F Brahm and J Tarzijan

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Article

Brahm, F and Tarzijan, J

(2016)

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Strategic Management Journal, 37 (12). pp. 2481-2502. ISSN 0143-2095

DOI: https://doi.org/10.1002/smj.2446

John Wiley & Sons

https://onlinelibrary.wiley.com/doi/full/10.1002/s...

Toward an integrated theory of the firm: The interplay between internal organization and vertical integration

Research summary. Two central issues in strategic management are the determination of a firm's internal delegation and its vertical boundaries. Despite the importance of these issues, there is scant analysis concerning their interaction. Using a comprehensive database of the construction industry, we show that vertical integration positively influences the centralization decision and that the main mechanism driving this relationship is an improvement in the hierarchically coordinated adaptation of firm activities when complexity and uncertainty are high. We also observe that centralization is negatively related to the extent of relational contracts between principals and agents and positively related to an exogenous increase in the cost of employee layoffs. Our results suggest that managers cannot consider firm boundaries and internal organization to be independent decisions.

Managerial summary. We ask whether a firm's decision about vertically integrating or outsourcing its activities affects the choice of centralizing or delegating its internal decision-making process. Our statistical analysis shows that firms with more vertical integration tend to centralize the decision-making process and that firms that outsource more tend to decentralize more. Why? Vertical integration enables the use of centralized authority to coordinate activities that interact intensively. Accordingly, we found that the positive relationship between vertical integration on centralization is especially significant in more complex and uncertain environments, when the need for coordination is higher. Thus, our results suggest that managers should choose vertical integration considering its effect on internal decision-making processes, particularly when coordination is important.

INTRODUCTION

A major body of literature within organizational economics considers the determination of firm internal organization. A cornerstone of this research examines the choice to centralize decision-making at the top of the organization or delegate it to lower level managers (Argyres and Silverman, 2004; Aghion, Bloom and Van Reenen, 2013). Another major body of literature in this field is concerned with the determination of firm boundaries, i.e., the make-or-buy decision (Coase, 1937; Williamson, 1975 and 1985). Despite the importance of these bodies of literature, there has been scant analysis of a possible interrelationship between them. This void is noteworthy because a sound theory of the firm requires an understanding of how internal organization and firm boundaries interact[1]. For instance, if delegation and outsourcing were complements, then for a given set of activities, we would observe either delegation and outsourcing or centralization and integration. A complementary relationship between these organizational decisions is consistent with theoretical arguments regarding the difficulty of integrating and then delegating (Baker, Gibbons and Murphy, 2001) but contradicts popular press advice for empowerment and delegation regardless of firm boundaries (Foss and Klein, 2014).

Calls to explore the internal organization and firm boundaries jointly have been issued in the literature (Acemoglu, Aghion, Lelarge *et al.*, 2007; Holmstrom, 1999; Bidwell, 2012). Garrouste and Saussier (2005) note, "*In addition to the questions regarding the nature and the boundaries of the firm, the theory of the firm should also be able to cope with the question of internal organization*." (p. 187). Received theory is insufficient. The new property rights theory by Hart and Moore (1990) posits that legal ownership of assets involves complete centralization of decision rights, that is, vertical integration and centralization are largely inseparable[2]. In contrast, the transaction cost economics (TCE) perspective indicates, "*Substantially the same factors that are ultimately responsible for market failures also*

[1] A third aspect that an integrated theory of the firm should account for is heterogeneity of firm performance (Mahoney and Qian, 2013). We do not address this issue explicitly in our paper.

[2] Attempts to extend the property rights model to include internal organization have been made: Powell (2015) uses influence costs, Rajan and Zingales (1998) use 'access to assets' and Hart and Holmstrom (2010) use 'reference points'.

explain failures of internal organization" (Williamson, 1973, p. 316), predicting that centralization and vertical integration will co-vary with transactional attributes but neglecting their direct mutual influence. Multitasking agency theory (Holmstrom and Milgrom, 1994) assumes a pattern of tasks interdependence that produces a positive relationship among centralization of authority, vertical integration and lack of incentives. However, assuming a pattern limits the theory´s explanatory depth on the relationship between these three governance instruments. Makadok and Coff (2009) extend the multitasking model to show that by altering the assumed interdependence between tasks, the model can account for a variety of organizational forms combining different levels of centralization, vertical integration and incentives. However, they cannot predict which combinations are more prevalent. As they indicate, "[our theory] *does not imply that every part of the governance space is populated with viable forms. Indeed, some parts of the space might be sparsely populated—or even empty, when the particular combination of governance elements is impractical, infeasible, or unstable*" (p. 300).

There is some empirical evidence that suggests a positive relationship between centralization (delegation) and vertical integration (outsourcing) (Withington, Pettigrew, Peck *et al.*, 1999; Hong, Kueng, and Yang, 2015; Alonso, Clifton and Díaz-Fuentes , 2015; Mcheleran, 2014; Weigelt and Miller, 2013; Arora, Belenzon and Rios, 2014; Chanson and Quelin, 2013). However, this evidence is correlational and thus cannot speak to whether these two decisions co-vary because of transaction characteristics, as TCE would predict, or whether there is a specific interdependence between them that would inform Makadok and Coff (2009)'s question regarding the feasibility of organizational forms. The distinction between transaction characteristics and complementarity of governance instruments is empirically important. For instance, Novak and Stern (2009) show that the effect of complementarity in vertical integration decisions is at least as relevant as the impact of the transaction characteristics themselves.

We contribute to this literature by providing a focused empirical analysis of the impact of vertical integration on centralization. In particular, we use appropriate instruments to evaluate the causal impact of vertical integration on centralization. This allows us to evaluate whether vertical integration correlates with centralization or whether it exerts a causal influence. By contrasting the impact of vertical integration on centralization with other canonical drivers (drawn from transaction characteristics), we can evaluate whether the interdependency is economically meaningful compared to these drivers. Finally, although some generalizability may be sacrificed, our focused approach permits us to i) provide detailed evidence that confirms a suggestive pattern found in previous studies, ii) distinguish the mechanisms that might be driving the results, and iii) spur theoretical work that is needed to develop a theory that jointly address firm boundaries and internal organization.

We proceed by introducing the two main determinants of the centralization decision, namely, adaptation costs and agency costs. To predict the impact of vertical integration on centralization, we discuss how vertical integration may affect the adaptation and agency costs of the centralization choice. Then, we estimate the impact of vertical integration on centralization. To explore the mechanisms that may be driving the results, we evaluate whether the impact of vertical integration on centralization varies by levels of adaptation and agency costs.

Our empirical setting, the construction industry, is appropriate for our study. The procurement of building materials is important in this industry and can be delegated to project managers or centralized at the corporate level. Materials procurement must be carefully coordinated with the various specialty trade activities that must be performed for each project (e.g., building and installing metallic structures, painting). These specialty trades can be executed internally or outsourced to subcontractors. We explore how changes in the vertical integration of specialty trades affect the likelihood of materials procurement centralization.

Our results show a positive impact of vertical integration of specialty trades on the centralization of materials procurement. This impact is stronger when coordinated adaptation among procurement and specialty trades is more important, which suggest that vertical integration *enables* centrally coordinated adaptation of materials procurement and specialty trades. More importantly, our results imply that the space of economic organization may indeed have a more "feasible" organizational form along with the complementarity of centralization (delegation) and vertical integration (outsourcing). We also found that the impact of vertical integration on centralization is economically important, which highlights the relevance of including interdependence of governance choices in our theories of the firm. Finally, we observe that the level of centralization of materials procurement increases with our measures of agency costs, namely lack of trust in project managers, distance to the project, and protection of workers from layoffs.

The remainder of this paper is organized as usual. Next section covers theory development and hypotheses. Then, we present the setting, the data, the methods, and the analysis. Finally, we close with a discussion and conclusion.

THEORY DEVELOPMENT AND HYPOTHESES

The location of decision rights is a critical organizational choice (e.g., Aghion *et al.*, 2013; Argyres, 1995; Argyres and Silverman, 2004; Gambardella, Panico and Valentini, 2013). Whereas decentralization implies the delegation of authority to managers, centralization is associated with the concentration of decision making, usually at the corporate level. In delegation, a principal with legitimate decision-making power typically grants decision-making authority. Next, we introduce two major determinants of centralization, adaptation costs and agency costs, and discuss how and through which of these determinants vertical integration affects centralization.

Adaptation and centralization

Adaptation to changing circumstances (e.g., technology, demography, environment, and trade) is a major organizational challenge. The existing research identifies two different types of adaptation. Whereas Hayek (1945) highlights the adaptation advantages of autonomous agents when knowledge about the choices of other agents is not required to obtain adaptive efficiency, Williamson (1975; 1991; 1996) highlights the advantages of hierarchically coordinated adaptation when activities are interdependent and require harmonized choices. In the former type, which we label autonomous adaptation, adaptation is achieved through local learning and optimization because interdependencies are not relevant, whereas in the case of coordinated adaptation, interdependencies must be optimized centrally to avoid inconsistent and non-synergistic choices. The centralization of decision-making enhances coordinated adaptation at the expense of autonomous adaptation; thus, the suitability of centralization over delegation depends on the importance of each type of adaptation to the current problem.

A simple framework based on previous research (e.g., McElheran, 2014) captures these ideas. Consider a stylized firm that performs two activities executed by two different agents sharing the same principal. The local conditions of information as well as available knowledge for each activity *i* are represented by θ_i. For both activities, a decision D_i must be made regarding the execution details of the activity. The decision-making process at the individual activity level can be centralized at the principal level. Alternatively, the choice can be decentralized at the agent level. The cost of autonomous adaptation of each activity can be captured by the expression $\alpha_i * (D_i - \theta_i)^2$, where α_i shows the importance of autonomous adaptation in activity *i*. If D_i is close to θ_i, there is a high level of adaptation of the decision *i* to the state of nature. Delegation can enhance the efficiency of the decision-making process because workers who hold hard-to-transfer information about local conditions and expertise in specific tasks solve local problems better than central managers (Jensen and Meckling, 1995).

In addition to the use of existing local knowledge, a second advantage of decentralization is that it favors the acquisition and development of new knowledge, that is, it favors learning. Aghion and Tirole (1997) formalize this notion. Roberts (2004) argues that decentralization favors internal exploration and learning from others as ways to change firm activities and to adapt skills to changing conditions. Acemoglu *et al.* (2007) and Birkinshaw *et al.* (2002) provide empirical evidence suggesting that more decentralization occurs when local learning is important.

Interdependence between activities creates the need for coordinated adaptation. In our framework, coordinated adaptation between activities can be modeled using the expression $\varphi * (D_1 – D_2)^2$, where φ captures the importance of coordinated adaptation. Prior research indicates that centralization can facilitate coordination of two interdependent activities (Alonso *et al.*, 2013; Nickerson and Zenger, 2004; Zhou, 2013). Thus, absent other considerations, the cost structure of this stylized two-activity firm is equal to $\alpha_1 * (D_1 – \theta_1)^2 + \alpha_2 * (D_2 – \theta_2)^2 + \varphi * (D_1 – D_2)^2$, where centralization is favored (disfavored) as the coordination of activities becomes more (less) important.

Both types of adaptation can be affected by complexity and uncertainty, leading to an unclear relationship between these variables and centralization. Simon (1962) defines a complex system as a system "made up of a large number of parts that interact in a non-simple way" (p. 486). Two opposing impacts of complexity on adaptation are derived from this definition. On the one hand, greater complexity may lead to decentralization because firms engineer decomposability in response. Simon (1962) indicates that an increase in the number of interdependent decisions requires a design in which choices are decoupled so that they may be addressed individually without requiring attention to the whole. Firms facing complexity may limit interactions among choices, separating them and allowing autonomous problem resolution, i.e., firms may design a problem structure in which α_1 and α_2 increase while φ decreases, promoting decentralization. On the other hand, greater complexity may lead to centralization because considerable non-decomposability may be essential to the problem, and interactions require coordination and careful centralized attention to avoid inconsistent and non-synergistic choices (McElheran, 2014; Argyres, 1995; Argyres and Silverman, 2004), i.e., more interactions may increase φ, promoting centralization.

Uncertainty, which is defined as the degree of unexpected disturbance faced in a transaction (Tadelis and Williamson, 2013), increases both autonomous adaptation and coordination needs, and thus, it has an ambiguous effect on centralization. Uncertainty increases the likelihood of decentralization by increasing the likelihood of unexpected events, increasing the variance of θ_i and the importance of adjusting D_i (Jensen and Meckling, 1995). Foss and Laursen (2005) provide empirical evidence that environmental uncertainty has a positive impact on delegation. However, depending on the covariance between θ_1 and θ_2, coordinating activities may become necessary as uncertainty increases, increasing the likelihood of centralization. Meagher and Wait (2013) present empirical evidence that uncertainty increases centralization.

Agency costs and centralization

The existence of asymmetric information and the impossibility of signing complete contracts between principals and agents lead to incentive misalignment (Aghion and Tirole, 1997). In terms of the previous framework, D^*_i is the principal's optimal choice, and the agency costs of each activity can be represented by $\sigma_i * (D_i - D^*_i)^2$, where σ_i captures the importance of incentive misalignment between principals and agents. Thus, the total cost of our stylized firm is represented as follows: $\alpha_1 * (D_1 - \theta_1)^2 + \alpha_2 * (D_2 - \theta_2)^2 + \varphi * (D_1 - D_2)^2 + \sigma_1 * (D_1 -$

$D^{*}_{1})^2 + \sigma_2 * (D_2 - D^{*}_{2})^2$. In this setup, allocating decision rights to employees increases their capacity to add value though autonomous adaptation at the expense of possible incentive misalignment (Jensen and Meckling, 1995). Consequently, when agency concerns are important (namely, when σ_i is large), centralization is more likely.

An important factor in the determination of agency concerns is the degree of congruence among preferences at various levels of the firm's organizational structure. Aghion and Tirole (1997) posited that delegation becomes optimal when preferences do not diverge "too much". Preference congruence can be proxied by the level of trust between principals and agents. Bloom *et al.* (2012) used the generalized trust measurement from the World Values Survey to demonstrate that trust increases delegation. The level of preference congruence can also be associated with the existence of relational contracts, namely, self-enforcing informal agreements (Gil and Marion, 2013; Gibbons and Henderson, 2012). Companies that maintain a higher level of relational contracting should exhibit fewer agency problems and greater decentralization of their internal structures. Empirical evidence of the impact of trust and relational contracts on delegation beyond Bloom *et al.* (2012) remains elusive.

Agency costs might also be affected by institutional change. By shaping laws and regulations, institutions establish the formal rules that influence the costs and benefits of the different organizational structures (Williamson, 2000). Changes in labor legislation that increase agency costs of employment can promote centralization. For example, an important body of literature in labor economics shows that legal changes that increase worker protection from dismissal decrease worker effort and increase firm agency costs (Ichino and Riphahn, 2005; Jacob, 2013; Martins, 2009). Agency costs are also affected by geographic distance because increasing distance is associated with higher monitoring costs, which has been shown in franchising (Perryman and Combs, 2012), entry mode of foreign direct investments (Lin and Png, 2003), and bidding behavior (Gil and Marion, 2013), among other areas.

Vertical integration and centralization

The firm must decide not only whether to centralize or decentralize its internal decision-making processes but also whether to integrate or outsource its activities (e.g., Coase, 1937; Williamson, 1985; Forbes and Lederman, 2009). The mainstream theory in the analysis of vertical integration is TCE. Recent developments in this theory (summarized by Tadelis and Williamson, 2013) have returned to the early emphasis on vertical integration as a solution to frequent and unexpected ex post adaptation of activities through hierarchical coordination (Williamson, 1975). Tadelis (2009) predicted that an increase in ex post adaptation caused by more complex bilateral contracting leads to greater vertical integration due to the need for fiat and coordination of activities. Forbes and Lederman (2009) present compelling evidence for this view, demonstrating that airlines decrease outsourcing to regional partners in regions with adverse weather in which there is high need for ex post adaptation. Williamson summarizes this view of fiat-inducing adaptation in interdependent activities, "*Some kinds of disturbances require coordinated responses, lest the individual parts operate at cross-purposes or otherwise sub optimize. Failures of coordination may arise because autonomous parties read and react to signals differently, even though their purpose is to achieve a timely and compatible combined response. [...] The authority relationship (fiat) has adaptive advantages over autonomy for transactions of a bilaterally (or multi-laterally) dependent kind*" (1996, p.103).

We analyze the impact of integrating an activity on the centralization of an adjacent activity[3]. In our framework, we assume that activity 2 is either exogenously outsourced to the market or vertically integrated into the firm and then analyze how this boundary decision

[3] An adjacent activity uses or provides inputs for the other activity, or both require some mutual coordination.

affects incentives to centralize activity 1. A first mechanism to consider is that, compared to outsourcing, the vertical integration of activity 2 *enables* the hierarchically coordinated adaptation of activities 1 and 2 because sharing a principal facilitates their coordination. If activity 2 is outsourced, it becomes more autonomous, and the hierarchical direction that a manager can exert decreases. Essentially, if the principal wants hierarchical coordination of two activities, then it is better to integrate both activities so authority can be effectively used.

Delegation can facilitate the interaction with external suppliers. As proposed by Aghion and Tirole (1997), delegation of authority over activity 1 motivates learning by the agent in charge of executing this activity, including learning the interdependencies with activity 2. This incremental expertise of delegation coupled with the power to react and make immediate decisions favors the development of mutual knowledge, trust and coordination routines between the agent responsible for activity 1 and the party responsible for interdependent activity 2. An agent 1 that is more knowledgeable about their interactions with activity 2 can write more complete contracts due to improved appraisals of quality, effort, and capacity to assess opportunistic threats from agent 2 (Mayer and Salomon, 2006). In contrast, a centrally managed activity 1 –detached from local details of interactions with activity 2 and with fewer face to face interactions– will have more difficulty creating knowledge, trust and learning about how to coordinate through the market and limit opportunistic behavior with external parties. Foss, Laursen and Pedersen (2011), Foss, Lyngsie and Zahra (2013) and Leijponen and Helfat (2011) show that delegation favors the use of external knowledge, providing evidence that decentralization of decision rights can facilitate the use of the market.

The vertical integration of activity 2 does not affect the autonomous adaptation costs of activity 1 because neither the adaptation of activity 1 to local circumstances (θ_1) nor the importance of this adaptation (α_1) is affected by the governance choice of activity 2. Thus, vertical integration enables hierarchical coordination between activities without affecting the autonomous adaptation of activity 1, suggesting that vertical integration increases centralization. In our framework, this prediction is stronger when the importance of aligning D1 and D2 is higher, that is, when φ is larger.

Vertical integration also increases company size in terms of the number of activities performed internally and the number of people directly employed by the organization. This larger size fosters free riding among team members and increases the difficulty of mitigating moral hazard problems (Rasmusen and Zenger, 1990), which negatively affects the quality and processing of communication (Hayek, 1945) and incentivizes strategic behavior among employees (e.g., McAfee and McMillan, 1995), increasing the likelihood of agency costs. In terms of our framework, vertically integrating activity 2 increase the distance between D_1 and D^*_1 as well as the likelihood of centralizing that activity. This relationship should be stronger when the importance of aligning D_1 and D^*_1 is higher, that is, when σ_1 is larger.

From this discussion, we develop hypotheses that relate firm boundaries and centralization. Hypothesis 1 (H1) represents our main prediction, and hypotheses 2 (H2) and 3 (H3) predict the conditions under which H1 is more likely to be observed:

H1: *A higher level of vertical integration of an activity increases the likelihood of centralization of an adjacent activity*

H2: *The positive impact of a higher level of vertical integration of an activity on the likelihood of centralization of an adjacent activity is larger when the importance of coordinated adaptation is higher.*

H3: *The positive impact of a higher level of vertical integration of an activity on the likelihood of centralization of an adjacent activity is larger when the importance of agency costs is higher.*

EMPIRICAL SETTING

Construction industry

The construction industry is an important economic actor in most countries. Typical activities in this industry are the following. A construction firm, also known as a contractor, builds a project for an owner/developer according to the specifications given by the designer. During the construction period, the contractor must decode and interpret the designer's documents to produce a quality product. For each project, the contractor must execute specialty trade activities to complete the project (e.g., install electrical services). The contractor can buy these specialty trades in the market using subcontractors or execute them through an internal unit. On average, subcontractors are used 40% of the time in our setting. Subcontractors typically specialize in an activity with little diversification. The contractor's main function is the coordination of subcontractors and internal teams to ensure timely delivery of specialty trade activities (Tommelein and Ballard, 1997).

Two characteristics of construction projects are worth highlighting before addressing building materials procurement in detail. First, contractors can delegate decisions to project managers or centralize operations within their corporate centers. Agency concerns between the corporate center and project organization are important because monitoring is imperfect and must be performed on site. Approximately one-half of project coordination occurs through face-to-face contacts, meetings, and site visits (Chang and Shen, 2009). Second, although construction projects require a priori plans, schedules and specifications, it is common to alter these plans (Bajari, Mcmillan, and Tadelis, 2008; Sun and Meng, 2009; Winch, 2001). Typically, these changes are managed using change orders and account for a substantial portion of project cost (Sun and Meng, 2001).

Materials procurement

Building materials procurement is important to project success for many reasons: i) 50–60% of project costs are from building materials (Turki, 2002); ii) nearly one-half of the variance in project schedules is explained by materials delivery timing (Turki, 2002; Ala-risku and Kärkkäinen, 2006); and iii) decreased labor productivity of specialty trades caused by late or erroneous materials deliveries is in the 20-50% range (Thomas and Sanvido, 2000).

The process of materials procurement involves many tasks (Ellegaard and Koch, 2014). The procurement manager must understand and comply with the designer's product specifications; coordinate the approval of any changes; solicit bids to select manufacturers; negotiate long-term agreements with suppliers; coordinate the fabrication of custom materials; schedule deliveries in coordination with the project organization; ensure quality control and the substitution of defective materials; and coordinate storage at the project site. Finally, the specialty trade´s internal team or subcontractor installs the materials.

The contractor may centralize materials procurement activities in their central offices, typically in a procurement department with tight relationships with finance and project control departments, or delegate these activities to the project procurement manager who is typically supervised by the project director but reports to the procurement department of the contractor's headquarters. Delegation does not imply that the headquarters' procurement function disappears. Typically, when a project procurement manager is appointed, she assumes responsibility for management of specifications, product changes, customized fabrication, delivery, quality control and storage, which are more operational tasks. Although the project's procurement manager may also participate in the two remaining activities, namely biding preparation and evaluation and long-term agreements, it is common for the main procurement department to retain decision rights over these tasks (Ellegaard and Koch, 2014). Both centralized and delegated procurement require intensive coordination with other project participants to ensure the proper quality and timing of materials.

The decision to delegate procurement tasks to a project-level procurement manager is not trivial. In addition to the large impact on project performance, delegating procurement tasks may alter the incentives of the procurement function. Centralized procurement may result in lower prices from suppliers but typically at the expense of higher operational costs due to incorrect deliveries and compromised quality. If procurement tasks are delegated, incentives will likely be more balanced (Ellegaard and Koch, 2014): headquarters may push for lower prices, but the procurement manager will insist that operational efficiency not be sacrificed.

Due to financial constraints and moral hazard concerns regarding the quality of building materials procured by subcontractors, contractors typically execute the bulk of materials procurement, allowing subcontractors to procure only small items that are not major determinants of project costs (Ala-Risku and Kärkkäinen, 2006; Ellegaard and Koch, 2014).

Autonomous adaptation is the adjustment of procurement tasks to changes in conditions that mainly affect procurement tasks, such as materials variety, price and novelty, supplier availability, quality assessment technologies, and laws that regulate material requirements. Coordinated adaptation is the management of the interdependencies among procurement and related project activities. Most interdependencies are associated with the specialty trades activities, such as delivery timing, change order management, quality testing, and warehousing. Agency concerns in procurement are related to potential misalignments in headquarters and project level manager objectives.

The materials procurement process is complicated by four factors that affect the coordination of specialty trades and procurement. First, total procurement costs are driven by price but also by costs incurred at the project level (e.g., storage, shrinkage, quality control, rework). Given that the latter are more difficult to measure than the former, contractors tend to focus on the price rather than on the total cost of materials, which may lead to the delivery of excessive quantities of materials at non-optimal times to obtain volume discounts (Ellegaard and Koch, 2014). Second, storing materials at project sites is difficult: small spaces, traffic congestion and distributed inventories put pressure on the scheduling of materials delivery (Ellegaard and Koch, 2014). Third, the visibility of inventory at the project site and the traceability of the stock and backlog of orders from suppliers are low, leading to difficulties in implementing precise scheduling (Ala-risku and Kärkkäinen, 2006). Fourth, the specifications received at the beginning of a project tend to change during project execution, creating opportunistic quality downgrading (Ibbs, 1984). These four factors are particularly salient in complex and/or uncertain projects, increasing the importance of coordination between procurement and specialty trades. Complex projects typically face storage problems and involve more products, which hinder the definition and timing of deliveries, the observation of the supply chain, and the ability of subcontractors to plan capacity across projects. Projects that are more uncertain create more product changes and amendments in specialty trade tasks, increasing the difficulty of rapid coordinated adaptation to changes.

DATA AND METHODS

Data

We used a unique database provided by ONDAC S.A., a firm that collects detailed data on construction projects and sells these primarily to building materials manufacturers and distributors. The database covers the period from January 2004 to October 2012 and includes 46,420,398 square meters built over 12,272 projects, which represents approximately 40% of the total square meters constructed in Chile during that period.

For each project, we observe whether materials procurement is centralized at headquarters or delegated to the project and whether the contractor performs each of the following activities internally or relied on a subcontractor: 1) building and installing metallic structures; 2) building formwork; 3) installing electrical services; 4) installing plumbing and water services; 5) installing heating and cooling systems; 6) building and installing windows; 7) painting; 8) building and installing furnishings and appliances, and 9) installing gas services. These activities generally account for a large proportion of construction costs (Riley *et al*.., 2005). We also obtained detailed information about the subcontractor and contractor (e.g., executives, websites, addresses, and company names) and each project (e.g., area in square meters, exact geographic location, project dates, and project description). Finally, each project is classified as one of the following types: housing complex, office building, residential building, health facility, educational facility, hotel, industry, commercial project, religious building or single-family home.

In construction, a significant number of small firms remain operative for only a few years, and according to our research and interviews with industry executives, these firms may behave differently. Therefore, we restricted the sample to contractors for which data were available for at least five years[4].

Variable measurement

Centralization. Our dichotomous measure of centralization assumes the value 1 if the materials procurement process is centralized and 0 if delegated to the project level. To identify this, ONDAC maintains a team of employees who visit the projects to gather information about them. This information is sampled and crosschecked by administrative staff at the central office. Using this process, ONDAC determines whether procurement of building materials for each project is fully executed at the contractor's headquarters or whether a substantial portion of the procurement activities is executed at the project level. Delegation requires that the project officers execute at least the following activities: management of specifications, coordination of customized fabrication, coordinating delivery,

[4] However, results are robust to other cut-off criteria. These results are available from the authors upon request.

execution of quality control, and management of materials storage. If delegation is identified, ONDAC collects the name and contact information of the person responsible for procurement at the project site. If centralization is identified, ONDAC indicates that "procurement occurs at headquarters" and provides the name and contact information of the chief procurement officer. Given that ONDAC collects this information to sell it to building material manufacturers and distributors, it takes great care to identify whether procurement is delegated or centralized and to identify the person conducting procurement for each project. Although our measure is unidimensional (cf. Weigelt and Miller, 2013), it captures a variety of procurement tasks that are of high importance to the success of the project. Figure 1 shows that there is considerable variation in the use of delegation among contractors.

[Insert figure 1 around here]

Vertical integration. We aggregated vertical integration choices at the level of specialty trade activity for each project. Each of the nine specialty trades observed for a project was assigned the value 1 if integrated and 0 otherwise. We standardized this measure for each specialty trade (across all projects) and averaged this standardized measure across specialty trades for each project; thus, our vertical integration measure represents the standardized percentage of integrated specialty trade activities at the project level[5].

Adaptation costs variables. Three variables measure adaptation costs: "project size", which is mainly related to project complexity; "non-housing project", which is related to project complexity and design uncertainty; and "fast-track project", which is mainly related to design uncertainty.

[5] Standardization is required to aggregate information at the contractor level because there was some missing data at the project level (i.e., we did not observe all specialty trade activities for each project) and the average level of integration in each specialty trade varies. We restricted the sample to projects in which there are at least 5 specialty trades with make-or-buy choice data. We tested other cut-offs, and the results are unchanged (available from the authors upon request).

Project size. Large projects tend to be more complex and face more interdependencies, which affect governance choices (Bajari *et al.*, 2008; Eccles, 1981). The natural logarithm of the project area (in square meters) measures project size.

Non-housing project. Non-housing projects face more alterations via change orders (which are a type of unplanned disturbance) and are more complex than housing projects because they are less standardized and face more interactions (Winch, 2001). Consistent with this fact, housing projects are well suited to a lean construction strategy (Hook and Stehn, 2008). We computed a dummy variable that assumes a value 0 if the project is a housing complex, residential building, or single family home, and 1 otherwise.

Fast-track project. Given that the time it takes to build a project is a key determinant of project profitability (Winch, 2001), some projects are accelerated. This reduced time is achieved by relaxing the design function, so construction begins when a basic design is ready and details are provided in conjunction with construction activities (Cacciatori and Jacobides, 2005). The literature identifies this fast-track strategy as the design-and-build project method (D&B) in contrast to the design-bid-and-build method (DBB) in which the design is completed before project tendering and construction. The D&B method is faster but increases uncertainty, unplanned disturbances, and thus the need for adaptive capacity. To avoid costly negotiations over changes and to align incentives, in a D&B project typically the project owner, designer, and contractor integrate under the same firm or coalition (Davis and Brady, 2000).

Given that firm governance or a costly coalition must be implemented to manage "on-the-fly" design and construction, a D&B strategy is primarily pursued by contractors that focus on housing projects, which allows for repeated business over time and recovery of the costs of establishing a coalition (Davis and Brady, 2000). Thus, we identified a project as "fast track" when a housing project is built by a contractor focused on housing. In contrast, if a contractor that focuses on non-housing executes a housing project, it is likely that this is a one-time occasion that will not allow an expensive investment in a D&B strategy. The division between housing and non-housing projects is observed in our data: there is considerable contractor focus on each of these sub-sectors; however, there is a small but non-negligible level of crossing sub-sectors (e.g., a housing project built by a non-housing contractor). The combination of focus with some crossing provides the variance needed to identify a shift in the likelihood of managing a fast-track project.

To obtain the fast-track variable, we first compute for each year and contractor the percentage of contractor volume that was executed in the housing market and then a dummy variable that takes the value 1 if the project is a housing project and the contractor executes at least 60% of its volume in housing and 0 otherwise. This dummy captures housing projects built by housing-focused contractors, where the likelihood of developing a fast-track strategy is high. We tested various cut-offs around this value, and the results remained unchanged.

Agency cost variables. We use three variables to measure the agency costs between a firm (i.e., the contractor) and management at the project level.

Prior interactions with the project director and warehouse manager. We observe the name of the project director and project warehouse manager for each project. Because the project procurement manager must interact intensively with these two officers, a contractor that has developed a close relationship with them might be more confident about delegating a project's procurement. We compute two dummy variables that capture prior interactions between the contractor executing the project and each project officer. The first assumes the value 1 if the project director has been the project director of any previous project for the contractor executing the focal project. The second dummy is analogous to the first but considers the project warehouse manager instead of the project director. We multiply these two dummies to capture the greatest trust in delegated procurement, corresponding to prior interactions of the contractor with both officers.

Changes in labor law. In March 2008, an important change in labor law dramatically changed the way in which labor justice informed the Chilean economy. Before the change, a disagreement between employers and employees, for example, regarding severance payments, could involve many hearings, last many years, and generate important financial costs for employees. The changes to the law combined the trials into one hearing, increased the number of labor court judges, decreased the monetary cost of trials for employees, weakened the legal evidence to demonstrate the existence of layoffs and created the position of labor defender to advice employees. These changes resulted in significantly faster trials and an increased percentage of cases that were decided in favor of workers. With worker-friendlier labor laws and faster judicial processes, firms experience more difficulties firing workers who underperform. As it is well established in labor economics (Ichino and Riphahn, 2005; Jacob, 2013; Martins, 2009), increasing worker protections decreases worker effort and increases employment agency costs.[6]

These changes in labor law were implemented in phases across Chile's 15 regions from the beginning of 2008 to the end of 2010. Because we control for region and year using dummies, this implementation allows for clean identification of the impact of the legal changes using difference-in-differences estimation. We observe the project start date and compute a dummy variable that assumes the value 1 if the project began after the legal change in each region.

Project distance. A distant project is more difficult to monitor, impeding clear control of procurement activities and increasing agency costs (e.g., Perryman and Combs, 2012).

[6] Consistent with increased agency costs of employment and prior evidence (González-Díaz *et al.* 1998), in unreported supplementary analyses, we found that the law significantly decreased vertical integration and increased fragmentation in the subcontractors market (i.e., more and smaller subcontractors).

Project distance was measured by computing the distance between a project's region and the region that contains the highest percentage of total square meters built by the contractor in that year. We tested other measures, such as the distance between the project location and contractor headquarters, and our results remained unchanged.

In the online appendix 1, we present the various control variables used in our empirical analysis. Table 1 provides the descriptive statistics and correlation matrix for our dataset.

[Insert table 1 around here]

Econometric model

We use the following econometric model to analyze the centralization of procurement:

$$\textit{Centralization}_{i,j} = \beta_0 + \beta_1 * \textit{Adaptation Costs}_{i,j} + \beta_2 * \textit{Agency Costs}_{i,j} + \beta_3 * \textit{Vertical Integration}_{i,j} + \textit{Controls} + \mu_{i,j}. \qquad (1)$$

The centralization of procurement executed by contractor *i* in project *j* depends on the adaptation costs (proxied by "project size", "non-housing project" and "fast-track project"), agency costs (proxied by "prior interactions", "change in labor law" and "project distance") and degree of vertical integration of specialty trades. We expect that $\beta_2 > 0$ and $\beta_3 > 0$. As indicated in the theory section, we cannot predict the sign of β_1. To explore how vertical integration interacts with agency and adaptation costs, we use model (2):

$$\textit{Centralization}_{i,j} = \beta_0 + \beta_1 * \textit{Adaptation Costs}_{i,j} + \beta_2 * \textit{Agency Costs}_{i,j} + \beta_3 * \textit{Vertical Integration}_{i,j} + \beta_4 * \textit{Adaptation Costs}_{i,j} * \textit{Vertical Integration}_{i,j} + \beta_5 * \textit{Agency Costs}_{i,j} * \textit{Vertical Integration}_{i,j} + \textit{Controls} + \mu_{i,j}. \qquad (2)$$

Model 2 allows us to evaluate the mechanisms through which vertical integration affects centralization. We expect that $\beta_4 > 0$ if vertical integration has a positive impact on centralization by facilitating hierarchical coordination between procurement and specialty trades. Given that vertical integration does not affect the costs of autonomous adaptation, the interaction reflects the impact of vertical integration on the costs of coordinated adaptation. On the contrary, we expect that $\beta_5 > 0$ if vertical integration affects centralization by decreasing agency costs[7].

Because centralization is dichotomous, we estimate a probit model. We follow Wieserman and Bowen (2009) to analyze the results of probit models, particularly those associated with interaction terms. To account for confounding factors, we use various control variables and dummies for region, project type, year, and contractor. Below, we address endogeneity concerns related to the direction of causality between vertical integration and centralization.

RESULTS

Table 2 presents the results of the probit regressions associated with equation (1). The fit of the models presented in table 2 indicates that over 70% of observations are correctly classified and the pseudo r-square values are in the 12-21% range. The average variance inflation factor (VIF) of these models is 4.3, below the recommended threshold of 7 for multicollinearity problems.

Models 1 and 2 present our estimations not including and including contractor fixed effects, respectively. Overall, the results remain robust to the inclusion of contractor dummies. Our main results are reported using model 2; the first column displays the regression coefficients, and the second displays the marginal effects. In probit models, the marginal effects change across observations because they depend on the covariates

[7] Our theory and econometric model assume that efficiency in quality and costs drive procurement decisions in the Chilean construction industry (rather than motives such as corruption). The positive response of Chilean infrastructure and buildings to the magnitude 8.8 Earthquake that occurred in February 2010 supports this assumption. Useem *et al.* (2015) indicate that the level of detail, enforcement capacity and adherence to strict building codes were important contributors to this positive result. Institutions that are well crafted to incentivize efficiency and punish deviant behavior discourage contractors, subcontractors, and other players from opportunistically sacrificing quality or costs.

(Wiersema and Bowen, 2009). Thus, we computed the marginal effect for each observation and reported the average marginal effect. The results unfold as follows.

None of the variables we use to measure adaptation costs is significantly correlated with centralization. This is not unexpected given that complexity and uncertainty increase the costs of both autonomous and coordinated adaptation. Consistent with our predictions, the three variables that measure agency costs are positive and statistically significant. First, the variable that measures the level of trust between contractors and project management indicates a negative marginal effect: the likelihood of centralization decreases by six percentage points (e.g., from 30% to 24%) when the project director and warehouse manager of the focal project both worked on prior projects with the contractor. Second, the labor law change has a positive marginal effect: the likelihood of centralization increases by eight percentage points after the legal change. Third, albeit significant only at the 85% level, we obtain a positive marginal effect for project distance: an increase of one standard deviation in the distance increases centralization by two and a half percentage points.

We obtain a highly significant result for the effect of vertical integration on centralization: a one standard deviation increase in vertical integration increases the likelihood of centralization by four percentage points. This result strongly supports H1.

[Insert table 2 around here]

Interactions of vertical integration with adaptation and agency costs

Table 3 presents models 3 and 4, which estimate equation (2), excluding and including contractor dummies, respectively. These models explore the interactions of agency and adaptation costs with vertical integration. Models 5, 6, 7 and 8, which check for endogeneity bias using instrumental variables and Heckman correction, are addressed in the next section.

Analyzing the marginal effects of interaction terms in probit models is complex because they not only vary in size across observations but may also vary in the direction (Wiersema and Bowen, 2009). We computed the average marginal effect across observations in the sample using the inteff command in Stata.

The interaction terms in model 4 reveal a clear pattern. All interactions of vertical integration with adaptation variables are positive and significant, whereas no interactions of vertical integration with agency costs are significant. Thus, our results support H2 but not H3. Figures 2, 3 and 4 depict our main findings. First, when vertical integration is high (i.e., mean plus one standard deviation), the expected likelihood of centralization increases by 5 percentage points (from 35% to 40%) when the project is large (i.e., mean plus one standard deviation), whereas it decreases 4 percentage points (from approximately 32% to 28%) when the project is small (i.e., mean minus one standard deviation). This result is statistically significant at the 90% level. Second, when vertical integration is high, the expected likelihood of centralization of a fast-track project is 39% but only 25% if the project is not fast tracked. This result is significant at the 99% level. Third, when vertical integration is high, the expected likelihood of centralization is 48% for a non-housing project but only 30% for a housing project. This result is statistically significant at the 90% level[8]. Because coordinated adaptation is more valuable in projects that are more uncertain and complex (i.e., larger, fast-track, and non-housing), our results indicate that the impact of vertical integration on centralization is realized by facilitating hierarchically coordinated adaptation between procurement and specialty trades.

[Insert table 3 and figures 2, 3 and 4 around here]

[8] The large economic significance is statistically significant only at the 90% level for two interaction terms (non-housing and project size). The explanation for this is the high level of multicollinearity among vertical integration, adaptation variables, and interactions between them. For instance, the interaction between non-housing project and vertical integration has a VIF of 8.3. Similarly, the interaction between vertical integration and project size has a VIF of 39. These factors generate large standard errors and low t-tests even though the marginal effects are large. This high collinearity provides indirect evidence supporting H3: vertical integration and coordinated adaptation are intertwined in how they affect centralization.

Direction of influence: from vertical integration to centralization

We have presented empirical associations in which we have assumed that causality occurs from vertical integration to centralization. In this section, we show that in our setting, this is the most likely direction of causality. It is important to advance our understanding of the mechanisms driving the associations between variables (Miller and Tsang, 2011), particularly when the analysis is conducted in specific settings, where causality can be determined with more confidence. However, we remain cautious in our analysis of causality, which is likely but not definitive. Additional research in new settings might confirm or disconfirm our proposed direction of causality.

In our study, there are good reasons to think that causality does not occur from centralization to vertical integration. Contracts with specialty trade subcontractors are typically executed well before activities start because matching a subcontractor's capacity to projects across location and time is a complex and consequential process in this industry (Bashford *et al.*, 2003). Moreover, delays from poor capacity planning cascade down to specialty trade services provided later in the project (Bashford *et al.*, 2003). In contrast, procurement of materials, whether centralized at headquarters or delegated to projects, does not require contractual commitments with independent third parties. Thus, there is more freedom to adjust the centralization, which can be made later along the project timeline. Our data indicate that the variance across projects within contractors is twice as large for centralization as for vertical integration, suggesting that vertical integration is stickier while centralization is an adjustment variable.

Notwithstanding, we cannot a priori rule out cases in which contractors address vertical integration and procurement choices simultaneously, potentially creating a reverse causality problem. To test whether our results are driven by reverse causality, we perform an instrumental variable analysis using the market thinness of the subcontractor market as an instrument for vertical integration. A small number of subcontractors with which to transact may increase the costs of using the market and promote vertical integration (Williamson, 1985). Because centralization of procurement is unlikely to be related to the market structure of a specialty trade, our instrument is likely exogenous to the centralization decision.

Because subcontractors specialize by activity and location (Somerville, 1999), the thinness of the subcontractor market was measured using a HHI in each specialty trade and geographical region. A high HHI indicates that a few subcontractors dominate the subcontractor market, increasing their bargaining power with contractors. The HHI was computed for a two-year window to avoid spurious changes. For example, the HHI for 2012 was computed using data for the 2011-2012 period. To measure market thinness for the project as a whole, we averaged the HHI values across specialty trades. The pair-wise correlations of subcontractor market thinness with vertical integration and with centralization are 0.3 and 0.04, respectively, suggesting that the instrument is strong (i.e., related to vertical integration) and exogenous (i.e., not related to centralization).

In Table 3, we present the results of the instrumental variable analysis. Model 5 replicates model 2 of Table 2. The results of a Hansen test indicate that our instrument is exogenous and the F-test of the first stage indicates that the instrument is strong. The Durbin-Wu-Hausman test indicates that vertical integration may be treated as exogenous, suggesting that reverse causality does not play a role in our setting. This is consistent with the description of vertical integration and procurement choices presented above. Model 6 of table 3, which replicates model 4 of the same table, corrects for endogenous interaction terms using the technique suggested by Wooldridge (2002: 236-237). The results using our instrument are consistent: there is a statistically significant and positive interactions between vertical integration and adaptation.

Endogeneity stemming from systematic self-selection might still be obscuring our results (Hamilton and Nickerson, 2003). Although we include an array of control variables and dummies, unobserved heterogeneity that might drive a systematic process of contractor self-selection remains (e.g., project characteristics and contractor's time-variant unobservables). We utilize a Heckman two-step correction to address this problem. In the first stage, we regressed a dummy variable for vertical integration (which took the value 1 for observations above the median of the continuous variable and 0 otherwise) on all model covariates, excluding the dummy for centralization and including subcontractor market thinness. In the second stage, we replicate our main regressions including the inverse Mills ratio. In model 7 of table 3, we replicate model 2 of table 2; in model 8, we replicate model 4. The Mills ratio is significant, which indicates that contractors select the vertical integration and centralization strategies that best suit them. The results become stronger in the self-selection correction. In model 7, we find that the mean impact of vertical integration more than doubles the impact obtained in model 2. Similarly, the interaction with adaptation variables remains positive and significant.

Robustness checks

We performed several robustness checks of the results reported in tables 2 and 3. We summarize them briefly.

Bargaining power in procurement (and related economies of scope). When many specialty trades are vertically integrated, bargaining power in procurement may increase, fostering centralization. We interact vertical integration with contractor market share and contractor size –related to market power– to evaluate whether these two variables increase the impact of vertical integration on centralization. However, these interaction terms were non-significant, and the results presented in tables 2 and 3 did not change with their inclusion. We also checked whether bargaining power was exerted in larger projects by including an interaction between market share and project size and found non-significant results. These results are not surprising because contractors procure the bulk of the products required for a project independent of the degree of vertical integration – primarily due to financial constraints and moral hazard problems in quality of products bought by subcontractors. Thus, choosing a centralization strategy to improve bargaining power should be independent of vertical integration[9].

Experience in specialty trades and prior interactions with subcontractors. We estimated additional regressions that included controls for contractor experience in executing specialty trades and prior interactions with subcontractors. The former was measured as the total square meters internally executed by the contractor over the prior four years (from t-4 to t-1) versus the total square meters executed by each subcontractor in the same market and period. The latter was measured as the frequency of interactions between the contractor and its set of subcontractors during the four-year period. The results do not differ from those presented in tables 2 and 3. We do not included these variables in the main tables because their inclusion requires dropping the first half of the sample period, limiting external validity.

The 2010 earthquake as an instrument. We used the earthquake that occurred in Chile on February 27th, 2010 as an alternative instrument to evaluate the sensitivity of our IV estimates. This magnitude 8.8 earthquake – the ninth strongest in recorded history – affected central Chile. We created a dummy that took the value 1 for projects executed after the earthquake in the regions it affected. The earthquake created a major demand expansion – depending on the region, 5% to 20% of homes were severely damaged– promoting vertical integration of specialty trades because the demand shock required securing and coordinating supply; avoiding delays from external players induced by temporal specificity; and

[9] Two other types of economies of scope might drive greater centralization when more trades are integrated, namely sharing storage and transportation across trades and projects. However, these alternative explanations are not likely affecting our results because i) we control for number of projects, ii) specialty trade services are completed sequentially, which limits resource sharing between trades.

controlling quality internally. In contrast, the choice to centralize procurement should not be affected by the earthquake[10]. Empirically, we confirmed that the earthquake increased vertical integration and did not affect centralization, corroborating its strength and validity as an instrument. The results using the earthquake as an instrument for the IV and Heckman correction models do not change from those reported in table 3, enhancing the confidence in our results and causal claim.

DISCUSSION AND CONCLUSION

We demonstrate that in our empirical setting, vertical integration promotes centralization. Although recent empirical research identifies a positive relationship between centralization and vertical integration (e.g., Arora *et al.*, 2014; Weigelt and Miller, 2013) , we show that this relationship is not a mere correlation based on similar responses to transaction characteristics, as TCE suggests, but is likely causal. The impact of vertical integration on centralization is equivalent to the impact of other canonical drivers we measure, confirming the importance of our results. We also show that the impact of vertical integration on centralization is larger when the need for coordinated adaptation is higher and that this impact is not affected by agency motives, suggesting that the effect of vertical integration on centralization is driven by improved coordinated adaptation rather than by an attempt to control agency costs. Our findings are consistent with literature that shows that vertical integration not only solves hold-up problems but also adaptation problems (e.g., Forbes and Lederman, 2009).

The implications of our findings are important for economic organization. First, internal organization may not be determined independently of firm boundaries. This result is

[10] The nature of the coordination between trades and procurement remains unchanged, and because building material suppliers are nationwide players, both inventory (level and variety) and prices in the regions affected by the earthquake should not differ from the prices and inventory in the rest of the country. Thus, neither coordinated nor autonomous adaptation changed importantly. For agency costs, the effects may offset each other. On the one hand, a larger future volume may increase (calculative) trust, promoting delegation; on the other hand, a larger volume is harder to monitor and may promote economies of scale in price, increasing centralization.

consistent with recent calls for a more comprehensive theory of the firm that connects internal organization to external firm boundaries (Garrouste and Saussier, 2005; Holmstrom, 1999; Bidwell, 2012). Second, positive interdependency between vertical integration and centralization suggests that firms are not equally distributed on the governance space surveyed by Makadok and Coff (2009); organizational forms may concentrate around two configurations: centralized firms with vertically integrated hierarchies and decentralized firms with higher levels of outsourcing. This does not imply that other organizational forms do not occur; they may simply occur less frequently. This pattern is consistent with extant research that suggests that a decentralized but vertically integrated hierarchy might be very difficult to attain (Baker *et al.*, 2001).

Our micro-level data also contributes to the relatively thin empirical literature exploring the determinants of centralization decisions. We show that firms tend to decentralize when the managers at the project level have more prior interactions with the company corporate center, probably because of relational contracting and trust. In a result that is consistent with the work of theorists who have analyzed the relationship between firm organization and the external environment (e.g., Williamson, 2000), we also observe that institutional variables are relevant to the centralization choice.

Beyond possible generalization of our results to other industries in which there are similar adaptation costs, agency problems, and centralization and vertical integration decisions (e.g., other project-based sectors, such as capital goods), we believe that our findings might extend to other procurement settings. For example, multi-establishment manufacturing firms must decide whether to procure raw materials locally at the plant or at the headquarter level in a setting where the level of vertical integration or outsourcing of different activities for each plant must also be decided. Our findings may also relate to the management of multidivisional firms, where delegation of decision rights to divisions would be accompanied by a much more "market-like" interaction between these divisions (i.e., transfer prices that match the market, autonomy to substitute the internal supplier with an external supplier). This is found in the TCE literature on divisional transfer price policy (Shelanski, 2004; Poppo, 2003). However, this literature, in contrast to our framework, studies covariance to transaction attributes and does not explore the interdependency among centralization and the type of relationship between divisions.

Based on our results, we can envision several avenues for further research relating organizational features and firm boundaries. First, additional empirical analysis is warranted. In addition to tests of this relationship in different settings, empirical studies should also address the reverse relationship that we do not address, namely, how internal organization may affect vertical integration (e.g., Weigelt and Miller, 2013; Bidwell, 2012). Second, an understanding of the dynamics of the optimization of each of these decisions and of their links is needed. Changes in either internal organization features or firm's boundaries are not instantaneous and present different levels of rigidities. For instance, a change in external conditions suggesting a move from integration to outsourcing may not be advisable if decentralization is highly complementarity with outsourcing and the centralization decision is costly to reverse. Third, further research to deepen the theoretical analysis of the relationship between vertical boundaries and internal firm organization is needed. Theoretical models have been developed in both areas, but attempts to analyze and explain their interaction might be fruitful. A recent example of such an effort is Powell (2015) whose model yields results consistent with ours. Finally, we believe that the relationship between formal organizational structure –of which firm boundaries is an important part– and informal organization –trust, cooperation, culture, and social norms– has been understudied, probably because of its complexity. We encourage researchers to address this important issue. Prior work on (formal v/s informal) inter-organizational relations can serve as an inspiration. Also, the view of

Makadok and Coff (2009) is both intriguing and exciting: formal structure is essentially a way to foster cooperation. The latter might carry more weight on performance than adjusting the former to transaction characteristics.

There are several limitations to our study. First, we use a one-dimensional measure of delegation and centralization, while other studies typically develop measures of delegation in a variety of decision rights rather than procurement alone. Second, given that the construction industry tends to be local and specific to the country context, caution should be exercised in generalizing our findings. Third, although our instrumental variable and institutional details helps in the identification of causality, any causal claim should be treated cautiously. Fourth, our measures of complexity and uncertainty are not unequivocally related to each construct.

In sum, we believe that the joint analysis of internal firm organization and vertical boundaries provides important pieces and motivation for developing a more comprehensive theory of the firm. This endeavor is important and worthwhile: after all, a proper theory of the firm should appropriately integrate firm boundaries and internal organization.

REFERENCES

Acemoglu, D., Aghion, P., Lelarge, C., Van Reenen, J., Zilibotti, F. 2007. Technology, Information, and the Decentralization of the Firm. *Quarterly Journal of Economics*, 122(4), 1759-1799.

Aghion, P., Tirole, J. 1997. Formal and real authority in organizations. *Journal of political economy*, 105(1): 1-29.

Aghion, P., Bloom, N., Van Reenen, J. 2013. Incomplete Contracts and the Internal Organization of Firms, *Journal of Law, Economics and Organization*, (advance access) doi: 10.1093/jleo/ewt003.

Ala-Risku, T., Kärkkäinen 2006. Material delivery problems in construction projects: a possible solution. *International Journal of Production Economics*, 104: 19-29.

Alonso, J., Clifton J., Díaz-Fuentes, D. 2015. Did New Public Management Matter? An empirical analysis of the outsourcing and decentralization effects on public sector size, *Public Management Review*, 17(5):643-660

Alonso, R., Dessein, W., Matouschek, N. 2013. Organizing to adapt and compete. Working paper. http://www-bcf.usc.edu/~vralonso/OTAC_April2013.pdf

Argyres, N. S. 1995. Technology strategy, governance structure and interdivisional coordination. *Journal of Economic Behavior & Organization*,28(3): 337-358.

Argyres, N., Silverman, B. S. 2004. R&D, organization structure, and the development of corporate technological knowledge. *Strategic Management Journal*, 25(8-9): 929-958

Arora, A., Belenzon, S., Rios, L. A. 2014, Make, buy, organize: The interplay between research, external knowledge, and firm structure. *Strategic Management Journal*, 35(3): 317-337.

Bajari, P., Mcmillan, R., Tadelis, S. 2008. Auctions versus negotiations in procurement: an empirical analysis. *Journal of Law, Economics and Organization* 25(2): 372-399.

Baker, G., Gibbons, R., Murphy, K. J. 2001. Bringing the market inside the firm? *American Economic Review*, 212-218.

Bashford H, Sawhney A, Walsh K, Hot K. 2003. Implications of even flow production methodology for US housing industry. *Journal of Construction Engineering and Management* 129(3): 330–337.

Bidwell, M. J. 2012. Politics and firm boundaries: How organizational structure, group interests, and resources affect outsourcing. *Organization Science*, 23(6): 1622-1642.

Birkinshaw, J., Nobel, R., & Ridderstråle, J. 2002. Knowledge as a contingency variable: do the characteristics of knowledge predict organization structure?. *Organization science*, 13(3): 274-289

Bloom, N., R. Sadun, and J. Van Reenen. 2012. The Organization of Firms Across Countries, *Quarterly Journal of Economics*, 127(4), 1663-1705.

Cacciatori, E., Jacobides, M.G. 2005. The dynamic limits of specialization: vertical integration reconsidered. *Organization Studies*, 26(12): 1851-1883

Chang, A. and F. Shen 2009, ‘Coordination needs and supply of construction projects,’ *Engineering Management Journal*, 21(4), 44–57.

Chanson, G., Quelin, B. V. 2013. Decentralization and contracting out: A new pattern for internal and external boundaries of the firm. *European Management Journal*, 31(6), 602-612.

Coase, R. H. 1937. The nature of the firm. *Economica*, 4(16): 386-405.

Davies, A., Brady T. 2000, Organizational capabilities and learning in complex product system: towards repeatable solutions, *Research Policy*, 29: 931–953.

Eccles, R. G. 1981, ‘The quasi-firm in the construction industry,’ *Journal of Economic Behavior and Organization*, 2(4), 335–357.

Ellegaard, C., Koch, C. 2014. A model of functional integration and conflict: The case of purchasing-production in a construction company, *International Journal of Operations & Production Management*, 34(3):.325 - 346

Forbes, J.,Lederman, M. 2009. Adaptation and Vertical Integration in the Airline Industry. *American Economic Review*, 99(5): 1831-49.

Foss, N. J., Laursen, K. 2005. Performance pay, delegation and multitasking under uncertainty and innovativeness: An empirical investigation. *Journal of Economic Behavior & Organization*, 58(2): 246-276.

Foss, N. J., Laursen, K., & Pedersen, T. 2011. Linking customer interaction and innovation: The mediating role of new organizational practices. *Organization Science*, 22(4): 980-999.

Foss, N. J., Lyngsie, J., Zahra, S. A. (2013). The role of external knowledge sources and organizational design in the process of opportunity exploitation. *Strategic Management Journal*, 34(12): 1453-1471.

Foss, N., Klein, P. 2014. Why managers still matter. Sloan Management Review, Fall 2014

Gambardella, A., Panico, C. and Valentini, G. 2013. Strategic incentives to human capital. *Strategic Management Journal*, advance access, doi: 10.1002/smj.2200

Garrouste, P., Saussier, S. 2005. Looking for a theory of the firm: future challenges. *Journal of Economic Behavior & Organization*, 58(2): 178-199

Gil, R., Marion, J. 2013. Self-Enforcing Agreements and Relational Contracting: Evidence from California Highway Procurement, *Journal of Law, Economics, and Organization*, 29(2): 239-277.

Gibbons, R., Henderson, R. 2012. Relational contracts and organizational capabilities. *Organization Science*, 23(5): 1350-1364.

González-Díaz, M, Arruñada, B., Fernández, A. 1998, Regulation as cause of firm fragmentation: The case of the spanish construction industry, *International Review of Law and Economics*, 18(4): 433-450.

Hamilton, B. H., Nickerson, J. A. 2003. Correcting for endogeneity in strategic management research. *Strategic organization*, 1(1): 51-78.

Hart, O., Moore, J. 1990. Property Rights and the Nature of the Firm. *Journal of political economy*, 1119-1158.

Hart, O., & Holmstrom, B. 2010. A theory of firm scope. *Quarterly Journal of Economics*, 125(2).

Hayek, F. 1945. The use of knowledge in society. *The American Economic Review*, 35, 519-530.

Holmstrom, B. 1999. The firm as a subeconomy. *Journal of Law, Economics, and organization*, 15(1): 74-102.

Hong, B., Kueng, L., Yang, M. 2015. Estimating Management Practice Complementarity between Decentralization and Performance Pay. NBER working paper No. 20845

Hook M, Stehn L. 2008. Applicability of lean principles and practices in industrialized housing production. *Construction Management and Economics* 26(10): 1091–1100.

Ibss, W. 1986. “Brand name or equal” product specifications, *Journal of Construction Engineering and Management.* 112(1): 1-13.

Ichino, A., Riphahn, R. T. 2005. The effect of employment protection on worker effort: Absenteeism during and after probation. *Journal of the European Economic Association*, 3(1): 120-143.

Jacob, B. A. 2013. The Effect of Employment Protection on Teacher Effort. *Journal of Labor Economics*, 31(4), 727-761.

Jensen, M.C., Meckling, W. H. 1995. Specific and general knowledge, and organizational structure. *Journal of Applied Corporate Finance*, 8(2): 4-18.

Lin, C., Png, I. 2003. Monitoring costs and the mode of international investment, *Journal of Economic Geography*, 3(3): 261-274.

Leiponen, A., Helfat, C. E. 2011. Location, decentralization, and knowledge sources for innovation. *Organization Science*, 22(3): 641-658

Mahoney, J. T., Qian, L. 2013. Market frictions as building blocks of an organizational economics approach to strategic management. *Strategic Management Journal*, 34(9): 1019-1041

Makadok, R., Coff, R. 2009. Both market and hierarchy: An incentive-system theory of hybrid governance forms. *Academy of Management Review*,34(2): 297-319.

Martins, P. S. 2009. Dismissals for cause: The difference that just eight paragraphs can make. *Journal of Labor Economics*, 27(2), 257-279.

Mayer, K. J., Salomon, R. M. 2006. Capabilities, contractual hazards, and governance: Integrating resource-based and transaction cost perspectives. *Academy of Management Journal*, 49(5): 942-959.

McAffee, R., McMillan, J., 1995. Organizational diseconomies of scale. *Journal of Economics & Management Strategy* 4 (3), 399–426.

McElheran, K. 2014. Delegation in multi-establishment firms: Evidence from I.T. purchasing. *Journal of Economics and Management Strategy*, 23(2): 225-258.

Meagher, K. J., Wait, A. 2013. Delegation of Decisions About Change in Organizations: The Roles of Competition, Trade, Uncertainty, and Scale. *Journal of Law, Economics, and Organization*, doi:10.1093/jleo/ewt011

Miller, K. D., Tsang, E. W. 2011. Testing management theories: critical realist philosophy and research methods. *Strategic Management Journal*, 32(2): 139-158.

Nickerson, J., Zenger T. 2004. A knowledge-based theory of the firm – The problem solving perspective. *Organization Science* 15(6): 617-632.

Novak, S., Stern, S. 2009. Complementarity among vertical integration decisions: Evidence from automobile product development. *Management Science*, 55(2): 311-332

Perryman, A., Combs, J. G. 2012, Who should own it? An agency-based explanation for multi-outlet ownership and co-location in plural form franchising. *Strategic Management Journal*, 33: 368–386.

Poppo, L. 2003. The Visible Hands of Hierarchy within the M-Form: An Empirical Test of Corporate Parenting of Internal Product Exchanges. Journal of Management Studies, 40(2): 403-430

Poppo, L., Zhou, K., Ryu, S. 2008. Alternative Origins to Interorganizational Trust: An Interdependence Perspective on the Shadow of the Past and the Shadow of the Future, *Organization Science* 19(1): 39-55.

Powell, M. 2015. An Influence-Cost Model of Organizational Practices and Firm Boundaries. *Journal of Law, Economics, and Organization*. Advance internet access

Rajan, R. G., Zingales, L. 1998. Power in a Theory of the Firm. *Quarterly Journal of Economics*, 387-432

Rasmusen, E., Zenger, T.R., 1990. Diseconomies of scale in employment contracts. *Journal of Law, Economics, and Organization* 6 (1), 65–92.

Riley, D., Varadan, P., James, J., Thomas, R., 2005. Benefit-cost metrics for design coordination of mechanical, electrical, and plumbing systems in multistory buildings, *Journal of Construction Engineering and Management*, 131(8): 877-889

Roberts, J. 2004. *The Modern Firm: Organizational Design for Performance and Growth*. Oxford University Press, New York.

Shelanski, H. A. 2004. Transaction-level determinants of transfer-pricing policy: evidence from the high-technology sector. *Industrial and Corporate Change*, 13(6): 953-966.

Simon, H. 1962 The architecture of complexity. *Proceedings of the American Philosophical Society*. 106, 467-482

Somerville, C. 1999. The industrial organization of housing supply: market activity, land supply and the size of the homebuilder firms. *Real Estate Economics* 27(4): 669-694.

Sun M, Meng X. 2009. Taxonomy for change causes and effects in construction projects. *International Journal of Project Management* 27(6): 560–572.

Tadelis, S. 2009. Complexity, flexibility and the make or buy decision. *American Economic Review* 92(papers and proceedings): 433-437.

Tadelis, S., Williamson, O.E. 2013. Transaction Cost Economics. *The Handbook of Organizational Economics*, chapter 3. Editors: Robert Gibbons and John Roberts. Princeton University Press.

Thommas, R., Sanvido, V. 2000. The role of the fabricator in labor productivity. *Journal of Construction Engineering and Management*, 126(5): 358-365.

Tommelein I, Ballard G. 1997. Coordinating specialists. Technical report no. 97-8: Civil and Environmental Engineering Department, University of California: Berkeley, CA.

Turki Ibn-Homaid N. 2002 A comparative evaluation of construction and manufacturing materials management. *International Journal of Project Management* 20: 263-270.

Useem, M., Kunreuther, H., Michel-kerjan, E. 2015 *Leadership dispatches: Chile's extraordinary comeback from disaster*. Stanford University Press

Weigelt, C., Miller, D. J. 2013, Implications of internal organization structure for firm boundaries. *Strategic Management Journal*, 34(12): 1411–1434.
Whittington, R., Pettigrew, A., Peck, S., Fenton, E., Conyon, M. 1999. Change and complementarities in the new competitive landscape: a European panel study, 1992–1996. *Organization Science*, 10(5): 583-600
Wieserman M, Bowen H. 2009. The use of limited dependent variable techniques in strategy research: issues and methods. *Strategic Management Journal* 30(6): 679–692.
Winch, G.M., 2001. Governing the project process: a conceptual framework. *Construction Management and Economics* 19, 799–808.
Williamson, O. E. 1973. Markets and hierarchies: some elementary considerations. The *American economic review*, 316-325
Williamson, O.E., 1975. *Markets and hierarchies: analysis and antitrust implications*. The Free Press, New York
Williamson, O. E. 1985. *The Economic Institutions of Capitalism*. The Free Press, New York.
Williamson, O.E. 1996. The Mechanisms of Governance. Oxford University Press. New York, NY.
Williamson, O. E. 2000. The new institutional economics: taking stock, looking ahead. *Journal of Economic Literature*, 38(3): 595-613.
Wooldridge J. 2002. *Econometric Analysis of Cross-Section and Panel Data*. MIT Press: Cambridge, MA.
Zhou. Y.M. 2013. Designing for Complexity: Using Divisions and Hierarchy to Manage Complex Tasks, *Organization Science*, 24(2): 339-355.

FIGURES AND TABLES

Figure 1. Histogram of average centralization by contractors.

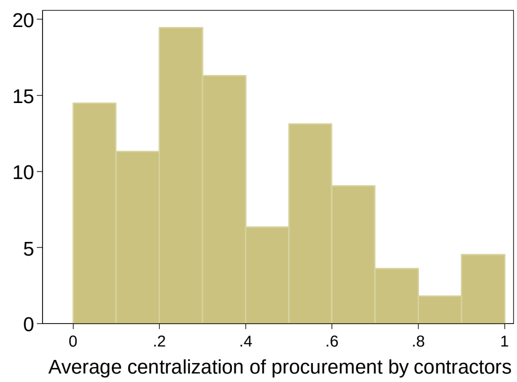

Figure 2. Impact of the interaction between vertical integration and project size

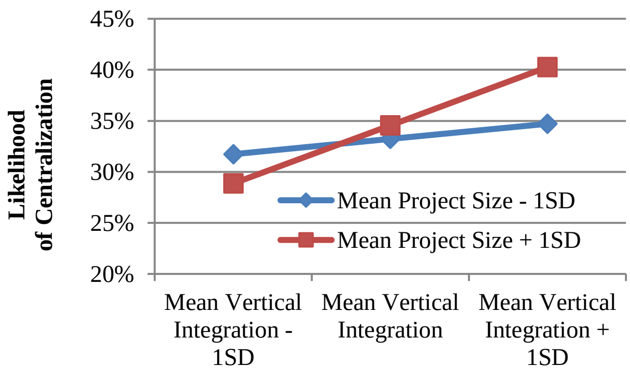

Figure 3. Impact of the interaction between vertical integration and fast track projects

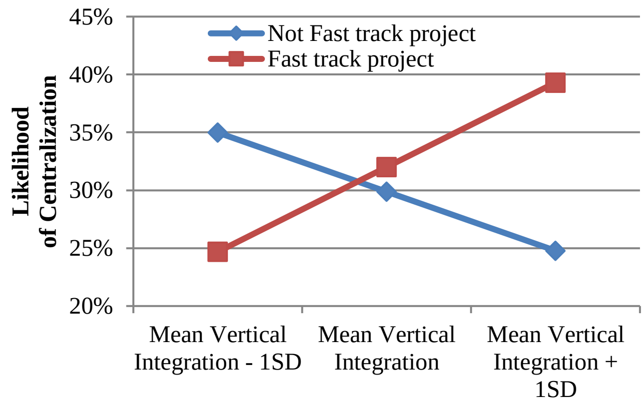

Figure 4. Impact of the interaction between vertical integration and non-housing projects

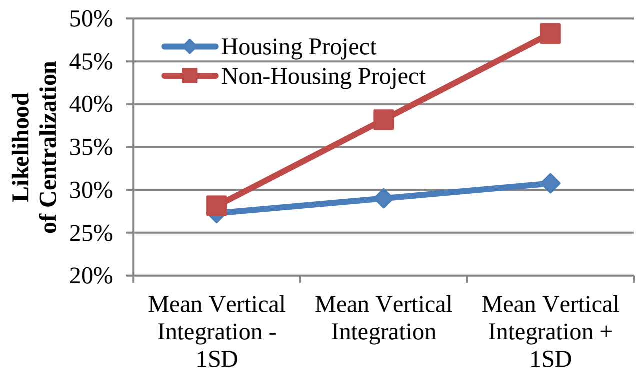

Table 1. Descriptive statistics and correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Centralization	1																	
2	Vertical integration	0.03	1																
3	Project size	0.05	-0.45	1															
4	Fast track project	0.01	0.01	0.02	1														
5	Non-housing project	-0.01	0.06	-0.04	-0.86	1													
6	Prior interactions PD & WM	-0.06	-0.02	-0.02	0.04	-0.05	1												
7	Change in labor justice	0.01	0.15	-0.08	-0.14	0.10	0.12	1											
8	Project distance	0.13	0.14	0.08	-0.07	0.09	-0.06	0.11	1										
9	Number of projects of contractor	-0.02	-0.08	0.14	0.00	-0.04	-0.03	-0.04	0.20	1									
10	1^{st} quintile of contractor size	0.06	0.11	-0.39	-0.01	0.02	-0.03	0.05	-0.12	-0.30	1								
11	2^{nd} quintile of contractor size	0.03	-0.06	0.05	-0.01	0.02	0.04	0.05	-0.05	-0.30	-0.17	1							
12	3^{rd} quintile of contractor size	0.06	-0.13	0.18	0.03	-0.03	0.01	-0.04	0.00	-0.19	-0.18	-0.19	1						
13	4^{th} quintile of contractor size	0.04	-0.15	0.24	0.07	-0.10	0.03	-0.05	0.03	0.09	-0.19	-0.19	-0.20	1					
14	5^{th} quintile of contractor size	-0.14	0.18	-0.08	-0.06	0.07	-0.04	0.00	0.13	0.64	-0.31	-0.32	-0.34	-0.35	1				
15	Contractor market share	0.09	0.14	0.22	-0.01	0.01	-0.02	0.13	0.22	0.32	-0.27	-0.14	-0.01	0.04	0.34	1			
16	Contractor diversification	-0.03	-0.22	0.12	-0.43	0.26	0.02	0.05	0.10	0.38	-0.24	-0.17	-0.01	0.11	0.27	0.05	1		
17	Geographical dispersion of contractor	0.07	0.03	0.12	-0.07	0.05	-0.02	0.09	0.42	0.50	-0.25	-0.21	-0.05	0.18	0.30	0.33	0.28	1	
18	Volume uncertainty	0.07	-0.01	-0.05	0.06	-0.03	0.04	-0.46	-0.01	0.12	0.00	-0.05	-0.01	0.03	0.02	-0.13	0.02	0.07	1
	Observations	2135	2135	2135	2135	2135	2135	2135	2135	2135	2135	2135	2135	2135	2135	2135	2135	2135	2135
	Mean	0.34	-0.34	8.54	0.70	0.22	0.17	0.25	0.41	5.72	0.15	0.17	0.20	0.24	0.25	0.04	0.24	0.19	47.68
	Std. Dev.	0.47	0.60	1.60	0.46	0.42	0.38	0.43	1.06	4.70	0.36	0.37	0.40	0.43	0.43	0.06	0.24	0.25	25.99
	Min	0.00	-1.30	0.69	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	5E-06	0.00	0.00	0.17
	Max	1.00	1.26	13.21	1.00	1.00	1.00	1.00	6.00	29.00	1.00	1.00	1.00	1.00	1.00	0.43	0.79	0.75	86.06

Table 2. Probit regression results (without interaction effects)

	Dependent variable: Centralization of material procurement			
	Model 1		Model 2	
Method:	Probit		Probit	
Variables:	Coefficient	Average Marginal Effect (AME)	Coefficient	AME
Vertical integration	0.203 ***	0.065 ***	0.222 ***	0.063 ***
	(0.059)	(0.018)	(0.078)	(0.022)
Adaptation variables:				
Project size	0.007	0.002	0.014	0.004
	(0.025)	(0.008)	(0.029)	(0.008)
Fast track project	-0.005	-0.001	-0.055	-0.015
	(0.128)	(0.041)	(0.160)	(0.045)
Non-housing project	0.040	0.013	-0.176	-0.050
	(0.295)	(0.094)	(0.335)	(0.095)
Agency variables:				
Prior interactions PD & WM	-0.228 ***	-0.073 ***	-0.208 **	-0.059 **
	(0.083)	(0.026)	(0.091)	(0.026)
Change in labor justice	0.188	0.060	0.272 *	0.077 *
	(0.139)	(0.044)	(0.153)	(0.043)
Project distance	-0.002	-0.001	0.082 †	0.023 †
	(0.036)	(0.011)	(0.052)	(0.015)
Control variables:				
Number of projects of contractor	0.006	0.002	0.013	0.003
	(0.010)	(0.003)	(0.014)	(0.004)
1st quintile of contractor size	0.634 ***	0.203***	0.584 **	0.166**
	(0.183)	(0.058)	(0.259)	(0.073)
2nd quintile of contractor size	0.444 ***	0.014***	0.238	0.068
	(0.145)	(0.046)	(0.200)	(0.057)
3rd quintile of contractor size	0.339 ***	0.108***	0.249	0.071†
	(0.125)	(0.040)	(0.170)	(0.048)
4th quintile of contractor size	0.245 **	0.078**	0.146	0.041
	(0.105)	(0.033)	(0.143)	(0.040)
5th quintile of contractor size	Omitted	Omitted	Omitted	Omitted
Contractor market share	1.200 †	0.384	-0.499	-0.142
	(0.746)	(0.238)	(1.014)	(0.289)
Contractor diversification	-0.042	-0.013	0.240	0.068
	(0.163)	(0.052)	(0.224)	(0.064)
Geographical dispersion of contractor	0.182	0.058	0.069	0.019
	(0.161)	(0.051)	(0.256)	(0.073)
Volume uncertainty	0.006 **	0.002**	0.003	0.001
	(0.002)	(0.000)	(0.003)	(0.001)
Type of project, year and region dummies?	Yes		Yes	
Contractor dummies?	No		Yes	
Constant	-2.44 ***		-3.90 ***	
	(0.598)		(0.572)	
Observations	2135		2135	
Percentage correctly classified	71.52%		74.10%	
Pseudo R-Square	12.04%		21.41%	
† 15% significance, * 10% significance, ** 5% significance, *** 1% significance // Robust standard errors in parentheses // Delta method standard errors in AME				

Table 3. Probit regression results (including interaction terms, Instrumental Variables

(IV) regressions and Heckman correction regressions).

	Dependent variable: Centralization of material procurement							
	Model 3		Model 4		Model 5	Model 6	Model 7	Model 8
Method:	Probit		Probit		IV - 2SLS	IV- 2SLS	Heckman Correction, 2nd Stage, Probit	
Variables:	Coefficient	AME	Coefficient	AME	Coefficient	Coefficient	AME	AME
Vertical integration	-1.186 ***	-0.377 ***	-1.075 ***	-0.304 ***	-0.065	-0.60 **	0.148***	-0.222†
	(0.388)	(0.122)	(0.449)	(0.126)	(0.157)	(0.263)	(0.034)	(0.153)
Project size	0.047 †	0.015 *	0.040	0.011	0.001	0.010	-0.009	0.008
	(0.029)	(0.009)	(0.032)	(0.009)	(0.10)	(0.012)	(0.008)	(0.010)
Fast track project	0.251	0.080 †	0.321	0.091	-0.017	0.111	-0.048	0.065
	(0.196)	(0.062)	(0.233)	(0.066)	(0.043)	(0.080)	(0.046)	(0.080)
Non-housing project	0.317	0.100	0.174	0.049	-0.064	0.070	-0.034	0.087
	(0.330)	(0.104)	(0.388)	(0.110)	(0.105)	(0.129)	(0.096)	(0.117)
Prior int. with PD & WM	-0.209 **	-0.066 **	-0.189 *	-0.053 *	-0.059**	-0.038	-0.066**	-0.087**
	(0.097)	(0.030)	(0.107)	(0.030)	(0.027)	(0.037)	(0.028)	(0.039)
Change in labor justice	0.173	0.055	0.272 *	0.077 *	0.071†	0.076	0.099**	0.070
	(0.144)	(0.045)	(0.159)	(0.045)	(0.050)	(0.059)	(0.047)	(0.053)
Project distance	-0.014	-0.004	0.073	0.020	0.026†	0.031*	0.025*	0.023†
	(0.037)	(0.011)	(0.053)	(0.015)	(0.016)	(0.017)	(0.014)	(0.015)
Interaction effects:								
Vertical integration X Project size	0.121 ***	0.038 ***	0.077 *	0.021 *		0.031*		0.024*
	(0.036)	(0.011)	(0.043)	(0.012)		(0.019)		(0.013)
Vertical integration X Fast track project	0.452 *	0.143 *	0.730 ***	0.206 ***		0.247**		0.184*
	(0.248)	(0.078)	(0.288)	(0.081)		(0.106)		(0.099)
Vertical integration X Non-housing project	0.295	0.093	0.488 *	0.138 *		0.179†		0.159†
	(0.268)	(0.085)	(0.296)	(0.076)		(0.125)		(0.104)
Vertical integration X Prior interactions with PD & WM	0.063	0.020	0.058	0.016		0.063		-0.040
	(0.149)	(0.047)	(0.164)	(0.046)		(0.059)		(0.057)
Vertical integration X Change in labor justice	-0.092	-0.029	-0.070	-0.020		-0.005		-0.080 †
	(0.130)	(0.041)	(0.145)	(0.041)		(0.075)		(0.052)
Vertical integration X Project distance	-0.014	-0.004	0.032	0.009		0.047*		0.004
	(0.049)	(0.015)	(0.059)	(0.016)		(0.027)		(0.017)
Inverse Mills Ratio							0.071***	0.065***
							(0.021)	(0.021)
Control variables?	Yes		Yes		Yes	Yes	Yes	Yes
Type of project, year and region dummies?	Yes		Yes		Yes	Yes	Yes	Yes
Contractor dummies?	No		Yes		Yes	Yes	Yes	Yes
Instrument for vertical integration?					Market Thinness of Specialty Trades' Subcontractors			
Constant	-3.071 ***		-4.391 ***		-0.536***	-0.700***		
	(0.629)		(0.889)		(0.201)	(0.216)		
Observations	2135		2135	2135	2135	2135	1777	1777
% correctly classified	71.33%		74.80%				75.01%	75.58%
[Pseudo] R-Square	[12.72%]		[21.87%]		23.16%	23.11%	23.05%	23.56%
Durbin-Wu-Hausman test (p-value)					0.40 (0.70)			
Hansen-test (p-value)					0.24(0.6) †			
F-test First Stage					2807			

† 85% significance, * 90% significance, ** 95% significance, *** 99% significance // Robust standard errors in parentheses // Delta method standard errors in AME // † We added a 2nd instrument to compute the Hansen test (with only 1 instrument the equation is exactly identified). We selected from Model 2 "Geographical dispersion of contractor", which is not correlated with centralization. The strength of the combined instruments (F test First Stage) decreased but remained high and valid.