes:* The dependent variable is *Integration*$_{f,j,i}$, a dummy equal to 1 if firm $f$ (producing final product $j$) integrates input $i$ within its boundaries. *CV Productivity*$_i$ is the coefficient of variation of labor productivity of the independent suppliers in input industry $i$ located in country $c$. *SD Stock Returns*$_i$ is the standard-deviation of the mean annual returns across firms in input industry $i$. *SD Output Growth*$_i$ is the standard-deviation of real sales growth across firms in input industry $i$. All regressions include *Mean Productivity*$_{i,c}$ as a control. Standard errors clustered at the input level in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.