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TRANSACTIONAL HAZARDS, INSTITUTIONAL CHANGE, AND CAPABILITIES: INTEGRATING THE THEORIES OF THE FIRM

FRANCISCO BRAHM and JORGE TARZIJÁN*
School of Management, Pontificia Universidad Católica de Chile, Santiago, Chile

Using a detailed dataset from the Chilean construction industry, we explore how the predictions of the transaction cost and capabilities theories interact to explain building contractors' decisions to 'make or buy' the specialty trade activities needed to complete a construction project. We show that the contractor's productive capabilities strongly mediate the relationship between transaction hazards that originate from either temporal specificity or an exogenous change in the subcontracting law and the vertical integration decision. The inclusion of differential capabilities and its interaction with transactional hazards infuse contractors' boundary choices with systematic patterns of heterogeneity and contribute to the integration of these theoretical perspectives. Our analysis corrects for the endogeneity of the capabilities variable and provides a detailed assessment of the marginal effects in logit models.

INTRODUCTION

Researchers have sought to explain firm boundaries since the pioneering work of Coase (1937). Scholars have theorized and empirically shown (see Macher and Richman, 2008 for a review) that transaction costs stemming from contracting difficulties, particularly from inefficient ex-post adaptation to high asset specificity (Williamson, 1979), from difficulties in measuring the quality of goods (Barzel, 1982) and from institutional change enacted through variations in law and regulation (Williamson, 2000), drive the comparative assessment of market versus firm governance.

In parallel, the development of the 'capabilities' theory of firm boundaries, which maintains that firms will vertically integrate the transactions for which they have stronger productive capabilities than their suppliers (Argyres, 1996; Jacobides and Winter, 2005), suggests that the differential in capabilities across firms may complement the generic prescription derived from the characteristics of the transaction *itself*, such as its specificity, its institutional setting, and its measurability. As such, the inclusion of capability differentials among firms has the potential to provide a more nuanced and comprehensive account of firm boundaries, permitting the analysis of the heterogeneity of firm boundaries and the evolving relationship between capabilities and transaction costs (Argyres *et al.*, 2012).

The current article contributes to the existing empirical research that seeks to fulfill the potential for integrating the roles of transaction costs and firm capabilities into assessments of firm boundaries (Fabrizio, 2012; Mayer and Salomon, 2006). Following Williamson (1999), we empirically explore how the predictions of these theories interact to explain the choice of Chilean

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*Correspondence to: Jorge Tarziján, School of Management, Pontificia Universidad Católica de Chile, Avda. Vicuña Mackenna, Macul, Santiago, Chile. E-mail: jtarzija@uc.cl

building contractors either to subcontract specialty trade activities (e.g., molding, plumbing, or heating) or to perform these activities internally. We show that all of the transactional hazards examined, including the hazards created by 'temporal specificity' (Masten, Meehan, and Snyder, 1991) and the hazards produced by an exogenous change in the subcontracting law that increases transaction costs, are associated with increased vertical integration. More importantly, however, we illustrate how a contractor's productive capabilities in specialty trade activities strongly mediate the relationship between transaction hazards and integration, acting as a shift parameter. A contractor with strong productive capabilities can better counteract the impact of the increased transaction hazards detailed above.

To reach this conclusion, our analysis identifies the capabilities' marginal effects in logit models, an aspect that is almost absent from previous research studies that use these models (e.g., Mayer and Salomon, 2006), and illustrates how the marginal effects differ depending on the *ex-ante* likelihood of integration of boundary choices.

We also make three additional contributions to the firm boundaries literature. First, we provide evidence of boundary choices for the construction industry, an industry that has been mostly neglected in previously published studies that address the boundaries of firms. Second, we provide additional evidence for a distinct type of specificity; namely, 'temporal specificity,' which has received relatively little empirical attention since its introduction by Masten *et al.* (1991).[1] Finally, we argue that capability heterogeneity may also be linked to prior governance choices in industries such as construction (Argyres and Zenger, 2012).

This article is divided into six sections. Following this introduction, the second section presents this study's empirical setting, and the third section develops its theories and hypotheses. The fourth section provides the database and variable measurements used for this investigation, and the fifth section presents its econometric model and main results, as well as the discussion of these results. Finally, the sixth section provides our conclusions.

[1] Some of the notable exceptions are the empirical studies by Nickerson and Silverman (2003a, 2003b), which document the presence of temporal specificity in trucking.

EMPIRICAL SETTING

We analyze the different hypotheses of this study within the context of the construction industry. This industry is important (it accounts for 8–10% of the GDP in many countries; see Gordon, 1992) and represents an ideal setting for research on governance because construction projects are long-lived, nonstandardized, and require cooperation between specialized project constituents, all of which lead to complex relations between firms and contractual intensity and incompleteness (Puddicombe, 2009; Winch, 2001). However, we know of only three studies that have empirically explored the vertical integration of this industry Eccles (1981) and Gonzalez-Diaz, Arruñada, and Fernández (1998, 2000). We seek to add to this literature by studying the 'make or buy' decision that building contractors must make for eight distinct specialty trade activities: (1) building and installing the metallic structure, (2) building the formwork, (3) installing the electrical services, (4) installing the plumbing and water services, (5) installing the heating and cooling systems, (6) building and installing the windows, (7) painting, and (8) building and installing the furnishings and the appliances. These activities account for a large proportion of the total number of activities in typical construction projects.[2] For each of these activities, the contractor must decide whether to rely on external subcontractors or to execute the task directly.

Our units of analysis are the specialty trade activities within projects. A building contractor may be in charge of different projects. Each project generally has an independent manager, workers, designers, and geographical location. The contractor may make different governance decisions regarding each of the activities to be performed in the projects. In this setting, 'to buy' implies using subcontractors (also known as 'specialty trades contractors'). These subcontractors are typically specialized in a particular activity, with little diversification of their abilities among

[2] For example, Riley et al. (2005) indicated that the construction activities (3), (4), and (5) account for 40–50% of the total construction costs in industrial, educational and health projects and for 20–30% of the total costs in commercial and housing complex projects. Activities (1) and (7) are typically expensive, especially in housing and residential building projects. All in all, the activities we specified capture approximately 50% or more of project costs.

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different activities (Ng and Tang, 2010). The contractor's main function in specialty trade activities is to coordinate the subcontractors and the internal teams that are executing those activities to ensure a timely and successful project delivery (Tommelein and Ballard, 1997).

The construction industry tends to be specific to the local context for at least two reasons. First, high transportation costs and the geographical specificity of projects incentivize the generation of 'construction districts'; that is, clusters of firms operating within a particular region (Buzzelli and Harris, 2006). Second, the industry relies heavily upon local regulations and institutions, as well as local governmental offices and quality inspectors (e.g., for building permit issuance), as all of these project components vary significantly among different regions and countries (Cacciatori and Jacobides, 2005; Winch, 2001). Contractors also tend to specialize in the types of projects they execute (e.g., residential buildings, office buildings, industrial buildings, educational facilities, or commercial buildings, among other categories) (Ball, 2003).

THEORY AND HYPOTHESES

Transactional hazards in subcontracting for specialty trades

Building upon the notion that market exchanges are costly (Coase, 1937) and may fail (e.g., Akerlof, 1970), a body of literature explaining firm boundaries as a function of transaction hazards emerged. The main theoretical construction introduced by this literature is transaction cost economics (TCE), which was developed by Williamson (1985). Assuming incomplete contracts, Williamson (1985) depicts firms as an alternative governance mechanism for hazardous contract-based market transactions that arise from specificity and bilateral dependency. The choice of the governance mechanism becomes apparent after comparing how the firm and the market address a particular transaction. The comparative assessment will favor vertical integration if the costs of using the market are larger than the costs of using the hierarchy.

In the construction industry, transaction hazards play a key role. First, transaction costs are important drivers of total project costs (Gebken and Gibson, 2006; Goetz and Gibson, 2009); second, disputes among project participants, including subcontractors, are common (Arditi and Chotibhongs, 2005; Kumaraswamy, 1997; Rubin and Wordes, 1998); and third, key success factors in construction projects include the appropriateness of the project governance mechanisms and the capability of the project managers to mitigate free-riding and opportunism among the project constituents (Lui and Ngo, 2004; Odeh and Battaineh, 2002; Palaneeswaran *et al.*, 2003; Winch, 2001).

Although the levels of asset and human specificity are generally low for specialty trade activities (Ng and Tang, 2010; Ng, Tang, and Palaneeswaran, 2009; Winch, 2001), Masten *et al.* (1991), Winch (2001), and Chang and Ive (2007a, 2007b) posit that a particular type of specificity arises in construction; namely, 'temporal specificity.' The success of specialty trade activities, and consequently of the project as a whole, is highly dependent on the timely completion of the activities (Ng and Tang, 2010; Ng *et al.*, 2009). Thus, the coordination among 'the trade parade' of activities, particularly the management of the sequential hand-offs and/or overlapping of these activities, is of paramount importance (Tommelein, Riley, and Howell, 1999). Accordingly, significant costs are incurred if the project sequence is broken and/or unbalanced (Bashford *et al.*, 2003 Tommelein *et al.*, 1999). These expenses include financial opportunity costs but, more importantly, operational costs, as an activity's productivity within projects is very dependent on the capacity planning that the subcontractor has to execute across different projects (O'Brien and Fisher, 2000), the timely delivery of previous activities (Bashford *et al.*, 2003; Ng and Tang, 2010), and the appropriate management of the interdependencies among activities (Tommelein and Ballard, 1997), all of which are significantly affected by delays or imbalances in the project schedule.

Knowing the importance of scheduling, subcontractors may opportunistically threaten the contractor with project delays to obtain price concessions (Masten *et al.*, 1991). Three conditions strengthen the credibility of this threat, and by extension, the importance of temporal specificity. First, temporal specificity will be higher whenever the contractor's costs of switching subcontractors are higher than the subcontractor's costs of leaving the project (Chang and Ive, 2007b; Winch, 2001).

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Second, because the contractor typically uses contractual terms, such as liquidation damages clauses or payment retentions and guarantees to weaken the subcontractor's threat (Chang and Ive, 2007b; Greenwood, Hog, and Kan, 2005), the threat of delay gains credibility whenever these contractual terms are undermined. A major factor causing the undermining of these clauses is the presence of 'change orders' in specialty trade activities, as these change orders cause a delay of the subcontractor activities that typically cannot be unambiguously claimed to be the subcontractor's responsibility (Chang and Ive, 2007a, 2007b; Greenwood *et al.*, 2005; Ibbs, Nguyen, and Simonian, 2011; Uher, 1991). This factor opens a window of opportunity for subcontractors to extract economic quasi-rents (Chang and Ive, 2007b), for example by overbidding on the price of the new works. Change orders are ubiquitous in construction activities (Bajari, McMillan, and Tadellis, 2008; Ibbs, 2005; Sun and Meng, 2009) and account for a relevant percentage of total project costs (Sun and Meng, 2009). Consequently, the degree of temporal specificity will be higher when a particular specialty trade activity has a higher likelihood of experiencing change orders with ambiguous responsibility apportionment.

Finally, the contractor will be more easily captured by the subcontractor's opportunistic use of the change order when the delay costs of an activity are higher (Chang and Ive, 2007a). This factor is particularly important for the initial set of activities for a project, as delays at this stage may cascade down to affect the entirety of the project (Hanna *et al.*, 1999).

It is important to note that each of these three conditions in isolation may not be sufficient to produce temporal specificity; instead, it is their joint occurrence that synergistically generates it. Sustaining a threat of delay solely upon high switching costs is not credible because if the apportionment of subcontractor contractual responsibilities is well defined and enforceable, then the contractor has the choice to enforce the subcontractor's contractual responsibility in court (Chang and Ive, 2007a). The same is the case for a threat based on high costs of delay. Thus, the presence of high switching or delay costs also requires the diffusion of responsibility provided by change orders to create temporal specificity.

Moving beyond classical TCE opportunism, other disruptions to subcontracting can also result from information asymmetries (Akerlof, 1970). Monitoring in construction activities is difficult (Navon and Sacks, 2007) and many specialty trade activities only reveal their quality after large time lags (e.g., plumbing). Thus, the contractor may not trust the subcontractor's quality claims, resulting in an excess of measurement and transaction hazards (Gwin and Ong, 2000). Using a game-theoretic model, Gwin and Ong (2000) demonstrate that the stipulation and enforcement of building standards by the local authorities play a key role in the solving of quality measurement problems in construction. We posit that if the enforcement of these standards is weak, then vertical integration between the contractor and the subcontractor is increasingly used as a mechanism to save 'measurement' transaction costs (Barzel, 1982).

Institutional change in Chilean subcontracting

By delineating the property rights embodied in laws and regulations, institutions establish the formal rules that help to define the types of organizations that will be selected to organize the exchange and production of goods (Coase, 1960; North, 1990; Williamson, 2000). Changes in property rights that affect the definition of the available uses of a good or an asset impact the transaction costs faced by economic actors. Williamson (1991) operationalizes this idea by defining the institutional environment as a set of higher order parameters whose changes 'shift' the comparative governance costs of markets and firms and thereby alter the governance choices that are made. Empirical evidence supports this 'shift-parameter' framework (Arruñada *et al.*, 2004, 2009; Fabrizio, 2012; Gonzalez-Diaz *et al.*, 1998).

In Chile, at the end of 2006, a new law affecting subcontracting came into effect for all the sectors of the economy.[3] The law in question modified three aspects of the relationship between a contractor and his specialty trade subcontractors. First, it modified the contractor's liability for the employment relationship between the subcontractor and its workers. Before the law was passed, the contractor had a liability in which the primary employment responsibilities were delegated to the subcontractor, and the

[3] This was a rather long public debate. In the online Appendix we detail the political motivations and the arguments that drove this debate.

employees of the subcontractor were allowed to sue the contractor for labor demands only if the subcontractor failed to respond in court. The new law imposed an additional liability on the contractor because the contractor may now be held directly responsible for the employment relationship, and an employee of the subcontractor may directly sue the contractor.

Second, the new law impeded the contractor from exercising overt direction and authority over the subcontractor's employees. Government labor inspections monitor workers' conduct and can lead to lawsuits against transgressing contractors with damages that include financial compensation and the re-integration of the employees in question. This structure decreases the contractor's capacity to direct, instruct, and coordinate external subcontractors, which is a central role of the contractor (Tommelein and Ballard, 1997).

Third, the new law mandated that the contractor is responsible for workplace safety and injury prevention for all of the workers at a project, including the subcontractors' employees. Although the law in question recognizes that the first party responsible for accidents involving subcontractors' employees is the subcontractor, the contractor's responsibility for workforce safety generates judicial uncertainty, causing a likely increase in the contractor's civil responsibilities in cases involving workplace accidents (Schwerter, 2008).

Consequently, the newly passed law increased the transaction costs of subcontracting, as contractors may be held responsible for labor obligations of the subcontractor that are not easily monitored and cannot easily compensate for this responsibility. Moreover, contractors are restricted in their authority over subcontractors' employees, limiting their coordinating effectiveness, and contractors are held responsible for the health and safety of subcontractor employees. From this discussion, we derive the following hypothesis:

H1: *The change in the 2006 Chilean subcontracting law increased the likelihood of vertical integration*.

Capabilities in specialty trades

The capabilities-based theory draws upon an evolutionary theory of economic change (Nelson and Winter, 1982), the resource-based view (Barney, 1986; Mahoney and Pandian, 1992; Peteraf, 1993), and the knowledge based-view (KBV) (Conner and Prahalad, 1996; Demsetz, 1988; Grant, 1996a, 1996b; Kogut and Zander, 1992, 1996).

The concept of capability refers to the productive efficiency of the firm in executing its activities: a strong capability implies a high productivity, whereas a weak capability implies a low productivity (Dutta, Narasimhan, and Rajiv, 2005; Jacobides and Hitt, 2005; Mahmood, Zhu, and Zajac, 2011). A key consequence of capabilities theory is that the heterogeneous distribution of productive capabilities between contractors and subcontractors impacts the degree of vertical integration in the construction industry (Argyres, 1996; Jacobides and Hitt, 2005; Mayer and Nickerson, 2005; Mayer and Salomon, 2006). A contractor will subcontract a trade activity if the available subcontractors are more efficient and productive than his internal procurement team and will internalize the activity if this condition is not satisfied.

The productivity of specialty trade activities has been a major focus in the construction literature. Consistent with research in many other sectors, heterogeneity in the productive efficiency of performing specialty trade activities is ubiquitous and of high magnitude (Crawford and Vogl, 2006). The impact of this heterogeneity on the boundary choice for specialty activities has been highlighted by Bridge and Tisdell (2004), albeit only conceptually.

The productivity of specialty trade activities and, more generally, the productivity of project-based organizations, is largely produced through a process that Davies and Brady (2000) termed the 'economies of repetition'; that is, the ability of contractors and subcontractors to learn from past problems on a project and to solve similar problems more easily for each subsequent project (Prencipe and Tell, 2001). In the construction literature, there is ample acknowledgement of the importance of learning, experience, and tacit knowledge in fostering productivity (Chan, Scott, and Chan, 2004; Egbu and Robinson, 2005; Jashapara, 2003; Pathirage, Amaratunga, and Haigh, 2007).

The construction literature shows that, due to structural features of the industry, the learning processes of individual subcontractors and contractors are fairly local and 'isolated' (Kululanga *et al.*, 1999), creating path dependencies that amplify capability differences and thereby augment the impact of these differences on governance choices.

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Several reasons are behind this conclusion. First, due to labor intensity (Gonzalez-Diaz *et al.*, 2000) and the 'craft' nature of construction work (Eccles, 1981; Stinchcombe, 1959), learning from repetition in specialty trades is a tacit process occurring primarily at the employee level (Egbu and Robinson, 2005; Kululanga *et al.*, 1999). Second, due to the high specialization and atomization of the industry and the loosely coupled structure between firms executing different projects (Dubois and Gadde, 2002), learning is highly local and decentralized, impeding knowledge transfer (Chinowski and Carrillo, 2007; Kao, Green, and Larson, 2009). Third, the historical sharing of knowledge between firms has been scarce, unstructured, informal and, when successful, sustained mainly by repeated personal contacts and trust rather than through structured exchanges (Styhre, Josephson, and Knauseder, 2004). Fourth, the industry's adversarial nature and high contracting hazards cause the '*gaps between the contracting parties (i.e., the general contractor and the subcontractor) . . . [to] have the potential to divide the construction team into 'islands', or self-centered decision-making units with conflicting interests . . . impairing site productivity to a great extent*' (Hsieh, 1998: 91).

The interplay of capabilities with transactional hazards and institutional change

Although the previous section suggests that capability heterogeneity may stem from the role of prior governance choices in isolating learning experiences (Argyres and Zenger, 2012), we treat current productive capabilities as a 'given' (Williamson, 1999) to analyze the interaction between these capabilities and transaction cost predictions. According to capabilities theory, contractors with low capabilities in a subcontractor's activity will be less likely to integrate vertically. However, this prediction is dependent on the level of transaction costs (Fabrizio, 2012; Jacobides and Winter, 2005). If the contractor uses the market to tap into a subcontractor's superior capability, then the productivity gains produced must be weighed against the higher transaction costs that are incurred when using the market. Thus, transaction costs generate a positive 'net tax' on the use of the subcontractor's capability. If this net tax increases, the range of a subcontractor's superiority in capabilities that generates changes in governance choice becomes smaller: only subcontractors with large productivity advantages are available for selection.

Consider the case of temporal specificity. When temporal specificity increases (e.g., because of increased change orders, switching costs, and costs of delay), the differential efficiency required to shift a subcontracting decision will need to be larger to compensate for the increased transaction costs. The same logic applies to the enforcement of building standards and changes in the law.

The previous rationale considers transaction costs to be exogenous. However, transaction costs may also be endogenous to capabilities (Mayer and Salomon, 2006). If a contractor is capable of performing a subcontractor's activity efficiently, then the contractor can use his capability to mitigate the contractual hazards of market transactions through three main mechanisms: (1) as a credible threat of vertical integration, (2) as support to recognize opportunistic behavior early in the relationship, and (3) as a help to draft more complete ex-ante contracts, including special clauses that limit subcontractors' opportunistic behavior. Moreover, a contractor that has capabilities in a subcontractor's activity can leverage these capabilities because: (1) it can manage change orders more efficiently, avoiding delays; (2) it can appoint responsibility for delays more easily; (3) it will know if a subcontractor's pricing for new work is justified, resulting in an improved bargaining stance in delay negotiations; and (4) the contractor can more easily replace the subcontractor. A similar analysis applies to the recent change in the Chilean law: a contractor that is knowledgeable and capable in the subcontractor's activities will have a greater ability to (1) monitor otherwise unobservable aspects of the employment relationship, (2) counteract the loss of hierarchical directive power through the improved selection of subcontractors, and (3) design, set up, and enforce safety and health programs. With respect to the measurement of the transaction costs, capable contractors may be more competent at assessing the quality of the work performed by the subcontractor, decreasing transaction costs associated with a lack of effective government enforcement of quality standards.

The endogenous and exogenous treatment of the relationship between transaction costs and capabilities are coherent in the sense that both suggest that the interaction between the factors discussed

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above will negatively impact the likelihood of vertical integration. From this discussion, we therefore obtain the following hypotheses[4]:

H2: *Increases in transactional hazards caused by temporal specificity will reduce the positive impact of differential capabilities on the likelihood of vertical integration*.

H3: *Increases in transactional hazards caused by the enforcement of quality standards will reduce the positive impact of differential capabilities on the likelihood of vertical integration*.

H4: *Increases in transaction hazards caused by the change in the subcontracting law will reduce the positive impact of differential capabilities on the likelihood of vertical integration*.

METHODS

Data

We used a unique database provided by ONDAC S.A. This firm collects detailed data on construction projects and sells these data to construction suppliers and building material manufacturers. The database covers the period from January 2001 to May 2009 and includes 28,951,131 square meters of building from 6,646 projects. However, the database has a higher density of projects for the period 2004–2008, during which it covers approximately 40 percent of the total square meters constructed in Chile.

The primary unit of the database is the project. For each project, detailed information about the contractor was available (i.e., executives' names and the contractor's website, address, and company name). In addition, for each project, we obtained information about the eight specialty trade activities detailed above. The data indicated whether the contractor performed this activity directly or relied on an external subcontractor. In the latter case, detailed information on the subcontractors was also available (again including executives' names as well as the subcontractor's website, address, and company name). We also obtained information about the variables that characterize each project, such as square meters (m^2), geographic location (state, city), specific materials used in six distinct categories (floor, walls, windows, coating, cement/concrete, and partition walls), starting and ending dates, stage of construction, project name, and detailed comments regarding the overall project characteristics. Finally, the database classified each project into one of the following ten categories: housing complex, office building, residential building, health facility, educational facility, hotel, industrial building, commercial project (e.g., bank or supermarket), religious building, or single-family house.

To analyze empirically the contractors' integration decisions, we created activity–project observations (eight activities per project) and then pooled these observations to perform a cross-sectional analysis with activity fixed effects. Due to data restrictions (e.g., in certain projects, we only observed the boundary choice for a fraction of the eight specialty trade activities) and our decision to restrict the analysis to the period from 2004 to 2008, we used a final sample of 10,548 project–activity observations. Previous scholars have already used pooled project data to analyze vertical integration decisions for collections of projects spanning time periods of several years (e.g., Azoulay, 2004; Novak and Stern, 2009).

Variable measurements

Dependent variable

The dependent variable *vertical integration* ($INTE_{n,j}$) was a dummy variable that assumed a value of 1 if the specialty trade activity j in the project n was internalized by the building contractor and zero otherwise. For a single project, we had eight dummy variables, one for each specialty trade activity.

Independent variables

Temporal specificity ($SPECIF_{n,j}$). *Temporal specificity* is a *combination* of switching costs, change orders, and costs of project delay. Thus, we developed a composite measure of temporal specificity that captures these three

[4] As stated, these hypotheses highlight the exogeneity of transaction hazards with respect to capabilities. A statement of these hypotheses that is focused upon the endogenous nature of transaction costs with respect to capabilities would place 'capabilities' at the start of each hypothesis and 'transactional hazards' at the end of each hypothesis.

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dimensions. Following Gonzalez-Diaz *et al.* (2000), we approximated 'switching costs' with a measure that captured the number of available subcontractors. Because subcontractors specialize geographically (Ball, 2003; Buzzelli and Harris, 2006) and by project type (Somerville, 1999), we associated the number of available subcontractors with the market concentration of subcontractors of the various construction activities for each project type in each geographical region of Chile using the Herfindahl-Hirschmann Index (HHI). Because there were 11 regions, 10 project types, and 8 different construction activities, we obtained 880 measures for 'switching costs.'[5]

Second, a higher number of expected change orders is a function of greater project customization and uncertainty regarding project design (Winch, 2001). There is a high level of standardization in the project types 'housing complexes,' 'residential building,' and 'office buildings,' which makes these project types well suited for a 'lean-construction' strategy (Hook and Stehn, 2008; Sacks and Partouche, 2010). Thus, we approximated the 'likelihood of change orders' by computing a dummy variable that takes the value of 1 if the project is not a 'housing complex,' a 'residential building,' or an 'office building,' and 0 otherwise.

Third, the higher the costs of delay are for the contractor, the greater the bargaining power of the subcontractor when negotiating delays stemming from change orders. We created a proxy for the 'cost of delay' by identifying the temporal positioning of a particular subcontractor activity within the timeline of the project. Delays in earlier activities in the project timeline are more costly than are delays in later activities (Hanna *et al.*, 1999; O'Brien and Fisher, 2000). Empirical evidence supports this asserted 'cascade effect,' as 29 percent of the variance in the duration of subcontractor activities is explained by the quality and prompt completion of previous work (Wambeke, Hsiang, and Liu, 2011). Thus, we approximated the cost of delay by creating an ordinal measure that takes the value of 1 for activities that occur at the end of a project (i.e., 'building and installing the windows,' 'painting,' and 'building and installing the furnishings and the appliances'); a value of 2 for the activities that occur during the middle of a project (i.e., 'installing the electric services,' 'installing the plumbing and water services,' and 'installing the heating and cooling systems'); and a value of 3 for activities that occur at the start of a project (i.e., 'building and installing the metallic structure' and 'building the formwork') (see Tommelein *et al.*, 1999). Additionally, project uncertainty is higher during the initial stages of a project (Winch, 2001), indicating that earlier specialty trade activities also increase the expected number of change orders.

We combined these three dimensions into a unique variable, SPECIF, by multiplying the variables representing these dimensions[6]:

$$\text{SPECIF} = {'}\text{Switching costs}{'} \times {'}\text{Number of change orders}{'} \times {'}\text{Cost of delay}{'}\,^{7}$$

Quality measurement. Construction quality is difficult to assess; as a result, the construction industry is plagued with information asymmetry problems (Lützkendorf and Speer, 2005). Consequently, governmental regulations typically appoint specialized agents that are responsible for evaluating construction quality and certifying that this quality meets required standards before issuing permits (Winch, 2001). In Chile, a key agent performing this activity is the 'Independent Reviewer of Construction Work' (IRCW). The IRCWs are only allowed to review the quality of projects executed in the region where they are registered. However, the quantity and quality of IRCWs may not adequately satisfy the quality enforcement requirements in each region. Because the contractor is liable for the subcontractor's work, he may eschew subcontracting if he cannot rely on capable IRCWs to decrease his quality risks, opting instead for internal procurement.

[5] Our results did not vary when we restricted the calculation of HHI to a geographical area or a specific project type.

[6] Each of these three dimensions was positively related to vertical integration when we ran regressions with each of the three variables separately. Using the specification of model 1, the coefficient for 'switching costs' is 0.196 (significant at the 99% confidence level), for 'change orders' is 0.028 (significant at the 95% confidence level), and for 'delay costs' is 0.021 (significant at the 99% confidence level). More details of these regressions are available from the authors upon request.

[7] According to Law, Wong, and Mobley (1998), multidimensional constructs that exist at the same level of their dimensions (such as ours) can be expressed as a mathematical function of their dimensions.

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Using June 2008 data about the quantity and quality of IRCWs by region from the centralized registry of IRCWs provided by the Chilean Ministry of Housing,[8] we created the variable $QUAL\_MEAS_n$, which was measured by multiplying the number of IRCWs in a particular region and the average IRCW quality for that region. A project that is executed in a region with few and inexperienced IRCWs will be more likely to feature vertical integration of its specialty trade activities. Since this variable is affected by the region's size we added a control variable to control for it.

Change in the Chilean outsourcing law. When the legislature approved the new law (LAW_CHANGE_n) on September 5, 2006, we added a dummy variable that assumes a value of 1 for projects that started after August 2006, and zero otherwise. The change in legislation is exogenous to individual firms because it was applied to all of the firms, industries, and geographical regions in the economy. Although the government may have had the objective of reducing subcontracting as a result of the law change, from the contractors' perspective the law was simply passed, and thus they had to adjust to this 'exogenous' shift in governance conditions. No single contractor had the ability to influence the law change.

Capabilities. Experience and learning have long been associated with efficiency (Balasubramanian and Lieberman, 2010) and, by extension, with productive capabilities (Dutta *et al.*, 2005). More importantly, different industry environments notably affect the relationship between learning and efficiency (Balasubramanian and Lieberman, 2010). In specialty trade activities, experience and learning are paramount for the development of productive capabilities ($CAP_{n,j}$) and efficiency (Davies and Brady, 2000).

Studies from the organizational learning literature have measured experience in terms of accumulated output (i.e., either volume or sales) (see Darr, Argote, and Epple, 1995; Ingram and Baum, 1997; Parmigiani and Holloway, 2011). Reviewing this literature, Argote and Miron-Spektor (2011) proposed that organizational learning *can be measured in terms of the cumulative number of task performances*. Consequently, the *differential in capabilities* between the contractor and the subcontractors with respect to the different specialty trade activities is approximated by their relative accumulated outputs. Specifically, we first compiled the list of the accumulated square meters built by subcontractors (for the entire period) for each of the eight trade activities considered in this study and for each geographic region (to capture the geographic dimension and the types of project specialization prevalent in the industry). We then computed a percentile for each contractor that corresponded to the ranking that the accumulated square meters built by that contractor (for the entire period) would have if it were placed within each list.[9] Thus, a higher percentile is associated with greater contractor capabilities in trade 'x' in region 'y' compared with the capabilities of the available subcontractors in trade 'x' in region 'y.'[10] Specialty trade activities possess a low level of economies of scale (Gonzalez-Diaz *et al.*, 2000); therefore, our measure of learning is not confounded by a 'scale effect.'

Control variables

We control by demand uncertainty, the degree of repeated interactions between each building contractor-subcontractor pair, project complexity, contractor diversification, contractor size, project distance from the contractor's most common project location, contractor market share, year, and by projects located in the metropolitan region. A detailed discussion of the control variables is provided in the online Appendix. Table 1 summarizes the descriptive statistics and displays the correlation matrix for the variables.

[8] The government determines the quality of the IRCW by classifying them according to a three-category scale.

[9] We did not measure capabilities up to the project at hand because we would have introduced measurement error at earlier years in our sample (due to a reduced number of observations). However, measuring capabilities for the entire period might affect those contractors that were divesting or investing in capabilities during the period of our sample. We checked for this bias by executing a regression for the 2008 boundary choices of contractors on a measure of capabilities computed up to the year 2007 (and the rest of covariates). The results did not change, supporting our measure of capabilities. The results of this regression are available from the authors upon request.

[10] The left-censoring of CAP is small, as only 4.6% of the variable has a value of 0. Thus, the expected bias on the coefficient of CAP is small, approximately 3% (Austin and Hoch, 2004).

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Table 1. The correlation matrix and descriptive statistics

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	INTE	1.000													
2	SPECIF	0.172	1.000												
3	QUAL_MEAS	−0.172	−0.490	1.000											
4	LAW_CHANGE	0.210	0.141	−0.130	1.000										
5	CAP	−0.145	−0.145	0.008	−0.213	1.000									
6	UNCERT_VOL	0.237	0.130	−0.072	−0.186	−0.336	1.000								
7	REP_INTER	−0.299	−0.161	0.135	−0.170	0.404	−0.209	1.000							
8	DIVERS	−0.248	0.041	0.023	−0.083	0.231	−0.168	0.127	1.000						
9	COMP	−0.153	−0.112	0.090	−0.316	0.092	−0.280	0.153	0.054	1.000					
10	SIZE	−0.373	−0.132	0.028	−0.245	0.772	−0.460	0.462	0.359	0.135	1.000				
11	GEODIS	−0.047	0.101	−0.228	−0.035	0.299	−0.042	0.068	0.246	0.014	0.443	1.000			
12	MKT_SHARE	−0.038	0.181	−0.383	0.000	0.279	0.018	0.127	0.067	−0.015	0.272	0.235	1.000		
13	YEAR	0.220	0.152	−0.118	0.790	−0.254	0.189	−0.204	−0.073	−0.361	−0.286	−0.047	−0.035	1.000	
14	D_REG	−0.173	−0.483	0.988	−0.129	0.025	−0.086	0.145	0.019	0.100	0.040	−0.228	−0.358	−0.125	1.000
	n	10,548	10,548	10,548	10,548	10,548	10,548	10,548	10,548	10,548	10,548	10,548	10,548	10,548	10,548
	Mean	0.61	0.58	212.36	0.73	0.43	0.73	1.79	0.24	0.12	8.95	1.91	0.03	8.59	0.75
	Std. Dev.	0.49	0.88	86.41	0.45	0.29	0.23	0.88	0.24	0.89	1.94	1.94	0.08	1.04	0.43
	Min	0	0	11	0	0	0	1	0	−6	4.8	1	0	6	0.0
	Max	1	6	262	1	1	1	7	1	2	12.8	17	1	10	1.0

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EMPIRICAL ANALYSIS

Econometric model

We use the following econometric model to examine the building contractor's vertical integration decisions:

$$INTE_{j,n} = \beta_0 + \beta_1 \times SPECIF_{j,n} + \beta_2 \times QUAL\_MEAS_n + \beta_3 \times LAW\_CHANGE_n + \beta_4 \times CAP_{j,n}$$
$$+\beta_5 \times (CAP_{j,n} \times SPECIF_{j,n}) + \beta_6 \times \left(CAP_{j,n} \times QUAL\_MEAS_n\right) + \beta_7 \times (CAP_{j,n} \times LAW\_CHANGE_n)$$
$$+CONTROLS + k_j + \mu_{j,n}$$

$INTE_{j,n}$ represents the contractor's vertical integration decision regarding the specialty trade activity j in project n. The vector k controls for the unobserved systematic factors within each activity. Because our dependent variable is dichotomous, we use a logit model. We address the marginal effects of logit models, following the recommendations of Hoetker (2007) and Wieserman and Bowen (2009).[11] OLS models are used as baselines and to explore the validity of our endogeneity corrections.

The variable indicating 'capabilities' (CAP) may suffer from endogeneity because a contractor that has already integrated activity j likely possesses the capabilities to perform that activity (Argyres and Zenger, 2012). This bias is known as 'simultaneous causality' and is corrected by the use of instrumental variables (IV) (Bascle, 2008; Murray, 2006). The two instruments we use are discussed below.

The interaction terms of CAP may also be biased. We correct for this problem by implementing Wooldridge's (2002: 236–237) solution. We use a model that includes all the covariates of Equation 1 and the instruments (but excluding the interaction terms), multiply the predicted value of CAP obtained from this model by the interaction variables (SPECIF, QUAL_MEAS and LAW_CHANGE), and use the result of this multiplication, namely $\widehat{CAP}$ * (Interaction Variable), as an instrument to assess the endogenous interaction terms CAP * (Interaction Variable). The simultaneous IV correction for four variables (i.e., CAP and its three endogenous terms) with these five instruments is supported by the IVREG2 routine from STATA.

RESULTS

The results are presented in Table 2. Model 1 is an OLS estimation, model 2 corrects for the potential endogeneity of CAP with an IV estimation and model 3 corrects for the potential endogeneity of CAP and its interaction terms with an IV estimation by implementing Wooldridge's (2002: 236–237) solution. The R^2 of these models is approximately 30 percent. We use models 2 and 3 to test our instruments; if the instruments were found to be valid, we replicated models 1–3 with the incorporation of logit estimations to obtain models 4–6.[12] We then evaluate the effects of our variables on vertical integration using models 4–6.

The majority of the coefficients of the fixed effects for the construction activities were significantly different from zero (99% confidence level). This finding indicates that the fixed effects capture the unobserved heterogeneity of the construction activities that affect the vertical integration decision.[13] Moreover, the estimated coefficients of the

[11] A concern with our empirical strategy was autocorrelation. A contractor might show persistence in its vertical integration decisions across projects. We performed the following checks to assess this potential problem: (1) we tested the model for several subsamples, (2) we tested the model for each year separately, (3) we included contractor fixed effects, and (4) we tested the model by clustering errors at the contractor level. Because the results did not change, we assumed that autocorrelation was not a problem. We suspect that project-level data might be less prone to autocorrelation than firm-level data because each project has unique characteristics, such as a particular starting and finishing date, and because organizational decisions tend to be project-specific. Along with the findings of previous studies (e.g., Azoulay, 2004), our results support the treatment of projects as independent observations.

[12] We also estimated model 5 using a probit estimation with instrumental variables that incorporated STATA's IVPROBIT procedure. The results did not change, validating the use of these instruments in LOGIT specifications.

[13] We also added a set of "project type" fixed effects, but they exhibited low statistical significance in the results. Moreover, their inclusion did not affect the results of the variables of interest. We used these variables for our IV models.

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Table 2. Model estimations: (1) OLS and 2SLS are baseline models and (2) LOGIT and IVLOGIT are the models for hypothesis evaluation[a–c]

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	OLS		2SLS IV Cap		2SLS IV Cap (Interactions instrumented)		LOGIT		LOGIT IV Cap		LOGIT IV Cap (Interactions instrumented)	
Variables of interest												
SPECIF	0.027^{***}	(0.005)	0.025^{***}	(0.007)	0.023^{***}	(0.006)	0.262^{***}	(0.049)	0.256^{***}	(0.055)	0.415^{***}	(0.094)
QUAL_MEAS	-0.001^{***}	(0)	-0.001^{**}	(0)	0.000	(0)	-0.005^{**}	(0.002)	-0.004^{*}	(0.002)	−0.001	(0.002)
LAW_CHANGE	0.037^{**}	(0.015)	0.037^{**}	(0.015)	0.121^{***}	(0.027)	0.180^{**}	(0.089)	0.183^{**}	(0.085)	0.777^{***}	(0.151)
CAP	0.620^{***}	(0.023)	0.534^{***}	(0.186)	0.920^{***}	(0.178)	3.617^{***}	(0.156)	3.429^{***}	(1.064)	6.324^{***}	(1.096)
SPECIF*CAP	—	—	—	—	0.166^{*}	(0.101)	—	—	—	—	−1.383	(0.881)
QUAL_MEAS*CAP	—	—	—	—	-0.001^{***}	(0)	—	—	—	—	-0.006^{***}	(0.002)
LAW_CHANGE*CAP	—	—	—	—	-0.178^{***}	(0.047)	—	—	—	—	-1.224^{***}	(0.261)
Controls												
UNCERT_VOL	0.095^{***}	(0.021)	0.098^{***}	(0.022)	0.073^{***}	(0.023)	0.525^{***}	(0.119)	0.450^{***}	(0.119)	0.424^{***}	(0.12)
REP_INTER	-0.079^{***}	(0.006)	-0.077^{***}	(0.007)	-0.073^{***}	(0.007)	-0.432^{***}	(0.038)	-0.407^{***}	(0.04)	-0.404^{***}	(0.04)
DIVERS	-0.265^{***}	(0.019)	-0.268^{***}	(0.019)	-0.264^{***}	(0.02)	-1.581^{***}	(0.107)	-1.475^{***}	(0.106)	-1.406^{***}	(0.107)
COMP	-0.018^{***}	(0.005)	-0.019^{***}	(0.006)	-0.020^{***}	(0.006)	-0.083^{***}	(0.031)	-0.080^{***}	(0.033)	-0.084^{**}	(0.033)
SIZE	-0.132^{***}	(0.004)	-0.122^{***}	(0.022)	-0.124^{***}	(0.023)	-0.745^{***}	(0.027)	-0.708^{***}	(0.124)	-0.743^{***}	(0.128)
GEODIS	0.028^{***}	(0.002)	0.027^{***}	(0.003)	0.025^{***}	(0.003)	0.159^{***}	(0.016)	0.145^{***}	(0.016)	0.147^{***}	(0.017)
MKT_SHARE	-0.234^{***}	(0.063)	-0.210^{***}	(0.078)	-0.411^{***}	(0.088)	-1.626^{***}	(0.364)	-1.583^{***}	(0.452)	-1.701^{***}	(0.497)
YEAR	0.363^{***}	(0.052)	0.356^{***}	(0.054)	0.384^{***}	(0.058)	2.049^{***}	(0.33)	1.852^{***}	(0.319)	2.177^{***}	(0.33)
YEAR^2	-0.020^{***}	(0.003)	-0.020^{***}	(0.003)	-0.021^{***}	(0.003)	-0.114^{***}	(0.02)	-0.103^{***}	(0.019)	-0.122^{***}	(0.02)
D_REG	0.050	(0.059)	0.067	(0.069)	−0.036	(0.071)	0.419	(0.423)	0.249	(0.439)	0.125	(0.438)
Subcontract fixed effect												
INCLUDED?	Yes		Yes		Yes		Yes		Yes		Yes	
Model constant												
CONSTANT	0.015	(0.226)	0.093	(0.23)	−0.227	(0.247)	−2.245	(1.408)	−1.801	(1.337)	-4.155^{***}	(1.391)
Goodness of fit												
Observations	10,548		10,548		10,548	—	10,548		10,548		10,548	
R square (%)	30.02		29.92		29.16							
F-1st-stage (Hansen test: p-value)	—	—	67.5 (0.33)		26.1(0.533)							
Hausman endog. test (p-value)			0.201		0.000							
Pseudo R square (%)							25.72		20.75		21.02	
Wald X^2							2211		2075		2096	
Correctly classified (%)							76.36		73.49		73.39	

[a] $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$
[b] Huber-White robust standard errors are indicated in parentheses.
[c] The IV correction of endogenous interaction terms follows Wooldridge (2002).

independent and control variables do not change significantly (compared with a model without fixed effects, with data available upon request), implying that the results may be robust.[14]

As noted by Bascle (2008) and Murray (2006), the appropriate use of instrumental variables requires instruments that satisfy two conditions: strength (i.e., the instruments should be able to explain CAP) and exogeneity (i.e., the instruments should not explain INTE). To identify these instruments, we explored a set of dummy variables related to the project type. If certain project types do not explain INTE but are correlated with CAP, then we have successfully identified a candidate set of instruments. Thus, we conducted a new regression of model 1 including a dummy-set of project types and found that only three types of projects were significantly related to vertical integration: 'office buildings,' 'industrial projects,' and 'commercial.' We then explored the relationship between CAP and the remaining types of projects. We found that the project type 'housing complex' was positively and significantly correlated with CAP (t-test of 11.7) and that 'educational facilities' was negatively and significantly correlated with CAP (t-test of 1.91). Thus, we obtained a candidate set of instruments for the IV estimation.

We applied the recommended statistical tests to confirm our choice of instruments. For models 2 and 3, the Hansen tests yield values of 0.12 and 0.37, respectively (p-values of 0.72 and 0.54), not rejecting the null hypothesis that the instruments are exogenous. In the F-test of the first stage, we obtained values of 64.5 and 25.2 for models 2 and 3, which exceed the minimum levels specified by Stock and Yogo (2002) for the strength of the instruments. We conducted a Hausman specification test and obtained p-values of 0.76 for model 2 and 0.000 for model 3. Thus, only in model 3 we do reject the null hypothesis that CAP and its interaction terms are indeed endogenous. As expected, the coefficient of CAP in model 2 is smaller than the value of this coefficient in model 1 because of reverse causality; however, this difference is not sufficient to cause us to reject the null hypothesis that CAP is exogenous. On the whole, these results indicate that our instruments are valid.[15]

In models 4–6, we present LOGIT estimations. We follow Hoetker's (2007) recommendation for the analysis of goodness of fit. The percentage of correctly classified observations in these models is in a range that goes from 73 to 76.5 percent, respectively. Given the base case of predicting 50 percent of the observations as 'make' and 50 percent as 'buy,' the models improve upon these predictions by 43 and 52 percent, respectively. If we assume that the 'informed predictor' knows that 61 percent of the observations are 'make' (see the average of INTE in Table 1), then the model improves upon the base predictions of the 'informed predictor' by 20 and 26 percent, respectively (73/61-1 and 76/61-1). On the whole, these figures represent an acceptable goodness of fit for logit models.

To report the results of the logit models, we followed the recommendations of Hoetker (2007) and Wieserman and Bowen (2009), which show that the coefficients of the individual variables in logit models possess an absolute value that unambiguously indicates their influence but a statistical significance that changes for each observation in the sample. Moreover, the coefficients of the interaction terms in logit models may display different signs of influence for different observations. We used the graphs recommended by Wieserman and Bowen (2009) to analyze the effects of individual and interaction terms.[16] For SPECIF, QUAL_MEAS and LAW_CHANGE, we constructed these graphs from model 4 (unchanged if model 5 was used); for CAP, we used model 5.

The coefficient of the variable ESPECIF possesses a positive sign in model 4. The marginal

[14] We also estimated models including dummy variables for the type of project and the project's region; however, the results from these models did not differ significantly from the findings presented in this article.

[15] We checked for the exogeneity of capabilities using three robustness analyses. First, we added contractor fixed effects to model 1 to correct for unobserved heterogeneity at the contractor level that might drive our results. Second, using model 1 we regressed the 2008 boundary choices of contractor on a measure of capabilities computed up to the year 2007 (including the covariates) in order to correct for reverse causality. And third, we combined both techniques to correct simultaneously for unobserved heterogeneity and reverse causality. All results yielded positive and significant (at the 99% confidence level) coefficients for capabilities, providing robustness to the identification of the impact of capabilities on vertical integration.

[16] We also explored the graphs proposed by Zelner (2009) for the interactions terms. We decided to use the recommendations of Wieserman and Bowen (2009) because Zelner's (2009) graphs do not display the interaction terms for the whole range of observations but instead only display the terms for a small subset of the observations.

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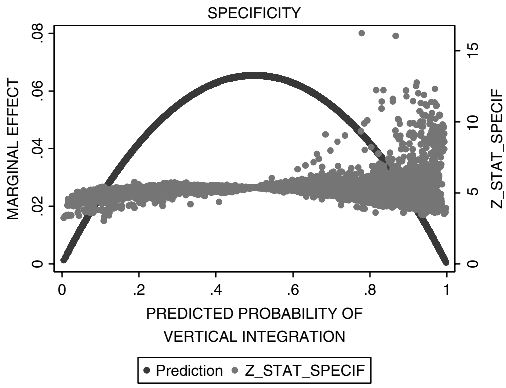

Figure 1. The marginal effect and significance of SPECIF (constructed from model 4)

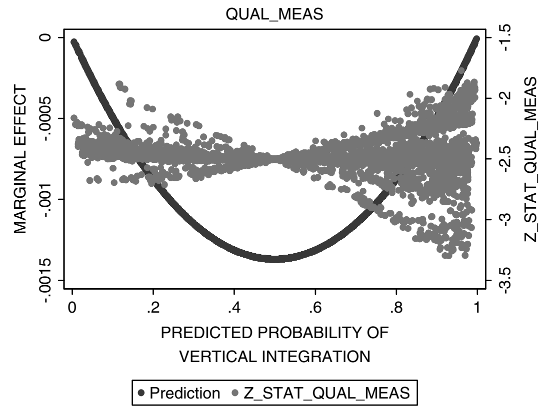

Figure 2. The marginal effect and significance of QUAL_MEAS (constructed from model 4)

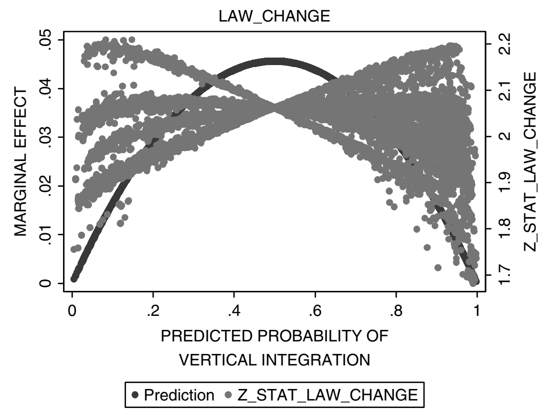

Figure 3. The marginal effect and significance of LAW_CHANGE (constructed from model 4)

effect and significance level (z-statistics) of this variable throughout the observations can be observed by examining the left and right vertical axes of Figure 1, respectively.[17] The darker dots (i.e., the inverted U) indicate the variable's marginal effect, whereas the lighter dots (i.e., the cloud of points) indicate its significance level. Because this variable is highly significant for the entire sample, we can conclude that the transactional hazards derived from temporal specificity increase the likelihood of vertical integration of the specialty trade activities.

The coefficient of the variable QUAL_MEAS possesses a negative sign in model 4. The marginal effect and significance level of this variable throughout the observations can be observed by examining the left and right vertical axes of Figure 2, respectively. Because this variable is highly significant for the entire sample, we can conclude that there is a strong negative correlation between the number and quality of the reviewers that enforce quality standards in a particular region and the vertical integration of specialty trade activities in projects performed within that region.[18]

The LAW_CHANGE variable yielded a positive coefficient with a significant marginal effect, at least at the 95 percent level for 89 percent of the observations, with the 11% of remaining observations being significant at least at the 90 percent level (Figure 3). The average effect implies that the new law increased the likelihood of vertical integration by approximately 3.5 percent. Thus, H1 cannot be rejected, supporting the view that the law change that occurred in Chile increased vertical integration.

The coefficient obtained for CAP in model 2 is positive and significant at the 99 percent confidence level. For model 5, Figure 4 illustrates that all of the observations are significant at the 99 percent confidence level. A contractor is more likely to integrate a specialty trade activity vertically if it has stronger capabilities

[17] The bell-shaped curve of the marginal effect follows the properties of the logistic probability distribution (left vertical axis of Figure 3). This shape indicates that the variable has a stronger influence on the observations for which the predicted probability of integration is not clearly tilted toward the extremes of internal or external procurement. This result is intuitive because under extreme conditions, other forces are already "fixing" the outcome of the integration decision, whereas at intermediate levels of the predicted likelihood of integration, the decision is more sensitive to any change in the environmental conditions.

[18] We correct for the size of the regions (which might affect both INTE and QUAL_MEAS) with D_REG. The inclusion of the size of the regional market did not change our results.

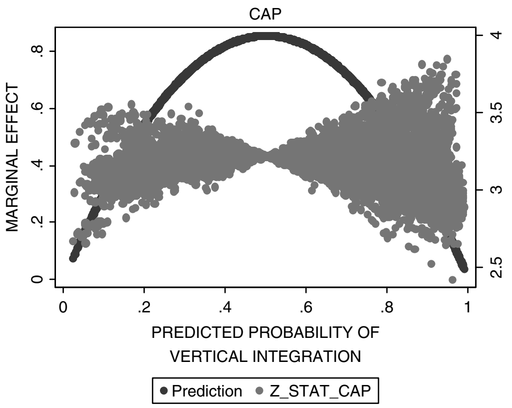

Figure 4. The marginal effect and significance of CAP (constructed from model 5)

in that activity. On average, an increase in CAP by one standard deviation produces an 18 percent increase in the likelihood of vertical integration (e.g., a change in the likelihood of vertical integration from 20 to 40%). This figure is much greater than the one-standard-deviation effects of SPECIF (approximately 2.5%), QUAL_MEAS (approximately −8%), or LAW_CHANGE (approximately 3.5%). These results indicate that governance choices of specialty trade activities will not 'homogenize' around their specificity or measurability but will be heterogeneous in accordance with the capabilities that each contractor possesses.

Interaction terms

We display the results for each variable in two graphs, one displaying the variable's marginal effect (graph (a)) and another displaying its statistical significance (graph (b)). For the interaction between CAP and SPECIF, graph (a) of Figure 5 illustrates that in 97 percent of the cases the observations have a negative sign, whereas graph (b) shows that a large portion of these observations (56% of them) are significant at least at the 95 percent level. Thus, H2 cannot be rejected, supporting the view that the interaction between capabilities and transaction costs decreases the likelihood of vertical integration, both because capabilities mitigate increases in transaction costs and because high transaction costs 'tax' the differential capabilities. The observations that are significant have a high level of ex-ante likelihood of integration, and hence it appears that the importance of capabilities in reducing temporal specificity hazards or, alternatively, the diminishment of the impact of capabilities at higher levels of temporal specificity is of greater importance if the contractor is more likely to integrate because of other factors.

The interaction between QUAL_MEAS and CAP, shown in graphs (a,b) of Figure 6, indicates that for roughly a third of the observations the marginal effect is positive and significant, not rejecting H3, and that for another third of the observations the marginal effect is negative and significant, rejecting H3. Thus, although the sign and statistical significance of the QUAL_MEAS individual variable leads us to conclude that when there is more monitoring and better quality measurement there are lower incentives to vertically integrate, we note that there is no clear conclusion regarding the interaction term between QUAL_MEAS and CAP.

Figure 7 presents the results of model 6 for the interaction between LAW_CHANGE and CAP. We find that almost every observation has a negative and highly significant interaction effect. Specifically, 97 percent of the observations are significant at least at the 95 percent level and 90 percent of the observations are significant at least at the 99 percent level. This result does not reject H4, supporting the notion that capable contractors were able to mitigate the effects of the law change (or alternatively, favoring the possibility that the law change decreased the explanatory power of capabilities). Additionally, the negative marginal effect becomes larger (and more significant) as the ex-ante likelihood of vertical integration increases. This result is consistent with the interaction that occurs between SPECIF and CAP: it appears that if other variables are 'already' pushing toward integration, the impact of capabilities in reducing the effect of the law change is greater.

The interaction terms discussed here also infuse 'systematic heterogeneity' into the 'generic' boundary choice predictions of TCE and institutional change. If these interactions terms are small compared to the stand-alone effects of SPECIF and LAW_CHANGE, then the systematic heterogeneity is only felt through the stand-alone effect of CAP. In Figures 8 and 9, we can gauge the relative weight of the interaction terms compared with the stand-alone effects. Figure 9 clearly shows that changes in CAP generate major shifts in the marginal effect of SPECIF around its average value, which roughly corresponds to the average stand-alone effect. Similarly, Figure 10 indicates

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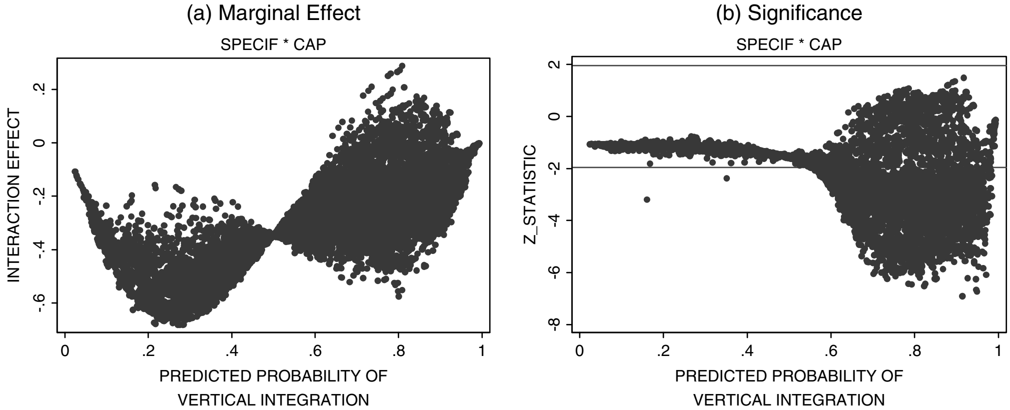

Figure 5. (a,b) The marginal effect and significance of the interaction term SPECIF*CAP (constructed from model 6)

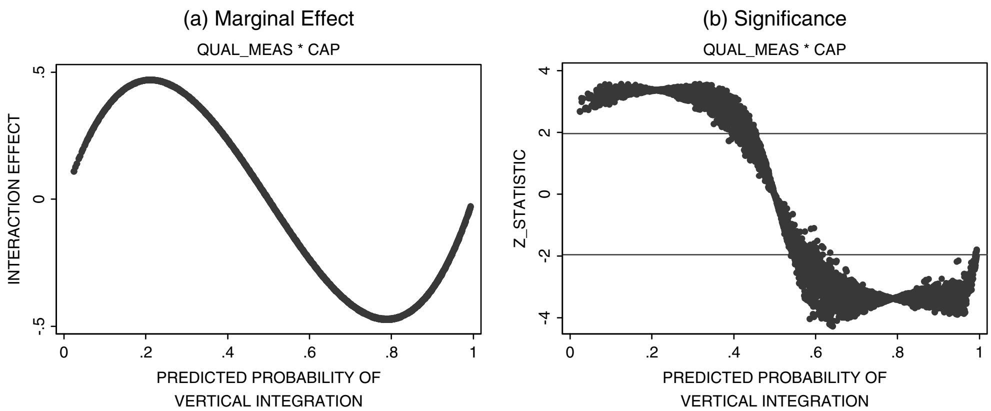

Figure 6. (a,b) The marginal effect and significance of the interaction term QUAL_MEAS*CAP (constructed from model 6)

that changes in CAP generate important shifts in the marginal effect of LAW_CHANGE around its average value. These graphs highlight the importance of the heterogeneity induced by the interactions between capabilities and transaction costs on firms' boundary choices. A contractor with capabilities situated one standard deviation above the 'mean capability' is affected by neither temporal specificity nor the law change. Conversely, a contractor with capabilities situated one standard deviation below the 'mean capability' is impacted by temporal specificity and the law change twice as strongly as a contractor with a 'mean capability.'

Furthermore, in Figures 10 and 11, we examine the reverse case: the degree to which variations in SPECIF and the change in the law influence the marginal effect of CAP. In contrast to Figures 8 and 9, which have the underlying rationale of examining the effect of CAP in mitigating transactional hazards, Figures 10 and 11 address the impact of 'exogenous' shifts in temporal specificity (affected by the activities' *given* characteristics) and in the law (exogenously determined) on capabilities. We observe that although the marginal effect of CAP does shift due to SPECIF or the law change, the changes around the mean are small; the sheer size of the stand-alone effect of CAP reduces the importance of the impact that transactional hazards might have on CAP. These results suggest that the effect of capabilities in (endogenously) mitigating the impact of transactional hazards is much stronger than the effect of (exogenous) transactional hazards in reducing the importance of differential capabilities in boundary choices.

In conclusion, the results for the interaction terms provide support for hypotheses H2 and H4. Transaction costs can be viewed as 'taxes' on capabilities, diminishing their impact; conversely,

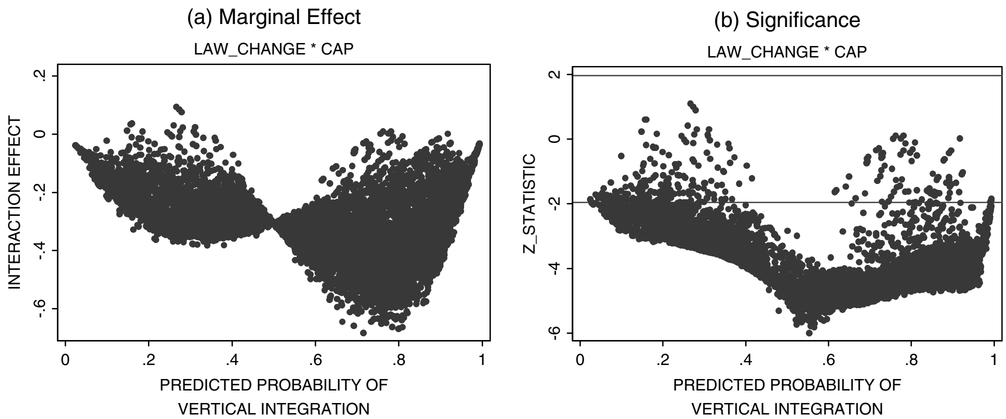

Figure 7. (a,b) The marginal effect and significance of the interaction term LAW_CHANGE*CAP (constructed from model 6)

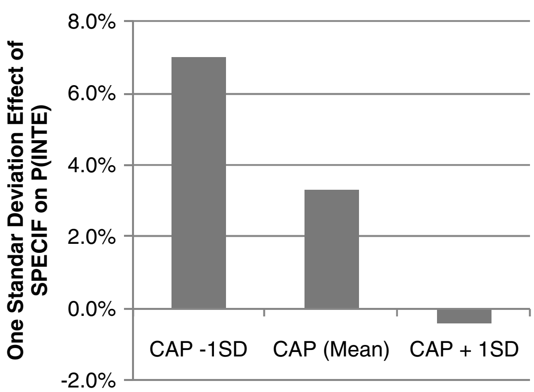

Figure 8. The change in the one standard deviation effect of SPECIF in response to changes in CAP [using the average marginal effects across observations in model 6, we evaluated the following expression: $\mathrm{ST\_DEV}_{\mathrm{SPECIF}}$ * d(INTE)/d(SPECIF)]

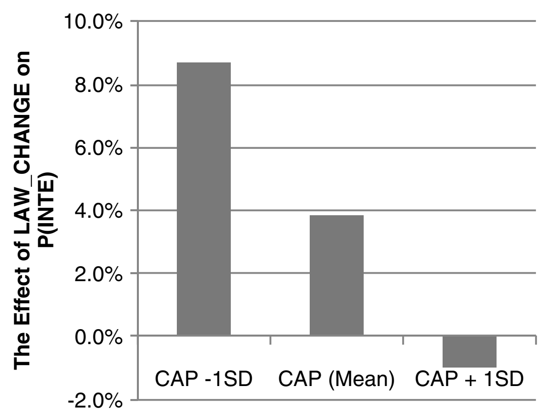

Figure 9. The change in the effect of LAW_CHANGE in response to changes in CAP [using the average marginal effects across observations in model 6, we evaluated the following expression: $\mathrm{ST\_DEV}_{\mathrm{LAW\_CHGE}}$ * d(INTE)/d(LAW_CHGE)]

and arguably more importantly, strong capabilities mitigate increases in transaction costs, driven by both temporal specificity and institutional change. Additionally, capabilities infuse boundary choices with heterogeneity, particularly through their role in modulating the marginal effects of specificity and institutional change.

Control Variables

The coefficients of the variables related to demand uncertainty, contractor diversification, project complexity, contractor size, distance of the project from the most common contractor's location, year effect, and contractor market power have marginal effects that were significant for all of the observations in the sample at the 95 percent confidence level. With the exception of complexity, these variables are aligned with the expected signs reported earlier in the literature. A more complete description of the results for the control variables is provided in the online Appendix.

Discussion of results

We show that the comparative governance costs of markets versus firms in specialty trade activities are determined by the interplay of conditions related to temporal specificity, institutional change and capabilities. As such, individual contractors will experience different comparative governance

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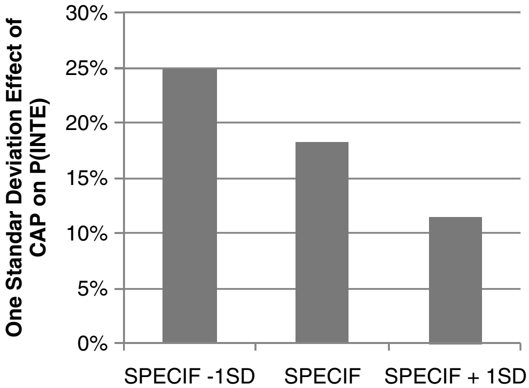

Figure 10. The change in the one standard deviation effect of CAP in response to changes in SPECIF [using the average marginal effects across observations in model 6, we evaluated the following expression: ST_DEV_{CAP} * d(INTE)/d(CAP)]

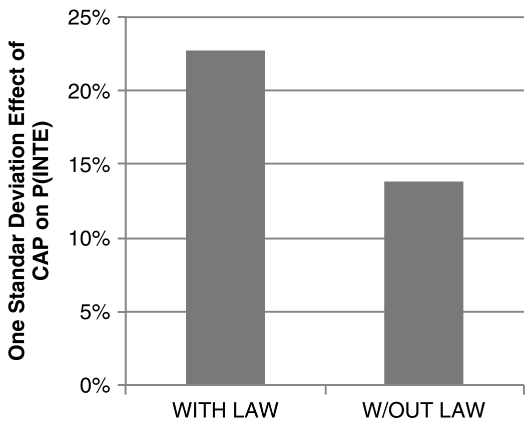

Figure 11. The change in the one standard deviation effect of CAP in response to change in LAW_CHGE [using the average marginal effects across observations in model 6, we evaluated the following expression: ST_DEV_{CAP} * d(INTE)/d(CAP)]

costs depending upon the conditions they face. We further show that the marginal effects of transaction hazards and the law change are greatly diminished when the differential in capabilities is of an important magnitude.

One of the main contributions of our study resides in explicitly recognizing that governance heterogeneity is infused by a differential in capabilities and, in particular, mediated by the negative effect of the interaction between capabilities and transaction costs on vertical integration decisions. This finding generates a more nuanced theory of firm boundaries than the notions offered by the historic account of TCE or the new institutional economics. As discussed below, further integration of the theory of the firm should address the reverse relationship, namely, how transaction hazards and institutional changes impact the process that generates differential capabilities.

Results similar to ours have also been obtained in the information technology services industry (Mayer and Salomon, 2006) and the electric utility industry (Fabrizio, 2012). Beyond the obvious generalization of our results into other industries in which temporal specificity may play a role (e.g., capital goods industries), we believe that the exogenous increase in transaction costs from the Chilean law change facilitates the generalization of our findings to other settings. Whereas temporal specificity is particular to the type of industry we analyzed, the law change is a 'generic' shift in the governance costs that squarely impacts all of the firms in the economy.

As has been shown graphically, we find that the mediating role of capabilities on the effect of transactional hazards in vertical integration decisions is much stronger than the converse relationship, a phenomenon that can be partially explained by the higher 'stand-alone' effect of capabilities. A naive reading of this result might produce the conclusion that, in our setting, capabilities have primacy over transactional hazards. On the contrary, however, we acknowledge that, along with our explicit recognition that 'the richness resides in the interactions,' we consider capabilities to be 'given,' and we do not explain their origin. Whereas the treatment of capabilities and transaction costs as distinct but interacting theories in the explanation of vertical integration aids progresses toward a unified notion of firm boundaries (Argyres *et al.*, 2012), it has been suggested that these theories are essentially inseparable because capability development, particularly in the face of uncertainty, is determined by prior governance choices (Argyres, 2011; Argyres and Zenger, 2012). Although we do not address this issue empirically, the view of productive capability development that derives from our review is consistent with both factors being inextricably related to prior governance choices.

We caution that capabilities must not be interpreted as generic in our study. In fact, capabilities are firm-specific, as the value of having capability 'X' in trade activity 'Y' is different for each contractor due to unique patterns of complementarities among assets, activities, and governance choices.

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For example, a contractor might develop capabilities in activities that are adjacent in the timeline of the project to facilitate coordination and capacity planning. Further research should address this issue.

CONCLUSION

The theory development and empirical evidence presented in this article enable us to conclude that the predictions of transaction costs, institutional change, and capabilities are intertwined in a predictable pattern in the Chilean specialty trade activities: high transaction costs (stemming from temporal specificity or the law change) and high capabilities interact negatively in the explanation of vertical integration. This scenario generates 'systematic heterogeneity' in boundary choices across firms.

Our results, and the compelling theoretical reasoning and empirical evidence provided by extant research (Argyres, 2011; Argyres *et al.*, 2012; Fabrizio, 2012; Jacobides and Winter, 2005), encourage us to suggest that further research exploring how heterogeneity, capabilities, and governance are mutually determined would be a fruitful endeavor. As strategic management has long recognized, competitive advantage stems from the complementarity of firms' choices. Choices associated with governance decisions and capability generation should not be an exception to this principle.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix. Measurement and discussion of results for control variables