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Can firms be both broad and deep?

Exploring interdependencies between horizontal and vertical firm scope

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Abstract

Firms can be horizontally diversified, with considerable breadth, or vertically integrated, with great depth. This study explores how breadth and depth affect each other as influenced by capability requirements and coordination demands. Using construction industry data, we assess the interdependence between contractors' portfolios of building types (horizontal scope) and the extent of integration of the activities needed to complete each project (vertical scope). We find that vertical and horizontal scope have a negative interdependency only when contractors face managerial constraints due to coordination challenges. Further, we show that this effect can be mitigated through organizational structures that centralize key functions. Our findings highlight the importance of coordination in the theory of the firm, as we link firm boundaries to managerial coordination and internal organization.

INTRODUCTION

Firms come in different shapes. Some are horizontally broad, with many product lines or project types; others are vertically deep, integrated into several stages of the value chain upstream or downstream. Other firms may be tightly focused in a single market or value chain stage; whereas some may be both broad and deep. Research has found that horizontal breadth improves performance due to scope economies, synergistic use of resources, and leveraging of complementary assets (Palich, Cardinal, & Miller, 2000; Panzar and Willig, 1981; Teece, 1982), but that coordination, adjustment and execution costs can limit these benefits (Hashai, 2015; Wan, Hoskisson, Short, & Yiu, 2011; Zhou 2011). Likewise, vertical depth may help firms to improve the governance of their activities and exploit strong internal capabilities, (Argyres, 1996; Leiblein & Miller, 2003; Williamson, 1985), but its benefits are limited by the costs of hierarchical governance, such as coordination and monitoring (Perry, 1989; Williamson, 1985).

Although the choice of horizontal breadth and vertical depth are among the most important decisions in corporate strategy, we don't fully understand the relationship between them. The few studies that have addressed this relationship have found interdependencies, but arrived at different conclusions. Some studies have suggested positive interdependencies between depth and breadth (Chandler, 1962; Leiblein & Miller, 2003; Tanriverdi & Lee, 2008; Zhou & Wan, 2016), while others have documented negative interdependencies (Rawley & Simcoe, 2010; Van Biesenbroeck, 2007; Zhou, 2011). In addition to these conflicting results, all of these studies investigated how a change in one type of scope subsequently influenced the other scope dimension. Although the nature of these decisions would imply mutual influence and simultaneity (Argyres & Zenger, 2012), no study has yet explored if breadth and depth do indeed affect each other simultaneously.

Building on previous studies and filling this gap, we explore the interdependencies between horizontal breadth and vertical depth. Based on the resource-based view of the firm, we begin analyzing the effect of capabilities, as they influence horizontal breadth and vertical depth (Argyres, 1996; Kogut & Zander, 1992; Penrose, 1959; Teece, 1982). We start with the premise that capabilities are often specific to a particular scope direction, such as marketing skills leading to horizontal breadth and production expertise leading to vertical depth (Perry, 1989; Tanriverdi & Lee, 2008; Teece & Pisano, 1994; Vorhies, Morgan, & Autry, 2009). In addition, we further recognize that executive capabilities, which we define as the ability of the top management team to administer, orchestrate and coordinate the entire set of firm activities, can affect both breadth and depth (Adner & Helfat, 2003; Helfat & Peteraf, 2015; Sirmon, Hitt, Ireland, & Gilbert, 2011). If executive capabilities are relatively unconstrained, then we should observe independence between breadth and depth, as firms can handle managing these differing activities using scope-specific capabilities. However, if executive capabilities become constrained, such as when coordination challenges are acute, we would see a negative interdependency between breadth and depth. We analyze the interdependency from breadth to depth and from depth to breadth to differentiate the direction of influence. It is possible that, due to a differential impact on executive capabilities, the effect might be more powerful in one direction than in the other.

We further analyze how the firm's organizational structure can affect executive capability constraints and thus relax the trade-off between horizontal breadth and vertical depth. We rely on transaction cost economics (TCE) to argue that even in the absence of asset specificity, frictions can generate costly haggling and renegotiations that will require coordinated adaptation, implying the use of common authority (e.g., Williamson, 1975; Gibbons, 2005). We focus on centralization as a structural feature that can mitigate these frictions and ease coordination. Centralization can facilitate the coordination and management of frictions that may arise from more horizontal breath or vertical depth and thus assuage the trade-off between breadth and depth when coordination needs are high.

We test our arguments through an investigation of the Chilean construction industry, using an extensive and rich database that spans 355 firms and nearly 40% of the projects built in the country over an eight-year period. Our data allow us to precisely measure horizontal breadth based upon the types of projects each contractor executes (e.g., residential housing, educational facilities, hospitals, etc.) and the contractor's vertical depth as indicated by the extent of vertical integration in specialty trade activities performed (e.g., plumbing, painting, formwork, etc.). This is a mature industry, with no dominant players, but with heterogeneity among approaches, as some firms are vertically deep, some horizontally broad, some quite focused, and still others both broad and deep. This high level of variation in terms of scope choices allows us to study breadth and depth simultaneously. Another advantage is that our industry setting has distinguishable capabilities that can be cleanly connected to vertical depth or horizontal breadth decisions, and thus, these measures can be used as instruments in our simultaneous equations model. Additionally, the availability of organizational structure variables at the firm level (e.g., centralization of internal decision rights) allows studying how centralization of decision making mitigates the trade-off between breadth and depth.

Our results support our premise and indicate that horizontal breadth and vertical depth decisions are driven by scope-specific capabilities and thus are essentially independent. However, we find that when coordination challenges are high, there is a significant negative trade-off between breadth and depth. That is, the greater the coordination demands, the more challenging it is for firms to be both broad and deep, or vice versa, affirming our predictions involving trade-offs based upon executive constraints. Finally, consistent with TCE, we find that centralized structures relax these constraints and therefore mitigate the negative trade-off between breadth and depth. We verify our results by interviewing industry executives who supported our findings and supported our proposed mechanisms.

Our paper contributes to the strategy literature by tackling the relationship between horizontal breadth and vertical depth decisions and proposing mechanisms that drive this interdependency. First, we study the simultaneous interdependency of breadth and depth, reflecting more accurately the realities and intricacies of these choices. The analysis of bidirectionality is important because the interrelationship between depth and breadth does not need to be symmetric. We provide both theoretical logic about this relationship and rigorous empirical testing that indicates the importance of both scope-specific and broader executive capabilities. Second, we provide a mechanism based upon constrained executive capability due to coordination demands that drives the relationship between breadth and depth. When these demands are modest, breadth and depth will be independent and can co-exist. However, when these demands are more severe, managers cannot attend to all of the details and activities involved, resulting in a negative and simultaneous relationship between breadth and depth.

Third, we analyze organizational structure variables that can influence the trade-off between these scope choices as they facilitate joint coordination of different firm-level functions. Although structure has been widely analyzed in the strategy literature, its effect on a possible trade-off between vertical depth and horizontal breadth has not been studied. Our novel analysis of how internal structure affects the tension between horizontal breath and vertical depth provides further insights about the interrelationships between major corporate strategy decisions. Finally, we contribute to the TCE literature by applying this theory both at the firm boundary level and within the firm. We use the opportunism strand to determine initial vertical firm boundaries and then the adaptation strand to understand how internal centralization can affect both horizontal and vertical boundaries through its impact on executive capabilities. Overall, our findings highlight the importance of coordination in the theory of the firm, as we link firm boundaries to managerial coordination and internal organization.

THEORY AND HYPOTHESES

Our study focuses on the interdependencies of horizontal breadth and vertical depth in firms. Interdependencies can be positive or negative. They are positive if an expansion in breadth (depth) results in an expansion in depth (breadth) and they are negative if an expansion in breadth (depth) results in a reduction in depth (breadth). Empirical evidence on interdependence between breadth and depth is mixed. Recently, Zhou and Wang (2016) used a detailed econometric case study of a soft-drink concentrate producer to show that vertical depth in the bottling industry improves product-level efficiency for the integrated company, increasing the incentives to expand its horizontal breadth. This result is similar in spirit to Chandler’s classic study (1962), and to Tanriverdi and Lee’s (2008) work in the software industry, who found that related diversification in software product-markets is complementary to increased scope in the vertical domain of operating systems platforms. In a similar vein, Leiblein and Miller (2003) show that a higher product market scope is associated with more vertical integration in semiconductor firms. In contrast, Rawley and Simcoe (2010) show that taxicab firms who diversify into the limousine business subsequently increase outsourcing, shifting their fleet composition toward more owner-operator drivers, whereas Zhou (2011) finds that outsourcing existing activities along the vertical value chain may free up coordination capability for horizontal diversification, supporting a negative relationship between breadth and depth. Further, Van Biesebroeck (2007) analyzed automobile plants and found that vertical and horizontal scope are substitutes with respect to productivity[1].

Thus, prior studies have analyzed the effect on horizontal breadth of a change in vertical depth and the effect on vertical depth of a change in horizontal breadth. However, we believe ours is the first study to go beyond a unidirectional relationship and instead analyze the simultaneous interaction between breadth and depth. This more accurately reflects the ongoing realities within firms as they must manage and coordinate both vertical and horizontal scope. As such, we can better understand the nuances and trade-offs of engaging in these activities and the drivers of these choices, such as managerial capabilities and organizational structure.

Capabilities as drivers of scope choices

To unpack the relationship between horizontal breadth and vertical depth decisions, we start by focusing on the capabilities possessed by the firm. Consistent with explanations offered by the resource-based view, an important driver of horizontal breadth involves the utilization of excess indivisible resources or capabilities to expand into multiple products and obtain scope economies (Panzar & Willig, 1981; Penrose, 1959; Teece, 1982; Wan et al., 2011). The literature on vertical integration has also shown that firms are more likely to integrate if they possess stronger capabilities than external suppliers to efficiently undertake upstream or downstream activities (Argyres, 1996; Kogut & Zander, 1992)[2].

Generally, the resources and capabilities that provide the foundation for horizontal and vertical scope decisions differ. Horizontal breadth is enabled by the ability of the firm to leverage capabilities that can be applied to different types of products or markets, whereas vertical depth is enabled by the ability of the firm to leverage capabilities across different stages of the value chain. Capabilities leveraged across horizontal domains are typically related to marketing skills, such as product knowledge, sales, branding, reputation and customer service (Vorhies et al., 2009), and skills to manage demand complementarities in customers and markets (Li & Greenwood, 2004; Tanriverdi & Lee, 2008). The literature shows that experience and capabilities in a specific product or project can be helpful in related activities (Helfat & Raubitschek, 2000; Tanriverdi & Venkatraman, 2005). On the other hand, capabilities involving vertical integration tend to be associated with production and process expertise, such as technology selection, asset utilization, risk reduction, and supply chain management (Perry, 1989; Teece & Pisano, 1994). These capabilities also include skills related to managing interdependent stages, since the value chain typically involves sequential or reciprocal activities, requiring smooth transitions (Eccles, 1981).

The dedicated nature of capabilities for horizontal breadth and vertical depth is not absolute, as some capabilities are more fungible than others. Fungibility is an attribute of a capability that facilitates its application to different organizational and market settings (Levinthal & Wu, 2010). Few, if any, capabilities are perfectly fungible, but we would expect greater fungibility in more closely related applications (Maritan & Lee, 2017). If the firm's horizontal capabilities are more easily devoted to other product markets rather than to vertical activities, that means they have greater within-scope than across-scope fungibility. Likewise, if vertical capabilities are more easily devoted to other vertical stages than to product markets, then they would also have greater within-scope than across-scope fungibility. We posit that, due to key differences in horizontal and vertical capabilities, within-scope fungibility will tend to be greater than across-scope fungibility. When within-scope fungibility is greater than across-scope fungibility, the choices of horizontal or vertical scope driven by capabilities will be independent.

A corollary of this fungibility assumption within and across scopes is that to obtain interdependency, something additional is required. This simplifies the theoretical and empirical analysis, as these new additional drivers can be studied without the complication of any cross-effects of scope-specific capabilities (e.g., horizontal capabilities affecting vertical depth). We propose that a crucial driver of breadth and depth interdependence are higher-order capabilities that involve top managers, which we term executive capabilities.

Executive capabilities and scope

Firms' executive capabilities, that is the ability of the top management team to administer, orchestrate, and coordinate the entire set of firm activities, can generate an interdependency between horizontal breadth and vertical depth, since they impact the overall management of the firm. These capabilities relate to the ability to broadly manage the firm, that is, to plan, execute and monitor firm activities. These capabilities include resource orchestration and parenting skills, involving the ability to make decisions to expand, allocate, and redeploy resources across businesses and activities (Adner & Helfat, 2003; Helfat & Martin, 2015; Sirmon et al., 2011). These executive capabilities are used to manage activities executed across scopes, as well as to guide the firm more broadly. The strategy literature has highlighted the relevance of the higher-order managerial skills, which usually reside at the top of the organization (Finkelstein, Hambrick & Cannella, 2009; Helfat & Peteraf, 2015).

Executive capabilities are more general than scope-specific capabilities, so they can be applied to managing and coordinating different activities. However, executive capabilities are not scale-free; their value diminishes with the magnitude of the operations and activities to which they are applied. This generates opportunity costs in their deployment, and thus their allocation to different activities becomes relevant and highly consequential to performance (Levinthal & Wu, 2010).

We focus on two sources that generate the non-scale free nature of these executive capabilities (Zenger, Felin, & Bigelow, 2011). First, information problems become more prevalent when scale increases, as information that is passed on from operations to management can be distorted. This happens unintentionally, as a by-product of passing the information across more layers (Williamson, 1985), or intentionally, when information is misrepresented and/or withheld due to delegation in larger organizations (Gibbons, Matouschek, & Roberts, 2013). In addition to information distortion, information processing also suffers with scale. As organizations grow larger or more complex, the amount of information that needs to be processed by managers increases. However, managers' information processing capability is limited (Eggers & Kaplan, 2013; Radner, 1992) and the amount and distortion of information affects the cognitive capability of managers, one subset of executive capability. Helfat and Peteraf (p. 835, 2015) defined cognitive capability as "the capacity of an individual manager to perform one or more of the mental activities that comprise cognition". They posit that this capability has an important context- or domain-specific aspect. Given limits to managers' cognition, managers tend toward inertia and similar decision-making processes based upon the context (Eggers & Kaplan, 2013; Shepard, McMullen & Ocasio, 2017). Thus, as a firm gains experience in a particular set of dominant activities or capabilities, managers accumulate knowledge in that particular domain, specializing their cognition and increasing the difficulty to optimally addressing other activities or capability sets that the firm might decide to pursue.

Another source of non-scalability of executive capabilities is related to moral hazard and effort. When organizations grow larger, monitoring and incentivizing effort become more difficult. Even if information is not distorted and managers would have infinite processing capability, the amount and complexity of activities still generates the problem of imperfect observability and divergence of objectives between workers and the firm (Canback, Samouel, & Price, 2006; McAfee and McMillan, 1995; Zenger, 1994).

Being both broad and deep will highly tax executive capabilities available to the firm. This claim on capabilities may not be overly costly if the firm is not burdened with other demands. However, if the company's management is already close to full capacity-utilization, then the effectiveness of executive capabilities will become impaired. Managers will be cognitively taxed and monitoring employees will become harder to accomplish. In turn, this will generate pressure to offload activities to reduce firm scope. Since executive capability is domain-specific, they likely will reduce activities in the more "different" area, suggesting a negative relationship between breadth and depth[3]. Although hiring more top managers can somewhat mitigate this problem, it is costly and lumpy to increase the size of the executive team, it does not fully address the information problems, and team size is affected by diseconomies of scale driven by communication distortions and bureaucratic insularity (Canback, et al., 2006; Williamson, 1967). Therefore, when executive capabilities are taxed, for example by greater coordination demands, a trade-off between breadth and depth can result. For instance, in project-based industries, the number of projects and their diversity will increase coordination demands due to information problems arising from activities that are time-dependent, challenging to plan, and hard to monitor.

To summarize, when coordination demands are modest, top managers can handle both horizontal and vertical activities, such that these will be independent. However, as these demands increase, executive capabilities become taxed and less effective. To cope with the constraints imposed by activity in one direction, firms will have the incentive to free-up executive capability by reducing the scope in the other direction. That is, we predict a negative relationship between breadth and depth when these coordination demands are high. The overall argument we have laid out is symmetric – a bi-directional, simultaneous interdependency between breadth and depth. However, we use two hypotheses to explicitly differentiate the direction of influence and to test if the effect might be more powerful in one direction than the other.

H1a: When the coordination demands on executive capabilities are high, an increase (decrease) in the horizontal breadth will cause a decrease (increase) in the vertical depth of the firm. This negative relationship will increase in strength as these coordination demands increase.

H1b: When the coordination demands on executive capabilities are high, an increase (decrease) in the vertical depth will cause a decrease (increase) in the horizontal breadth of the firm. This negative relationship will increase in strength as these coordination demands increase.

Organizational structure and the trade-off between horizontal breadth and vertical depth

In this section, we explicitly include transaction cost economics (TCE) as it applies to the trade-off between horizontal breadth and vertical depth. TCE focuses on the ex-post adaptation problem in transactions, under conditions of contract incompleteness and self-interested behavior. Gibbons (2005) recognizes that TCE comes in two streams. First and most commonly employed, asset specificity can yield ex-post opportunistic behavior by exchanging parties in order to appropriate quasi-rents; to avoid inefficient hold-up, common ownership and the use of authority are recommended (Williamson, 1985; 1979). Second, even in the absence of asset specificity, frictions, interdependencies and coordination problems will ensue in the contract execution stage, which can lead to costly haggling, renegotiations and inefficient adaptation (Williamson, 1975). In these settings, adaptation to changing circumstances and unexpected events (e.g., redefining routines, reacting to disruptions, apportioning responsibilities, etc.) and the ability to manage interdependencies are major organizational challenges.

The use of a centralized structure and authority allows the firm to manage interdependencies and facilitate adaptation to changing circumstances and events (e.g., Williamson, 1975; 1991; 1996). A mechanism to create a common authority and improve adaptation is centralization of decision-making processes, which can be done through a more centralized structure and integration of key functions. A centralized structure enhances coordinated decision making among activities when a careful attention to interdependencies and changing events is required (McElheran, 2014; Argyres and Silverman, 2004), whereas integrating key functions provides a solution to frequent and unexpected adaptation problems through a common authority which facilitates coordination (Williamson, 1975; Tadelis and Williamson, 2013).

Inspired by the coordination problems in construction projects, Tadelis (2002 and 2009) predicted that an increase in ex post adaptation caused by a higher number and more complex set of tasks and activities leads to greater integration due to the need for fiat and coordination of activities. Forbes and Lederman (2009) provide empirical evidence, showing that major airlines are more likely to use owned regionals (rather than independent regional carriers) on routes that have adverse weather with more disruptions that need to be coordinated. Tadelis and Williamson (2013) summarized recent developments in TCE, returning to the early emphasis on integration as a solution to frequent and unexpected ex-post adaptation.

We take this perspective and suggest that, by enabling managers to use authority and fiat in the decision-making process, organizational structures facilitating centralized decision-making should reduce the strength of the trade-off between breadth and depth. Regarding breadth, when expanding into new products, segments or industries, functional areas such as sales, marketing, and product design will display more frictions and inconsistencies, and these functions will coordinate more effectively if central authority is granted. For example, marketing campaigns require higher coordination and alignment when they involve more products or customer segments. The same occurs with upstream or downstream activities in the value chain. Given that these activities display frictions and interdependencies, integrating them within the same firm provides the benefit of centralizing key coordinating functions, such as quality control, procurement, and production planning, increases.

This logic is consistent with prior work that links related diversification to structures with higher functional centralization (Hill & Hoskisson, 1987; Guadalupe et al 2013; Collis et al 2007), and with recent empirical evidence that suggests a positive relationship between centralization and vertical integration (Arora, Belenzon, & Rios, 2014; Weigelt & Miller, 2013; Brahm and Tarzijan, 2016). It also aligns with the notion of the firm as a “coordination device”, implying that internal hierarchy is superior to the market to coordinate activities (Langlois & Robertson, 1993; Okyhusen & Bechky, 2009; Puranam & Srikanth, 2014).

Thus, we propose the following two hypotheses:

H2a: When the coordination demands on executive capabilities are high, centralization lowers the negative impact that an increase in the horizontal breadth causes on the vertical depth of the firm.

H2b: When the coordination demands on executive capabilities are high, centralization lowers the negative impact that an increase in the vertical depth causes on the horizontal breadth of the firm.

Our theoretical framework and hypotheses are summarized in Figure 1.

Insert Figure 1 about here

EMPIRICAL SETTING

We test the hypotheses of this study within the context of the Chilean construction industry, focusing our attention on contractors, who build multiple residential or commercial projects. These projects tend to be varied with heterogeneity in design, specifications, geographic location, size, and other attributes. Typically, a contractor creates a project for an owner/developer according to the specifications provided by the architect or designer. Projects are the “production units” for contractors. They assign resources to projects, control and monitor performance, and coordinate administrative tasks, such as procurement, logistics, warehousing and staffing across projects. The contractor’s managerial team spends an important part of its time coordinating and overseeing the project portfolio.

We have detailed information about all relevant project types: housing complexes, office buildings, residential buildings, health facilities, educational facilities, hotels, industrial buildings, commercial projects (e.g., banks or supermarkets), religious buildings, and single-family houses. Horizontally, diversification of contractors increases with the type of projects they undertake. For each project, we also have detailed information regarding the contractors’ sourcing decisions for nine distinct specialty trade activities: 1) building and installing the metallic structure, 2) building the formwork, 3) installing electrical services, 4) installing plumbing and water services, 5) installing heating and cooling systems, 6) framing and installing windows, 7) painting, 8) installing gas services, and 9) building and installing furnishings and appliances. These activities account for the vast majority of building project activities (Riley, Varadan, James, & Thomas, 2005) and each requires a considerable amount of specific expertise (Ng & Tang, 2010). The greater the number of vertical activities performed by the contractor, aggregated over its total project portfolio, the deeper its depth.

Because we study a single industry with clearly defined and observable horizontal and vertical activities, we can distinguish which capabilities are more prone to horizontal or vertical activities and which ones are useful for both types of activities. In addition, this industry provides plenty of variation in terms of breadth and depth of contractors: some are vertically deep but horizontally narrow, some are vertically shallow and horizontally wide, and others are either “deep and wide” or “shallow and narrow”.

DATA AND VARIABLES

We used a unique database provided by ONDAC S.A. This firm collects detailed data on construction projects and sells this data to construction suppliers and building material manufacturers. The database covers the period from January 2004 to October 2012 and includes 46,420,398 square meters built in 12,272 projects. The database covers approximately 40% of the total square meters constructed in Chile during that period. We had to compute lags on some variables, thus losing the first four years in our database. Our final sample included 355 contractors, with an average of three years of data per contractor.

The primary unit of analysis in our estimation is the firm-year. The firm (contractor) is a collection of projects. 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 relevant data, such as size in square meters, geographic location (state, city), starting and ending dates, stage of construction, detailed comments regarding project characteristics, and sourcing data on the nine specialty trade activities. To obtain firm-year information, we used the start date of the project to aggregate the collection of projects into a firm-year panel data structure.

Variable measurement

Dependent variables. We have two dependent variables, one measuring the contractor’s breadth of project types and another measuring their depth of vertical activities.

*Breadth of horizontal portfolio***.** We measure horizontal breadth by the degree of diversification based on the ten types of projects, which we calculate annually using the Herfindahl-Hirschman Index (HHI). To compute the HHI, we first calculate the share of the total square meters built by the contractor for each project type and then sum the squares of these shares; since the HHI reflects concentration, we then take 1-HHI to create a final variable to measure horizontal breadth [4].

*Depth of vertical activities***.** To measure the vertical depth we aggregated, at the contractor-year level, all the sourcing choices made in the different specialty trades in all the different projects. First, each of the nine activities took the value of 1 if integrated and 0 if outsourced. Second, across all contractors, we standardized this measure for each activity[5]. Then, we averaged the standardized measure across activities for each contractor and each year. This results in a vertical depth measure that is equal to the standardized percentage of integrated specialty trade activities at the contractor level.

Independent variables. We have four sets of independent variables. The first set measures capabilities that are specific to the horizontal breadth; the second sets measures capabilities and transaction hazards that are specific to the vertical depth. The third set is comprised of variables that proxy for coordination demands while the fourth set of independent variables is used to capture centralization of decision making.

Horizontal capabilities. The experiences of project designers and administrators are important capabilities for contractors, which we measure as follows:

Designer experience in different project types. To measure designer experience, we first compute the diversification level of each designer across different project types, using the formula of one minus the HHI index. We calculate the HHI index as the sum of the squares of the percentages of the designer’s square meters built in each type of project. This generates a measure of experience across project types for each designer. For each contractor, we compute the average diversification of designers used in projects started in that year.

Project director experience in different project types. Project directors are an important resource for contractors, since they lead on-site project execution. We compute experience across project types for each director by adding a dummy variable with a value of 1 if the director had been involved with more than one project type over the last three years and 0 otherwise[6]. For each contractor-year, we compute an average such that the resulting measure reflects the percentage of a contractor's project directors with broader experience. We chose this option instead of an HHI index because only 20% of the directors had experience in more than one project type.

Vertical capabilities and transaction hazards. We use three measures to capture expertise, transaction hazards, and supplier relationships.

Trade expertise. This variable is associated with experience and know-how in each vertical activity. There is a substantial literature that shows that greater trade expertise and capability in executing upstream activities drives greater integration (Jacobides & Winter, 2005; Mayer & Salomon, 2006). For each specialty trade activity within each region, we compute the total historical volume (in square meters) conducted by the contractor and by all subcontractors in that specific trade. To capture the notion of comparative capabilities (Jacobides & Hitt, 2005), we then compute the volume percentile for the focal contractor, considering the total volume for each activity in periods t-4 to t-1, omitting year t to avoid reverse causality. Then, we average these percentiles across specialty trades to obtain a contractor-year measure of overall vertical trade expertise. In simple terms, we rank all the "players" in a specific trade using previous volume, both by subcontractors and the internal teams, and then obtain the percentile at which the internal team of each contractor is placed. Then, we average across trades[7].

Prior interactions with suppliers. Prior interactions with suppliers engenders goodwill, decreasing the risk of opportunistic behavior and thus increasing the likelihood of outsourcing, as well as improving coordination and contracting (Gulati & Nickerson, 2008; Mayer & Argyres, 2004). We measure the number of interactions between each pair of contractors and suppliers prior to the focal firm-year. For each trade activity and region, we created adjacency matrices between contractors and suppliers to obtain the number of projects each contractor executed with each supplier over the prior four years (from t-1 to t-4). If the contractor had no prior projects with a supplier in a particular trade activity, we set this variable to zero. To obtain a measure at the contractor-year level, we average across regions and specialty trades the repeated interactions for each contractor-year.

Thinness of supplier market. This variable captures the transaction hazards that are generated by the small numbers problem (Williamson, 1975). In construction, suppliers specialize geographically and by project type (Ball, 2003; Somerville, 1999). Thus, we measure supplier market thinness using the market concentration of firms in each specialty trade activity for each project type by region using the HHI. A high HHI indicates that a few suppliers dominate, increasing their bargaining power and promoting vertical integration. The HHI measure was computed for a two-year window. For an aggregate measure for each contractor-year, we average the HHI index across trades by region and compute a weighted average for each contractor based upon their total square meters built in each region[8].

Coordination demands. We use three measures for coordination demands.

Number of projects. The number of projects that a contractor is simultaneously managing affects the managers' ability to efficiently manage and coordinate each project. More projects imply more transitions within and between projects and more difficulties in allocating resources and transmitting and processing information. In specialty trades, this involves more handovers between trades, with scheduling and quality control challenges.

(O'Brien & Fisher, 2000). In terms of horizontal breadth, more projects implies more complex allocation of selling and service ability, price planning across projects, and more design iterations due to sharing specifications. We computed the number of projects started in each year to measure each contractor's number of projects. Since projects typically last over a year, this measure captures the simultaneous contractor's project load.

Project distance to headquarters. In construction, project oversight and coordination is largely done on-site due to project specificities and the need for more accurate information (Navon & Sacks, 2007). Therefore, the distance of each project to the contractor's headquarters might affect coordination within and between projects. For each contractor, we observe the county location for the headquarters and the specific location of each project. Using the latitude and longitude coordinates, we compute the distance between each project to headquarters for each year, then take an average and convert this figure to its natural logarithm by adding one (logarithm of zero is undefined; see Kalnins, 2003).

Distance between projects. Coordination among geographically distant projects is difficult, particularly for allocating resources between projects and generating common understandings in terms of procedures, administrative processes and informal rules. In the specialty trades, distance between projects increases coordination needs for timing across projects, more difficult adaptation and travel time for personnel, and differing specifications due to local rules and conditions. In terms of horizontal breadth, greater distance increases coordination demands since it increases customer heterogeneity and custom specifications, as well as complicates service personnel allocation. To estimate the distance between projects, we compute the geographic centroid of the contractor's set of projects by year. The centroid is the latitude and longitude that minimizes the weighted distance of the projects, using project size in square meters as the weights. We compute the average distance of the projects to this centroid, transforming this to its natural logarithm by adding one.

Centralization of decision-making. We measure centralization using two variables, procurement centralization and design integration. The former facilitates centralized coordination across the vertical tasks (i.e., specialty trades), whereas the latter facilitates centralized coordination across horizontal tasks.

Procurement centralization. Materials procurement is a critical activity in construction, as materials represent 50% of project costs and their timing is important for scheduling and productivity. Material procurement involves many tasks such as soliciting bids, bargaining long-term deals, co-designing custom-made items, coordinating deliveries, controlling quality and managing storage. Contractors buy the majority of materials and this activity can be centralized at headquarters, who aggregate the requirements, or delegated to the project, where each project manager procures independently. Centralization can facilitate the coordinated adaptation between the specialty trades as it facilitates smoother allocations and better timing of materials to each project (Bashford et al, 2003). It can also improve the knowledge sharing across projects and provide centralized quality control (Ellegaard & Koch, 2004). For each project, we coded a dummy variable that takes the value of 1 when procurement is centralized, and zero in case of delegation. Then, we aggregated this variable by computing its mean at the contractor-year level.

Design integration. For each project, we observe whether the design is done by internal designers or outsourced to an external firm. In-house design allows for better adaptation and coordination over multiple and distant projects. More projects, and more distant projects, increase heterogeneity in design and specifications. This heterogeneity affects contractors' horizontal tasks, such as budgeting, pricing, and marketing, all of which require adaptation to the different projects and coordination to avoid inconsistencies. For each project, we computed a variable with the value of 1 if design is integrated and zero if it is outsourced. Then, we aggregated this variable by computing its mean at the contractor-year level.

Control variables. We include control variables at various levels. For contractors, we include size, market share, geographic dispersion, metropolitan focus, and housing sector focus. At the market level, we include project type uncertainty, demand imbalance, and market size. We also include year fixed effects to control for average changes in scope over time. See our appendix for a summary of our controls. Table 1 provides descriptive statistics and correlations for our dataset.

Insert Table 1 about here

EMPIRICAL ANALYSIS

The appropriate econometric strategy to address our question must incorporate the interdependency between horizontal breadth and vertical depth. To do so, we use the following simultaneous equation model at the firm-year level:

$$Breadth\_Hor_{it} = \alpha_0 + \alpha_1 \times Depth\_Ver_{it} + \alpha_1 \times Hor\_Cap_{it} + Controls + \theta_t + \pi_i + \mu_{it} \quad (1)$$

$$Depth\_Ver_{it} = \beta_0 + \beta_1 \times Breadth\_Hor_{it} + \beta_2 \times Vert\_Cap\&TransHaz_{it} + Controls + \theta_t' + \pi' + \mu_{it} \quad (2)$$

In equation (1), the breadth of the horizontal portfolio of contractor *i* in year *t* ($Breadth\_Hor_{it}$) is modeled as a function of the depth of vertical activities ($Depth\_Ver_{it}$), horizontal capabilities (Hor_Cap_{it}) (i.e., designer and project manager experience), control variables, and time effects. In equation (2), the depth of vertical activities of the contractor *i* in year *t* is modeled as a function of the breadth of the horizontal portfolio, vertical capabilities and transactional hazards ($Vert\_Cap\&TransHaz_{it}$) (i.e., trade expertise, prior interactions and market thinness), a set of control variables, and time effects. The terms π_i are estimated using random-effects. Random effect models combine within-firm and between-firm variation to compute the coefficients.

The coefficients α_1 and β_1 are prone to endogeneity bias driven by reverse causality (i.e., the vertical depth affects the horizontal breadth and vice-versa) and by potential omitted variable bias. To correct for these biases, we use an instrumental variable (IV) technique (Bascle, 2008). This procedure requires an estimation of endogenous variables using instruments that are both valid and strong (Murray, 2006). The ideal candidates for instruments in our setting are the sets of variables that drive vertical depth in equation (2) and those that drive horizontal breadth in equation (1), because these are specific to each boundary choice (strength condition) and do not affect the other decision (validity condition).

In Equation (1), we instrument $Depth\_Vert_{it}$ using $Vert\_Cap\&Trans\_Haz_{it}$. This variable is not present in equation (1), satisfying (in principle) the validity condition and is present in equation (2), satisfying (in principle) the strength condition. Analogously, we use the instrument of Hor_Cap_{it} for $Breadth\_Hor_{it}$ in equation 2. As it is shown below, the tests recommended by Bascle (2008) confirm the validity and strength of our instruments (i.e., Hansen test). Having two instruments for horizontal breadth and three for vertical depth allows a local average treatment effect closer to the average treatment effect.

In Table 2, we present the results of the estimations that test the baseline relationship between breadth and depth. Model 1 does not include the instrumental variables and is presented only as a naïve, baseline random effects model[9]. The results of this model support our drivers of horizontal depth in that greater designer experience across project types and broader project manager experience are both associated with a greater breadth in the horizontal project portfolio. Also, more trade expertise, fewer interactions with suppliers, and thin supplier markets are all associated with greater vertical depth, as expected. This provides support for using these sets of variables as instruments.

In Model 2, we present the instrumental variable (IV) estimation, which fully conforms to our theoretical model. This and the remaining models are estimated using the XTIVREG2 command in the STATA package. To evaluate the validity and strength assumptions of our instruments we evaluated the F-test of the first stage and computed the

Hansen test (Bascle, 2008). The F-test shows that the instruments have strength (i.e., they explain the endogenous term), surpassing the threshold proposed by Stock and Yogo (2002). Moreover, the Hansen test indicates that our instruments are valid (i.e., they do not explain the dependent variable, conditional on covariates). This is in line with our contention that horizontal and vertical capabilities are scope-specific. These results indicate that we are effectively testing how scope changes generated by capabilities affect each other.

Part of the justification for the exogeneity of the instruments was the use of lags in the measurement of capabilities, particularly for project director experience, supplier expertise and prior interactions. However, if breadth and depth are persistent, lagging might not be enough. In order to address this concern, we included in Model 1 lagged measures for breath and depth as controls (for t-1, t-2 and t-3). Results, which are available from the authors upon request, do not change. This provides additional confidence on the empirical strategy[10].

The main results of Model 2 indicate the changes in breadth and depth generated by capabilities are independent. This agrees with our baseline assumption. Capabilities at each scope are distinct and uniquely influence its own scope. When no other constraint is present, the firm does not need to trade-off breadth and depth.

Insert Table 2 about here

The role of coordination demands

To explore Hypotheses 1 and 2, we add the interaction effects of the coordination variables, using the following equations:

$$\text{Breadth\_Hor}_{it} = \alpha_0 + \alpha_1 \times \text{Depth\_Ver}_{it} + \alpha_2 \times \text{Hor\_Cap}_{it} + \alpha_3 \times \text{Depth\_Ver}_{it} \times \text{Coord\_Demands}_{it} + \text{Controls} + \theta_t + \mu_{it} \quad (3)$$

$$\text{Depth\_Ver}_{it} = \beta_0 + \beta_1 \times \text{Breadth\_Hor}_{it} + \beta_2 \times \text{Vert\_Cap\&Trans\_Haz}_{it} + \beta_3 \times \text{Breadth\_Hor}_{it} \times \text{Coord\_Demands}_{it} + \text{Controls} + \theta_t + \mu_{it} \quad (4)$$

Equation (3) is identical to equation (1), except for the inclusion of the interaction term between vertical depth and coordination demands ($Coord\_Demands_{it}$). The same applies for equations (2) and (4), which include the interaction term between horizontal breadth and coordination demands. The individual term for coordination demands is included in the controls. The coefficients α_3 and β_3 must be evaluated to gauge support for Hypotheses 1a and 1b. To correct for the potential endogeneity problem of interaction terms, we use the technique suggested by Wooldridge (2002: 236-237)[11].

The results are displayed in Table 3. Again, for all models, the Hansen test and the F-test of the first stage indicate that our instruments are valid and strong. In Models 3, 4 and 5 we introduce the interaction terms for each type of coordination demand. In Model 3, we include the interaction with the number of projects. The results show that the interaction terms are negative and statistically significant. Figure 2 shows that a one standard deviation increase in vertical depth is associated with a decrease of a quarter of a standard deviation in horizontal breadth when the number of projects is large (defined as one standard deviation above the mean). In contrast, when the number of projects is low, vertical depth has little effect on horizontal breadth. Figure 3 shows that a one standard deviation increase in horizontal breadth decreases vertical depth by a third of a standard deviation only when the number of projects is large, but the effect is much smaller when this number is low. In Model 4, we include the interaction terms with the distance to headquarters, whose coefficients are negative but not statistically significant. In Model 5, we include the interaction terms with the distance between projects, whose coefficients are negative and statistically significant. These results, displayed in Figures 4 and 5, indicate that a one standard deviation increase in vertical depth (horizontal breadth) decreases horizontal breadth (vertical depth) by a quarter (third) of a standard deviation[12].

Overall, our results support the prediction that coordination demands lead to higher integration. All coefficients have the expected sign, and only those associated with the distance to headquarters are not statistically significant. It is likely that the distance to headquarters also captures the cost of monitoring, which in this industry has to be largely performed on site (Navon & Sacks, 2007). Also, while the number of projects and the distance between projects capture coordination difficulties between projects, distance to headquarters captures coordination problems within projects. Whereas the former can be a task for a high-level manager, the second can be delegated to a project director. Delegation would reduce the daily demands on high level managers, and thus mute the interactions estimated in Models 4a and 4b of Table 3.

Insert Table 3 and Figures 2, 3, 4, and 5 about here

Our random effects analysis lumps together within and between variance. Given that coefficients may vary across levels, and following the suggestions by Certo et al (2016), we studied the intraclass correlation coefficients and compared the random effects models with their fixed effects counterparts (results available upon request). In general, we found that fixed effects models yield very similar results to those displayed in Tables 2 and 3. This is particularly the case for the interaction coefficients of Table 3. Hausman tests confirmed the reasonability of random effects models. Besides discarding theoretical differences across levels, this shows that time invariant unobservables do not alter our results significantly. Notwithstanding, the coefficients in the regression explaining Depth Vert, particularly trade expertise and prior interactions, decreased somewhat in their size and significance, mainly because of the low within firm variance in vertical scope.

As a robustness test, we also checked whether contractor market share could be driving vertical depth through its effects on horizontal breadth (e.g., market share may increase market power with suppliers, decreasing vertical depth), and found no support. We also replaced the number of projects with contractor size and obtained consistent results. Overall, our results show that the interdependency of vertical depth and horizontal depth exists only when coordination demands are high, supporting Hypotheses 1a and 1b.

Centralization of decision making reduces the impact of coordination demands

To study the role of hierarchical adaptation on the trade-off between breadth and depth, we use the following model:

$$\begin{aligned} Breadth\_Hor_{it} &= \alpha_0 + \alpha_1 \times Depth\_Ver_{it} + \alpha_2 \times Hor\_Cap_{it} \\ &+ \alpha_3 \times Depth\_Ver_{it} \times Coord\_Demands_{it} + \alpha_4 \times Depth\_Ver_{it} \times Cent_{it} \\ &+ \alpha_5 \times Coord\_Demands_{it} \times Cent_{it} + \alpha_6 \times Depth\_Ver_{it} \times Coord\_Demands_{it} \times Cent_{it} \\ &+ Controls + \theta_t + \mu_{it} \end{aligned} \quad (5)$$

$$\begin{aligned} Depth\_Ver_{it} &= \beta_0 + \beta_1 \times Breadth\_Hor_{it} + \beta_2 \times Vert\_Cap\&Trans\_Haz_{it} \\ &+ \beta_3 \times Breadth\_Hor_{it} \times Coord\_Demands_{it} + \beta_4 \times Breadth\_Hor_{it} \times Cent_{it} \\ &+ \beta_5 \times Cent_{it} \times Coord\_Demands_{it} + \beta_6 \times Breadth\_Hor_{it} \times Coord\_Demands_{it} \times Cent_{it} \\ &+ Controls + \theta_t + \mu_{it} \end{aligned} \quad (6)$$

In these models, we add to equations (3) and (4) the interactions with the centralization variables ($Cent_{it}$), that is, procurement centralization and design integration. According to TCE, centralization facilitates the handling of high coordination demands, which should lead to positive coefficients for α_6 and β_6.

In Table 4 we present the results for centralization of procurement. Models 6a and 6b study the interaction with number of projects. In Model 6a we do not find significant results, whereas in Model 6b we find a positive and highly statistically significant coefficient for the triple interaction (β_6). Given the large variance inflation factor of β_6 (equal to 13) we gauge its statistical significance using a joint t-test, finding that the first derivative of vertical depth over horizontal breadth and the second derivative of depth over breadth and number of projects are highly significant. In Figure 6 we display graphically the derivative d(depth)/d(breadth). The magnitude of the effect is large. When centralization is 0%, moving from “mean – 1 standard deviation (SD)” to “mean + 1 SD” in the number of projects implies a reduction of 0.45 SD in depth after an increase of 1 SD in breadth (moving along the top edge of the surface of Figure 6). If centralization is 100%, then the same reduction in the number of projects implies a reduction of 0.05 SD in depth after an increase of 1 SD in breadth (moving along the opposite edge of the surface of Figure 6). This is consistent with our theory: the presence (absence) of centralization mitigates (exacerbates) the trade-off imposed on depth by an increase in breadth under conditions of high coordination demands.

In Models 7a and 7b we study the interaction with distance between projects. The results are very similar to those of Model 6; we find statistically significant results in 7b but not in 7a. In Figure 7, we display the derivative d(depth)/d(breadth). The magnitudes are again large. If centralization is equal to 0%, moving from "mean – 1 SD" to "mean + 1 SD" in the distance between projects implies a reduction of 0.35 SD in depth after an increase of 1 SD in breadth. If centralization is 100%, then this reduction is equal to 0.04 SD.

Not finding results in Models 6a and 7a is expected because procurement centralization affects coordination of specialty trades activities; therefore, it should influence vertical depth (Models 6b and 7b) and not horizontal breadth (Models 6a and 7a). We believe that these expected null results in horizontal scope enhance the credibility of our findings.

Overall, these results strongly support Hypothesis 2a: centralized decision-making mitigates the negative trade-off between breadth and depth that arises when coordination demands are high. In our setting, the centralization of procurement facilitates adaptation between materials' procurement and specialty trades and resolves coordination frictions across projects such as those due to personnel allocation and quality control.

Table 5 displays the results using design integration. In Model 8a we find significant results. In Figure 8 we display graphically the derivative d(breadth)/d(depth). If design integration is equal to 0%, moving from "mean – 1 SD" to "mean + 1 SD" in the number of projects means a reduction of 0.30 SD in breadth after an increase of 1 SD in depth. If design integration is 100%, this effect is equal to a breadth increase of 0.05 SD. As expected, we do not find significant results in Model 8b: design integration affects the coordination of horizontal activities (e.g., budgeting, costing, pricing, bidding), not vertical ones. These results are supportive of Hypothesis 2b: centralization of decision making mitigates the trade-off imposed on breadth by a higher depth. In this case, design integration facilitates the coordination across projects that top managers have to execute on the horizontal tasks such as budgeting, costing, pricing, bidding, communication, marketing and selling, all of which have design as a crucial input. With many projects and increased depth, if design integration is not present, then coordination using the market interface becomes more difficult, forcing the firm to narrow down horizontally.

In Models 9a and 9b, we repeat the analysis using "distance between projects", failing to find significant results. It could be that the heterogeneity in projects and the changes in design and associated coordination issues increase more with the number of projects than with the distance between them.

In sum, we found that design integration mitigates the negative trade-off between depth and breadth when there is a high number of projects, but not when there is an increasing distance between projects.

Insert Tables 4 and 5 and Figures 6, 7 and 8 about here

Robustness checks

In addition to the checks above, we conducted three other robustness checks.

Proxy of managerial diseconomies. To check that constrained executive capabilities, that is managerial diseconomies, is the mechanism driving our results, we use data on the contractor's top management team (TMT). We looked at the number of unique individuals occupying four TMT positions -- Chief Executive Officer, Chief Commercial Officer, Head of Budgeting, and Head of Procurement. Many contractors do not have an exclusive person filling each role. All else equal, if there are fewer than four people filling these roles, they will be more time-constrained and occupied. Based on 2012 data, we found the average number of unique names to be 2.92 with a standard deviation of 0.86. To measure managerial constraints, we divided the number of TMT unique members by the number of projects and replicated our analysis. If our previous results are truly driven by managerial diseconomies, they should become stronger when we divide them by the number of TMT members since measurement error would lead to a downward bias in coefficients.

Results are presented in Table 6. Model 10 estimates equations 3 and 4. Model 10a replicates Model 4a of Table 4. The coefficient of -0.089 for the interaction with projects per TMT member is 4.7 times the coefficient of -0.019 obtained for the interaction with number of projects. The coefficient of projects per TMT member is a scaled coefficient of the number of projects. Given that the mean of TMT members is 2.92, the size of the impact of managerial diseconomies has increased by 62% (4.7 divided by 2.92 minus 1). Model 10b replicates Model 4b of Table 4. The coefficient of -0.442 for projects per TMT member is now 3.6 times larger than the coefficient for the number of projects. Descaling the coefficient, we find that the impact increased by 25% (3.6 divided by 2.9 minus 1). For the triple interaction, results are similar. In Model 11a the results are not significant, as in Model 6a of Table 5. Model 11b replicates Model 6b of Table 5. The coefficient of 0.588 for the triple interaction with projects per TMT member is 3.3 times larger than the coefficient for the number of projects. Descaling leads to an increase in the impact of managerial diseconomies of 13%. Overall, our results support Hypotheses 1a and 1b as they are consistent with managerial diseconomies, that is constrained executive capabilities, being the mechanism driving our results.

Insert Table 6 about here

Growth as dependent variable. Another way of testing the interdependency of two variables is using some performance outcome as the dependent variable specifying a model of the type: outcome = b1 + b2 x vertical scope + b3 x horizontal scope + b4 x vertical scope x horizontal scope + controls. If b4 is > 0 (<0) and statistically significant, then there is a complementarity (substitutive) relationship. Our data does not include performance measures such as profits or costs, but we do observe contractor size and therefore can compute a growth rate. The growth rate is positively correlated with market share, an indication that growth generally captures a contractor's competitive advantage and performance. Using growth as our outcome in a fixed effects regression, where we also control for the growth trend for each contractor plus its previous rate of growth, we find that while each scope is strongly correlated with growth, their interaction is not. This is consistent with Model 2 of Table 2. In addition, when we analyzed how these results varied with the number of projects, we found that the interaction goes from positive with few projects, to negative with many projects. Even though statistical significance is not strong in this result, it is consistent with Model 3 in Table 3.

Corroboration by senior managers. In order to improve our understanding and to help confirm the mechanisms driving our results, we also reached out to seven senior executives of different contractors. Our correspondence contained a summary of our empirical findings without any interpretation regarding the underlying mechanisms. Then we asked the executives to respond to two questions regarding our findings: 1) Is this finding consistent with what you know of the industry? 2) Why do you think that these patterns arise? We obtained six replies, each about three pages long. Given the tenure of our respondents, we estimate that collectively these executives have experience in managing over 100 projects. Their answers are consistent with our interpretation of the findings, as summarized below.

- *Differences in capabilities.* Managers noted that *w*hen companies grow horizontally, they tend to use and leverage similar resources and capabilities (e.g., contract management, monitoring, capability to manage teams). A typical example was that the systems to control and supervise the management of the different types of projects are the same across project types. Executives also mentioned that when firms grow vertically by performing different activities, they need different sets of technical capabilities, because many capabilities required in one type of vertical activity are different from those required in another activity.

- *Constraints to breadth and growth*. As the number, variety and dispersion of projects grows, executives indicated that complexity increases, putting pressure on the ability to monitor, control and administer the myriad of contracts, particularly in terms of quality control and timing, such as transitioning between tasks and projects. Executives also pointed to the key role of top management team cohesion and experience in project success. They indicated that when coordination demands increase, it is generally better to give away the benefits of internally performing vertical activities in favor of not losing the management team capability to supervise and coordinate the many activities to complete a project. For firms growing vertically, the opposite is true. In order to increase the number of vertical trades performed internally, firms have to free-up capacity by decreasing project variety. This confirms our empirical findings that constrained executive capabilities leads to a trade-off between breadth and depth.

DISCUSSION AND CONCLUSION

In this study, we explored the interdependencies between horizontal breadth and vertical depth, grounding our arguments in the effects of capabilities and coordination, which have been widely used to explain firm scope decisions. We theorize and empirically demonstrate that the capabilities underlying breadth and depth are scope-specific (i.e., vertical capabilities impact depth but not breadth, and horizontal capabilities impact breadth but not depth), and therefore, breadth and depth are independent. But, when executive capabilities are constrained due to coordination challenges, we did find a negative interdependency between breadth and depth. Further, we found that organizational structure variables, such as decision centralization, can affect the strength of the mechanism driving the interdependency between breadth and depth. Our results, and their underlying mechanisms, were further validated by executives with considerable project experience.

We contribute to a slim literature that has analyzed interdependencies between scope choices (Chandler, 1962; Rawley & Simcoe, 2010; Tanriverdi & Lee, 2008; Van Biesenbroeck, 2007; Zhou and Wan, 2016). However, we go beyond previous literature by studying the simultaneous and bi-directional influence of horizontal breadth and vertical depth, by measuring capabilities that are specific to horizontal or vertical scope, by considering executive capabilities, and by empirically assessing the effect of organizational structure. The analysis of the bidirectionality is important because the interrelationship between depth and breadth does not need to be symmetric. Additionally, our novel analysis of how internal organizational structure affects the tension between horizontal breath and vertical depth provides further insights about the interrelationships between managerial and organizational decisions. Thus, our findings inform how firms manage different scope choices and the mechanisms that enable and constrain scope decisions, suggesting potential barriers to overcome and modes of organizing if firms want to be both broad and deep.

Our work provides several theoretical contributions and implications. Through our simultaneous analysis of horizontal and vertical choices we hope to contribute to theories of the firm as a system of activities, supporting the notion of coherence and interrelatedness among firm activities (Porter & Siggelkow, 2008; Teece & Pisano, 1994). By finding that coordination is the key factor that limits bi-directional growth, we also contribute to recent work that emphasizes the costs of diversification over its synergies (Hashai, 2015; Sakharhov & Folta, 2014; Zhou, 2011). Our results also imply that there may be some underlying fungible executive capability, such as resource orchestration or parenting skills (Adner &

Helfat, 2003; Sirmon et al., 2011), that can enable both breadth and depth, perhaps more likely in younger, smaller firms. Extending the work on the co-evolution of capabilities and boundaries (Argyres & Zenger, 2012; Brahm and Tarzijan, 2014; Mayer, Somaya, & Williamson, 2012), we add the importance of coordination and posit that these skills may also co-evolve and be intertwined with scope choices, supporting a coordination-based theory of the firm (Kogut & Zander, 1996; Srikanth & Puranam, 2014). Our empirical results regarding how the firm´s organizational structure can influence the extent of the trade-off between breadth and depth, support the findings of recent studies that show that related (unrelated) diversification correlates with higher centralization (delegation) of specific functions (Guadalupe et al, 2013; Collis et al, 2007). It also is consistent with the coordination strand of TCE that sees the "firm as a coordination device" (Puranam and Srikanth, 2014). This perspective focuses on coordination as the main organizational problem, and suggests that firms are better than markets for coordinating certain types of activities and problems.

Several novel managerial implications emerge from our study. First, the tensions and trade-offs between vertical and horizontal growth appear to be real, but arise from coordination challenges, not clashes of capabilities. Thus, managers should focus particular attention on managing costs of coordination rather than on gaining synergies from shared capabilities when considering both horizontal and vertical decisions (Hashai, 2015; Sakarahov and Folta, 2014; Zhou 2011). For instance, managers should be conscious of the limitations of monitoring far-flung operations and recognize when they are becoming constrained in their abilities to administer and coordinate a diverse firm. Second, our results show that managers of firms that want to expand both vertically and horizontally should think about implementing a more centralized decision-making process, but this may not be necessary for firms that do not want to pursue simultaneous expansion. As such, centralization can be useful in settings different from the ones traditionally analyzed and should not be determined independently of the horizontal breadth and the vertical depth of the firm. Third, our results confirm that tradeoffs are important and that managers should seek coherence at the aggregated activity level rather than optimization at the individual activity level. More generally, managers should look for coherence among capabilities, horizontal breadth, vertical depth and the internal organizational structure of the firm.

Our study is not devoid of limitations, which we hope stimulate research extensions. Construction is a relatively mature, low technology industry with well-established horizontal and vertical activities and capability drivers; it would be intriguing to replicate our study in a rapidly changing context to see if our results hold. Our setting also considers horizontal breadth in the same industry (e.g., different types of construction projects). It would be interesting to evaluate what happens with the breadth and depth relationship when horizontal and vertical decisions are between-industries rather than within-industries. Although intra-industry diversification is more prevalent than inter-industry diversification, it is not obvious what type of diversification more strongly affects capability sharing and coordination costs (Zahavie and Lavie, 2013). In less related industries, the effect of centralization on relaxing the breadth/depth tension may also be different. Given that our setting considers horizontal breadth in the same industry, this could be a boundary condition for our results.

Another limitation is that by considering project-based firms, we do not consider the case of traditional manufacturing sectors. In that context, there may be significant gains from economies of scale and a difficulty in securing suppliers, which may be more likely to drive a positive correlation between horizontal expansion and vertical integration (Chandler, 1962; Van Biesebroeck, 2007). Project-based firms typically have relatively thick supply markets, perform projects that require a unique combination of inputs that are coordinated on-site, involve projects with various stages that use the work of other stages without incorporating this work into an intermediate product, and have less significant scale economies (Eccles, 1981; Hobday, 2000). Thus, it is possible that the strong impact of coordination is less pronounced in contexts where production stages are more independent and/or less temporally connected. In addition, regulations that affect this industry, such as those related to labor and subcontracting, vary across countries, and thus studies in other locations and in other sectors would be welcomed. The lack of a direct measure of executive capabilities is also a limitation of our study but does provide an opportunity for further research. Although in the robustness section we did measure executive capabilities more directly using information about the TMT, further efforts in this direction will be useful.

Endogeneity is always an issue when studying organizational matters such as the interdependency of scope choices. While we cannot claim that we fully addressed this issue, we are confident in the three techniques we used to mitigate this concern. First, we add a set of well-behaved instruments that are coherent with the prescriptions of strategic management theory (vertical capabilities as instruments for vertical scope and horizontal capabilities as instruments for horizontal scope). Second, we add a wide set of control variables and performed multiple robustness checks, which confirmed our results. Third, we corroborated the causal mechanism between our main variables with interviews of senior executives.

In conclusion, we find that horizontal breadth and vertical depth are independent, until coordination demands become significant when we find a negative interdependency. Thus, these dimensions of firm scope should not be addressed or studied in isolation, particularly when senior managers become constrained with coordination demands. Moreover, the interplay between these decisions cannot be isolated from the analysis of internal organizational choices. As strategic management has long recognized, the fit between strategic choices is a key determinant of a firm’s competitive advantage (Porter & Siggelkow, 2008; Teece & Pisano, 1994). Our study indicates that choices of breadth and depth should be considered simultaneously and include both scope-specific capabilities, overall executive capability and internal organizational decisions. In sum, the joint analysis of vertical and horizontal scope choices is under-researched, and we hope that our study motivates additional work in this important area.

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ENDNOTES

[1]Prior studies that analyzed the relationship between breadth and depth have subtle methodological differences. When performance is available, as in Tanriverdi and Lee (2008) or Van Biesebroek (2007), complementarity or substitution is studied, that is, the extent to which both variables reinforce or hinder one another in the impact they exert on an outcome. When performance is not available, as in Rawley and Simcoe (2010), the analysis centers on interdependency - how one variable directly affects the other by using exogenous variation. These two approaches frequently imply one another, but they are logically distinct.

[2]To keep our analysis parsimonious, we have chosen not to emphasize transaction costs at this stage, although we recognize that these are important drivers of vertical scope. Rather, we focus our discussion on capabilities, as these have been shown to be influential for scope decisions and are intertwined and interdependent with transaction costs (Argyres and Zenger, 2012).

[3]There is an assumption implicit in this argument, namely that the amount of attention, time and resources that high-level managers devote to external suppliers is less than the time devoted to internal teams. The reasoning behind this is that independent suppliers are motivated by residual profits and have stronger incentives. Attention does need to be devoted to handling suppliers, haggling, and opportunism but it is likely that these frictions occur irregularly, when transaction hazards manifest themselves. In contrast, monitoring and motivating of internal personnel require constant attention.

[4]We checked whether our results are robust to two alternative measures of breadth, the “entropy” measure and a simple “count” measure of the number of different types of projects. The results, which are available from the authors upon request, remained unchanged.

[5]Standardization is required at the contractor level due to some missing data at the project level and because the average level of integration of each trade activity varies (e.g., average integration in building the metallic structure is higher than in installing gas services). By standardizing, we avoid biases of nonrandom missing data that would bias the aggregated percentage at the contractor level.

[6]We also computed a variable that counts the number of types of projects per project director. The results using this variable are almost identical (available upon request). The reason for this is that, given that projects typically last one to two years, using a three years window allows for two projects on average; thus, the two measures converge. We also computed a variable with the experience of t-1, t-2 and t-3 (not considering the focal year) and the results remained consistent in terms of size and sign. However, we lose more than half of the sample, which hurts statistical significance. The alternative solution of using t-1 and t-2 is not ideal as projects last typically more than a year – typically one or two years– and therefore only a small portion of project directors are present in more than one project. Given that this leaves some reverse causality problems in our models, we rely on the

Hansen test to empirically argue for the validity of the use of "project director experience" and "designer experience" as instruments.

[7]By measuring prior experience relative to the experience of available subcontractors in the local market, we obtain a measure of the relative position of the contractor. Given that a relative position in a market is not easily affected by an increase in the integration of the previous projects, this variable captures more neatly a medium to long-term contractor´s expertise.

[8]Consistent with the notion that geographic specialization can increase market concentration (Ball, 2003), our HHI index has an average of 0.23, typically considered "moderately concentrated". This could potentially affect the exogeneity of the instrument, but we addressed this in several ways. First, we include contractor size and market share (measured at the region level) as controls. Second, the use of lagged supplier market thinness yields consistent results. Third, our instrumental variable estimation does not change if we drop market thinness from the analysis.

[9]We studied the extent of multicollinearity in Models 1a and 1b. The average VIF is located around 2.3, and only four variables are above the threshold of 4 (Obrien, 2007), with a maximum VIF of 4.8. Therefore, per usual standards, multicollinearity is not a significant concern in our sample.

[10]Of course, absent a clean theoretically "exogenous" shock/instrument it is hard to be fully certain, based only on the Hansen-test and other empirical analysis, about the validity of the IV strategy. This issue is particularly salient when trying to test more complex –but arguably more complete– theoretical models such as ours (cf., the one-directional model of Rawley & Simcoe, 2010). This trade-off between structure in the model to be tested and the clean identification that one can afford is a long-standing issue in econometrics (Angrist & Pischke, 2010; Nevo & Whinston, 2010).

[11]We multiply the predicted value of the breadth of horizontal portfolio obtained from Model 1 estimated by OLS (excluding the depth of vertical activities and adding Vert_Cap&Trans_Haz) with the interaction variable, and use the results ("breadth_hat x coordination demands") as an instrument for the endogenous interaction term: "breadth of horizontal portfolio x coordination demands". An analogous procedure was followed for the interaction between depth of vertical activities and coordination demands. Then, in the first stage of the estimation of equation 3 we execute two equations, one for the endogenous term "Depth_Ver" and another for the endogenous interaction term "Depth_Ver x Coord_Demands". In both of these first stages all the controls variables and instruments –including "breadth_hat x coordination demands"– are covariates (except, of course, Depth_Vert and Breadth_Hor). An analogous procedure is used for equation 4. This way of correcting endogenous interaction terms is based on Wooldridge (2002: 236-237) and is consistent with recent econometric theory research on the topic (Bun and Harrison, 2019).

[12] We did not include here a model where all the interactions terms are estimated jointly. That model does produce consistent coefficients but their statistical significance is reduced. The problem with such a model, and the reason for its exclusion, is that all moderators are measuring the same construct, and therefore a joint estimation generates multicollinearity. A marker of this problem is that while individual statistical significance suffered, statistical significance in a joint t-test improves. For Tables 4 and 5 below we proceeded in the same manner, and therefore we did not include models that jointly estimated all moderators.

Table 1
Correlation matrix and descriptive statistics.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Depth of vertical activities	1.00																				
2	Breadth of horizontal portfolio	-0.28	1.00																			
3	Designer experience	-0.13	0.21	1.00																		
4	Project director experience	-0.06	0.19	0.13	1.00																	
5	Trade expertise	0.11	0.07	-0.04	0.01	1.00																
6	Prior interactions with suppliers	-0.40	0.22	0.07	0.08	0.18	1.00															
7	Thinness of supplier market	0.19	-0.10	-0.16	-0.05	0.11	-0.03	1.00														
8	Number of projects	-0.16	0.47	0.11	0.05	0.28	0.28	-0.12	1.00													
9	Distance to headquarters	-0.03	0.21	0.07	-0.01	0.02	0.13	-0.01	0.36	1.00												
10	Distance between projects	-0.17	0.51	0.07	0.02	0.11	0.26	-0.02	0.59	0.59	1.00											
11	Contractor size	-0.32	0.40	0.12	0.01	0.26	0.35	-0.08	0.57	0.32	0.52	1.00										
12	Uncertainty of main project type	0.16	-0.15	-0.06	-0.06	0.02	-0.08	0.45	-0.19	-0.04	-0.17	-0.23	1.00									
13	Demand imbalance	0.00	0.04	-0.01	0.02	-0.04	0.01	-0.06	0.03	0.04	0.05	0.04	-0.22	1.00								
14	Contractor market share	-0.01	0.10	-0.03	-0.06	0.26	0.08	0.41	0.28	0.23	0.28	0.43	0.11	-0.10	1.00							
15	Geographic dispersion	-0.13	0.40	0.07	-0.03	0.05	0.15	0.03	0.53	0.55	0.84	0.43	-0.10	0.03	0.28	1.00						
16	Metropolitan region focus	-0.17	0.05	0.06	0.04	-0.09	0.27	-0.29	0.04	-0.10	-0.09	0.02	-0.13	0.00	-0.41	-0.19	1.00					
17	Housing sector focus	0.09	-03	0.02	-0.10	0.12	0.06	-0.05	0.03	-0.03	-0.07	0.01	0.11	-0.07	0.07	-0.05	-0.02	1.00				
18	Market size	-0.25	0.29	0.11	0.01	-0.07	0.33	-0.33	0.36	0.26	0.40	0.26	-0.19	0.08	-0.20	0.34	0.72	-0.01	1.00			
19	Procurement centralization	0.13	-0.04	0.01	0.08	0.04	-0.15	-0.04	-0.06	-0.02	-0.02	-0.11	-0.12	-0.05	0.06	0.01	-0.26	-0.09	-0.27	1.00		
20	Design integration	0.09	-0.09	-0.08	0.00	0.23	0.09	0.07	0.05	-0.03	0.02	0.06	-0.05	0.01	0.11	-0.02	0.01	0.10	-0.04	0.01	1.00	
21	Top management team	-0.23	0.23	0.04	-0.02	0.15	0.29	0.03	0.28	0.22	0.31	0.38	-0.08	0.03	0.23	0.27	-0.00	-0.06	0.12	-0.03	0.01	1.00
	Observations	815	815	815	815	729	729	815	815	815	815	815	815	815	815	815	815	815	815	713	815	812
	Mean	-0.14	0.15	0.12	0.18	0.27	1.43	0.23	3.05	2.91	1.79	9.12	0.64	0.99	0.03	0.11	0.54	0.72	15.09	0.35	0.11	2.92
	Standard deviation	0.55	0.22	0.16	0.33	0.19	1.02	0.10	3.02	1.98	2.21	1.79	0.29	0.20	0.06	0.21	0.46	0.40	0.96	0.40	0.29	0.86
	Min	-1.33	0.00	0.00	0.00	0.00	0.00	0.05	1.00	0.00	0.00	0.24	0.14	0.64	0.00	0.00	0.00	0.00	12.37	0	0	1
	Max	1.24	0.79	0.65	1.00	0.93	8.41	0.87	29.00	7.00	6.90	13.62	1.00	1.54	0.43	0.75	1.00	1.00	16.42	1	1	4

Table 2. Random effects and instrumental variables models for horizontal and vertical scope.
(Note that these are simultaneous models, encompassing two regressions: 'a' for horizontal; 'b' for vertical)

	Model 1		**Model 2 – Instrumental Variable**	
	(a)	**(b)**	**(a)**	**(b)**
Dependent Variable:	Breadth of horizontal portfolio	Depth of vertical activities	Breadth of horizontal portfolio	Depth of vertical activities
Depth of vertical activities	-0.046*** (0.012)		-0.046 (0.034)	
Breadth of horizontal portfolio		-0.199** (0.104)		-0.455 (0.307)
Designer experience in different project types	0.173*** (0.040)		0.158*** (0.040)	
Project director experience in different project types	0.077*** (0.021)		0.079*** (0.021)	
Trade expertise		0.300*** (0.098)		0.583*** (0.105)
Prior interactions with Suppliers		-0.174*** (0.026)		-0.185*** (0.025)
Thinness of supplier market		0.418* (0.240)		0.452 (0.304)
Number of projects	0.018*** (0.004)	0.019** (0.012)	0.018*** (0.004)	0.017 (0.011)
Distance to headquarters	-0.013*** (0.004)	0.014 (0.010)	-0.013*** (0.003)	0.026* (0.013)
Distance between projects	0.040*** (0.007)	0.005 (0.012)	0.041*** (0.007)	0.018 (0.025)
Contractor size	0.011*** (0.004)	-0.076*** (0.015)	0.009* (0.005)	-0.076*** (0.016)
Uncertainty of main project type	0.066 (0.065)	-0.135 (0.206)	0.080 (0.062)	-0.200 (0.167)
Demand imbalance	-0.044 (0.389)	0.049 (0.114)	-0.032 (0.036)	0.099 (0.126)
Contractor market share	-0.231 (0.159)	0.120 (0.412)	-0.044 (0.164)	-0.097 (0.564)
Geographic dispersion	-0.069 (0.083)	-0.010 (0.146)	-0.037 (0.078)	-0.061 (0.155)
Metropolitan region focus	-0.013 (0.029)	0.093 (0.074)	-0.004 (0.029)	0.074 (0.088)
Housing sector focus	-0.116*** (0.020)	0. 183*** (0.059)	-0.115*** (0.021)	0.129* (0.080)
Market size	0.008 (0.015)	-0.084* (0.043)	0.005 (0.015)	-0.056 (0.051)
Constant	-0.186 (0.216)	1.819*** (0.657)	-0.085 (0.234)	1.262 (0.079)
Year fixed effects?	YES	YES	YES	YES
Observations	815	1033	729	729
R-Squared	43.71%	27.59%		
Kleibergen-Paap F-test first stage			27.79	17.01
Hansen test (p-value)			0.38 (0.82)	0.07 (0.78)

(†) p < 0.1 *; p < 0.05 **; p < 0.01 ***. Model 1 is estimated using a panel data random effect model. Model 2 is estimated using a random effect model with instrumental variables. Robust standard errors in parentheses (Huber-white "sandwich" estimator). The IV correction of endogenous interaction terms follows Wooldridge (2002: 236-237).

Table 3. Impact of coordination demands on the interdependency of breadth and depth
(Note that these are simultaneous models, encompassing two regressions: 'a' for horizontal; 'b' for vertical)

	Model 3		Model 4		Model 5	
	(a)	**(b)**	**(a)**	**(b)**	**(a)**	**(b)**
Dependent Variable:	Breadth of horizontal portfolio	Depth of vertical activities	Breadth of horizontal portfolio	Depth of vertical activities	Breadth of horizontal portfolio	Depth of vertical activities
Depth of vertical activities	0.014 (0.035)		-0.030 (0.039)		-0.006 (0.033)	
Breadth of horizontal portfolio		-0.109 (0.337)		-0.294 (0.425)		-0.224 (0.423)
Depth of vertical activities x Number of projects	-0.019*** (0.007)					
Breadth of horizontal portfolio x Number of projects		-0.122* (0.070)				
Depth of vertical activities x Distance to headquarters			-0.007 (0.011)			
Breadth of horizontal portfolio x Distance to headquarters				-0.082 (0.080)		
Depth of vertical activities x Distance between projects					-0.030** (0.013)	
Breadth of horizontal portfolio x Distance between projects						-0.162** (0.060)
Number of projects	0.012*** (0.005)	0.060* (0.032)	0.017*** (0.004)	0.018 (0.114)	0.018*** (0.004)	0.021* (0.012)
Distance to headquarters	-0.013*** (0.003)	0.025* (0.014)	-0.013*** (0.003)	0.033** (0.016)	-0.013*** (0.003)	0.029** (0.014)
Distance between projects	0.043*** (0.007)	0.003 (0.021)	0.041*** (0.007)	0.024 (0.025)	0.037*** (0.007)	0.034 (0.028)
Rest of covariates? (including capabilities and constant)	YES	YES	YES	YES	YES	YES
Year fixed effects?	YES	YES	YES	YES	YES	YES
Observations	729	729	729	729	729	729
Kleibergen-Paap F-test first stage	21.49	9.51	18.85	11.78	20.62	10.04
Hansen test (p-value)	0.39 (0.82)	0.03 (0.86)	0.60 (0.73)	0.10 (0.76)	0.35 (0.83)	0.09 (0.876)

$p < 0.1$ *; $p < 0.05$ **; $p < 0.01$ ***. Robust standard errors in parentheses (Huber-white "sandwich" estimator). The IV correction of endogenous interaction terms follows Wooldridge (2002: 236-237). All models are a random effect model with instrumental variables.

Table 4

The moderating role of centralization on the impact of coordination demands

(Note that these are simultaneous models, encompassing two regressions: 'a' for horizontal; 'b' for vertical)

	Model 6		Model 7	
	(a)	**(b)**	**(a)**	**(b)**
Dependent Variable:	Breadth of horizontal portfolio	Depth of vertical activities	Breadth of horizontal portfolio	Depth of vertical activities
Depth of vertical activities	0.002 (0.049)		-0.003 (0.046)	
Breadth of horizontal portfolio		0.366 (0.388)		0.341 (0.507)
Depth of vertical activities x Number of projects	-0.021** (0.008)			
Depth of vertical activities x Procurement centralization	0.018 (0.067)			
Depth of vertical activities x Number of projects x Procurement centralization	0.010 (0.029)			
Breadth of horizontal portfolio x Number of projects		-0.199** (0.091)		
Breadth of horizontal portfolio x Proc. centralization		-1.658*** (0.584)		
Breadth of horizontal portfolio x Number of projects x Procurement centralization		0.179† (0.144)		
Number of projects x Procurement centralization	0.018 (0.010)	-0.014 (0.060)		
Depth of vertical activities x Dist. between projects			-0.047** (0.021)	
Depth of vertical activities x Proc. centralization			-0.014 (0.056)	
Depth of vertical activities x Dist. between projects x Procurement centralization			0.057 (0.044)	
Breadth of horizontal activities x Dist. between projects				-0.328** (0.161)
Breadth of horizontal activities x Proc. centralization				-1.973** (0.847)
Breadth of horizontal activities x Dist. between projects x Procurement centralization				0.427** (0.201)
Dist. between projects x Procurement centralization			0.012 (0.014)	-0.049 (0.055)
Number of projects	0.010* (0.005)	0.071* (0.036)	0.017*** (0.004)	0.019 (0.011)
Distance between projects	0.041*** (0.007)	0.010 (0.023)	0.032*** (0.008)	0.062 (0.042)
Procurement centralization	-0.019 (0.021)	0.219** (0.109)	0.004 (0.017)	0.214*** (0.072)
Rest of covariates? (including capabilities and constant)	YES	YES	YES	YES
Observations	627	627	627	627
Kleibergen-Paap F-test first stage	14.20	5.37	13.41	3.49
Hansen test (p-value)	0.99 (0.61)	0.04 (0.84)	0.53 (0.77)	0.04 (0.84)

$p < 0.1$ *; $p < 0.05$ **; $p < 0.01$ ***. (†) This triple interaction has a high collinearity, inflating its standard error (the VIF of this triple interaction is 13.42); a joint t-test of the derivative d(depth)/d(breadth) has a p-value of 0.0004 (i.e., a joint test of "breadth + breadth*num of proj + breadth*cent + breadth*num of proj*cent"), and a joint t-test of the second derivative $d(depth)^2/d(breadth)d(\text{Number of projects})$ has a p-value of 0.02 (i.e., a joint t-test of "breadth*num of proj + breadth*num of proj* cent"). Robust standard errors in parentheses (Huber-white "sandwich" estimator). The IV correction of endogenous interaction terms follows Wooldridge (2002: 236-237). All models are a random effect model with instrumental variables.

Table 5

The moderating role of designer integration on the impact of coordination demands

(Note that these are simultaneous models, encompassing two regressions: 'a' for horizontal; 'b' for vertical)

	Model 8		**Model 9**	
	(a)	**(b)**	**(a)**	**(b)**
Dependent Variable:	Breadth of horizontal portfolio	Depth of vertical activities	Breadth of horizontal portfolio	Depth of vertical activities
Depth of vertical activities	0.010 (0.036)		-0.013 (0.035)	
Breadth of horizontal portfolio		-0.269 (0.363)		-0.169 (0.429)
Depth of vertical activities x Number of projects	-0.021** (0.009)			
Depth of vertical activities x Design integration	-0.026 (0.082)			
Depth of vertical activities x Number of projects x Design integration	0.025** (0.012)			
Breadth of Breadth portfolio x Number of projects		-0.135* (0.073)		
Breadth of horizontal portfolio x Design integration		1.084 (1.171)		
Breadth of horizontal portfolio x Number of projects x Design integration		-0.053 (0.227)		
Number of projects x Design integration	-0.035*** (0.011)	-0.055 (0.057)		
Depth of vertical activities x Dist. between projects			-0.024* (0.014)	
Depth of vertical activities x Design integration			0.045 (0.077)	
Depth of vertical activities x Dist. between projects x Design integration			-0.021 (0.048)	
Breadth of horizontal activities x Dist. between projects				-0.140* (0.082)
Breadth of horizontal activities x Design integration				-0.164 (1.807)
Breadth of horizontal activities x Dist. between projects x Design integration				-0.126 (0.859)
Dist. between projects x Design integration			-0.027* (0.014)	0.028 (0.066)
Number of projects	0.018*** (0.004)	0.073 (0.046)	0.018*** (0.004)	0.018 (0.013)
Distance between projects	0.045*** (0.007)	0.011 (0.023)	0.044*** (0.008)	0.026 (0.035)
Design integration	0.037 (0.029)	0.165 (0.127)	-0.015 (0.021)	0.100 (0.105)
Rest of covariates? (including capabilities and constant)	YES	YES	YES	YES
Observations	729	729	729	627
Kleibergen-Paap F-test first stage	13.48	4.46	3.77	13.44
Hansen test (p-value)	0.44 (0.80)	0.18 (0.66)	0.24 (0.89)	0.04 (0.84)

$p < 0.1$ *; $p < 0.05$ **; $p < 0.01$ ***. Robust standard errors in parentheses (Huber-white "sandwich" estimator). The IV correction of endogenous interaction terms follows Wooldridge (2002: 236-237). All models are a random effect model with instrumental variables.

Table 6

Using projects per TMT member as proxy for managerial diseconomies

(Note that these are simultaneous models, encompassing two regressions: 'a' for horizontal; 'b' for vertical)

	Model 10		Model 11	
	(a)	**(b)**	**(a)**	**(b)**
Dependent Variable:	Breadth of horizontal portfolio	Depth of vertical activities	Breadth of horizontal portfolio	Depth of vertical activities
	Instrumental Variables	Instrumental Variables	Instrumental Variables	Instrumental Variables
Depth of vertical activities	0.051 (0.044)		0.041 (0.052)	
Breadth of horizontal portfolio		-0.468 (0.460)		
Depth of vertical activities x Projects per TMT member	-0.089*** (0.027)		-0.081*** (0.031)	
Depth of vertical activities x Procurement centralization			0.047 (0.083)	
Depth of vertical activities x Projects per TMT member x Procurement centralization			-0.046 (0.097)	
Breadth of horizontal portfolio x Projects per TMT member		-0.442*** (0.125)		-0.494*** (0.182)
Breadth of horizontal portfolio x Proc. centralization				-1.644*** (0.579)
Breadth of horizontal portfolio x Projects per TMT member x Procurement centralization				0.588† (0.378)
Projects per TMT member x Procurement centralization			0.010 (0.027)	-0.068 (0.130)
Projects per TMT member	0.028** (0.012)	0.167*** (0.056)	0.024* (0.015)	0.169** (0.071)
Procurement centralization	0.001 (0.016)	0.095* (0.054)	-0.008 (0.023)	0.239** (0.106)
Rest of covariates? (including capabilities and constant)	YES	YES	YES	YES
Observations	625	625	625	625
Kleibergen-Paap F-test first stage	20.23	9.85	13.94	5.76
Hansen test (p-value)	1.55 (0.46)	0.02 (0.88)	1.64 (0.44)	0.06 (0.80)

$p < 0.1$ *; $p < 0.05$ **; $p < 0.01$ ***. (†) This triple interaction has a high collinearity, inflating its standard error; a joint t-test of the derivative d(depth)/d(breadth) has a p-value of 0.003 (i.e., a joint test of "breadth + breadth*num of proj + breadth*cent + breadth*num of proj*cent"), and a joint t-test of the second derivative $d(depth)^2/d(breadth)d(Number of projects)$ has a p-value of 0.018 (i.e., a joint t-test of "breadth*num of proj + breadth*num of proj* cent"). Robust standard errors in parentheses (Huber-white "sandwich" estimator). The IV correction of endogenous interaction terms follows Wooldridge (2002: 236-237). All models are a random effect model with instrumental variables.

Figure 1

Summary of the Hypotheses

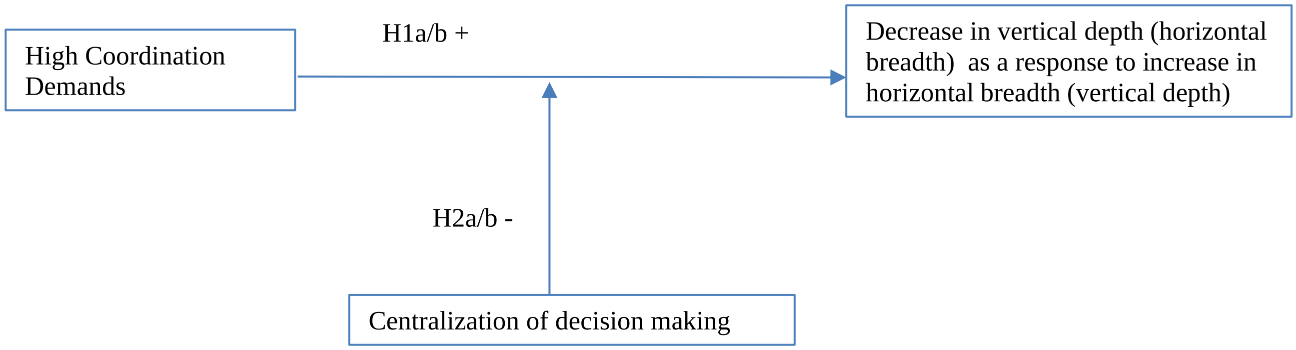


Figure 2

Interaction effect between "depth of vertical activities" and "number of projects"

Note: in this graph we plot the following derivative d(breadt)/d(depth)

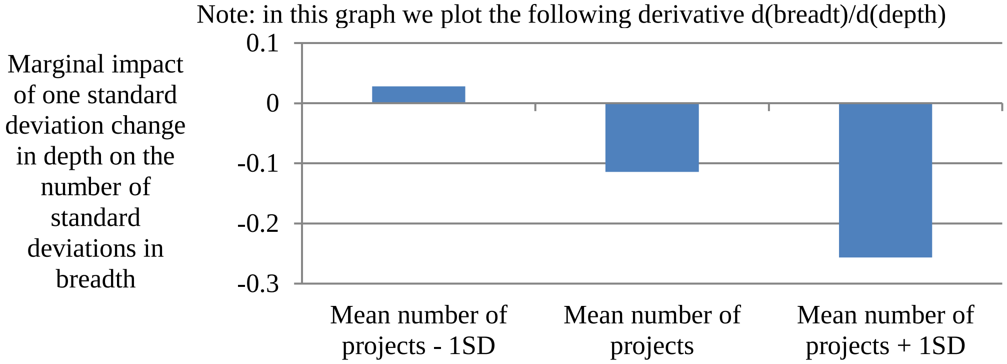


Figure 3

Interaction effect between "breadth of horizontal portfolio" and "number of projects".

Note: in this graph we plot the following derivative d(depth)/d(breadth)

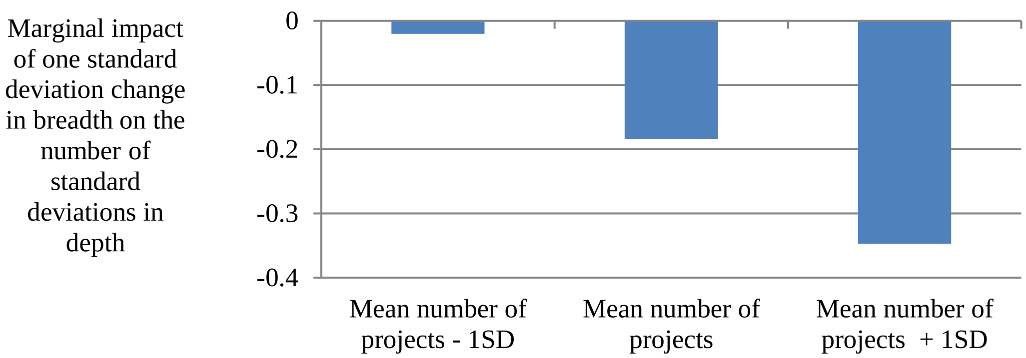


Figure 4

Interaction between "Depth of vertical activities" and "distance between projects"

Note: in this graph we plot the following derivative d(breadt)/d(depth)

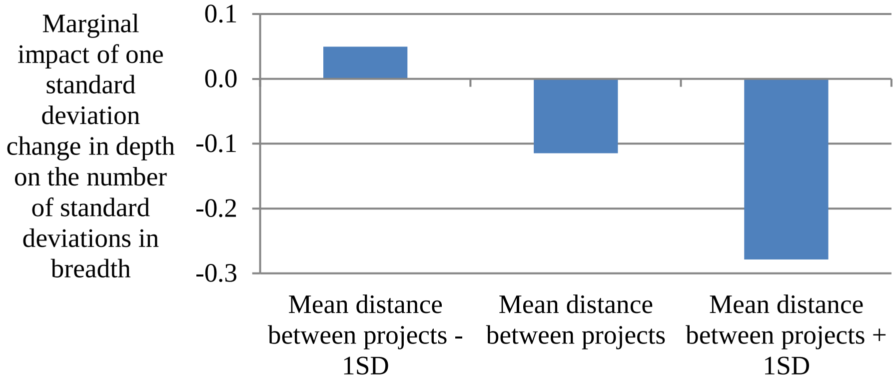


Figure 5

Interaction between "breadth of horizontal portfolio" and "distance between projects".

Note: in this graph we plot the following derivative d(depth)/d(breadth)

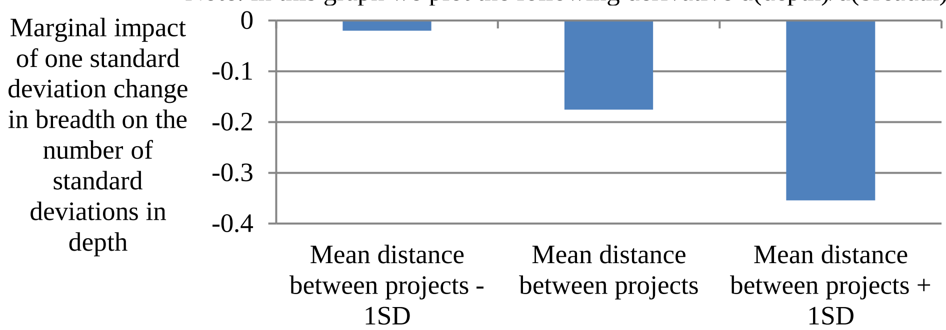


Figure 6

Moderating effect of procurement centralization on the impact of number of projects

Note: in this graph we plot the following derivative d(depth)/d(breadth)

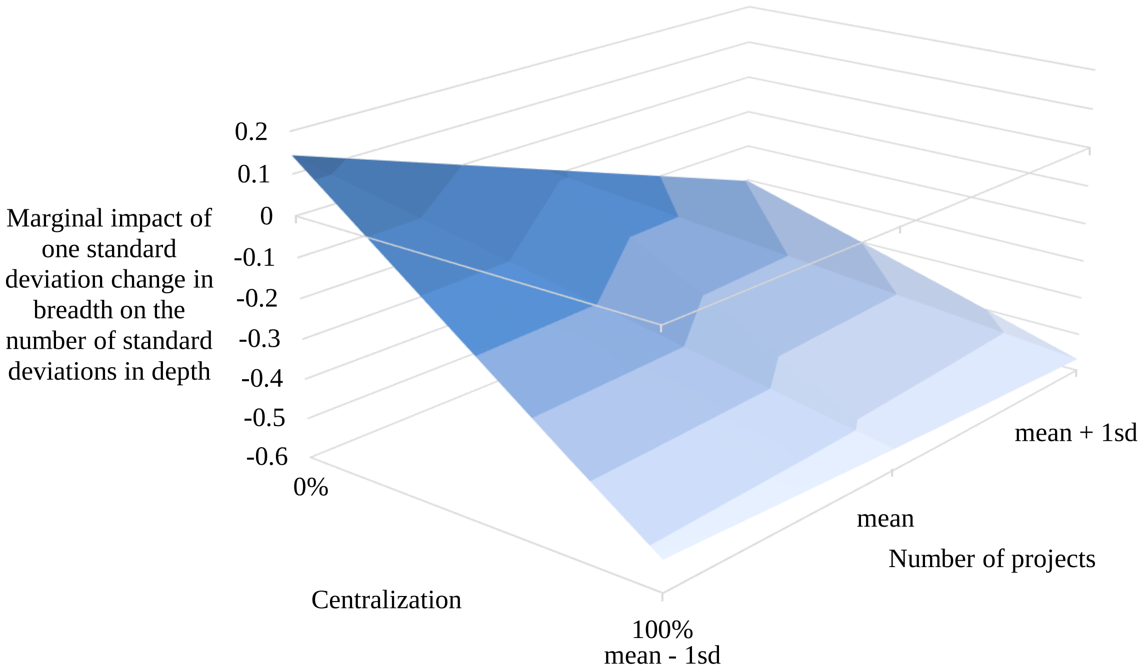


Figure 7

Moderating effect of procurement centralization on the impact of distance between projects

Note: in this graph we plot the following derivative d(depth)/d(breadth)

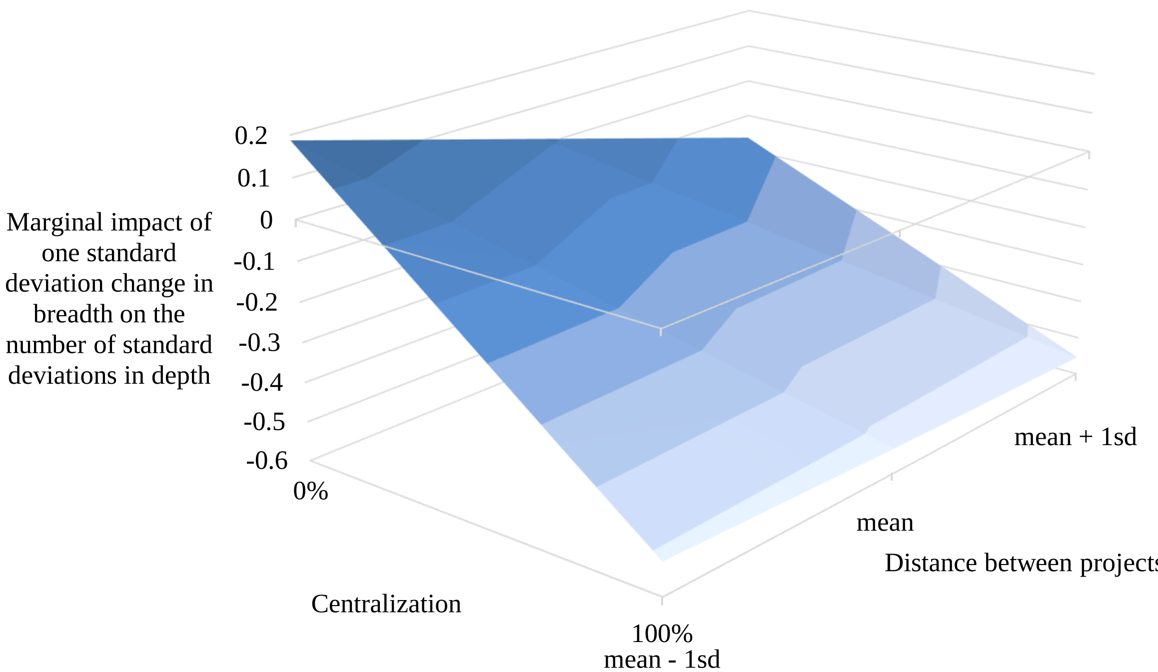
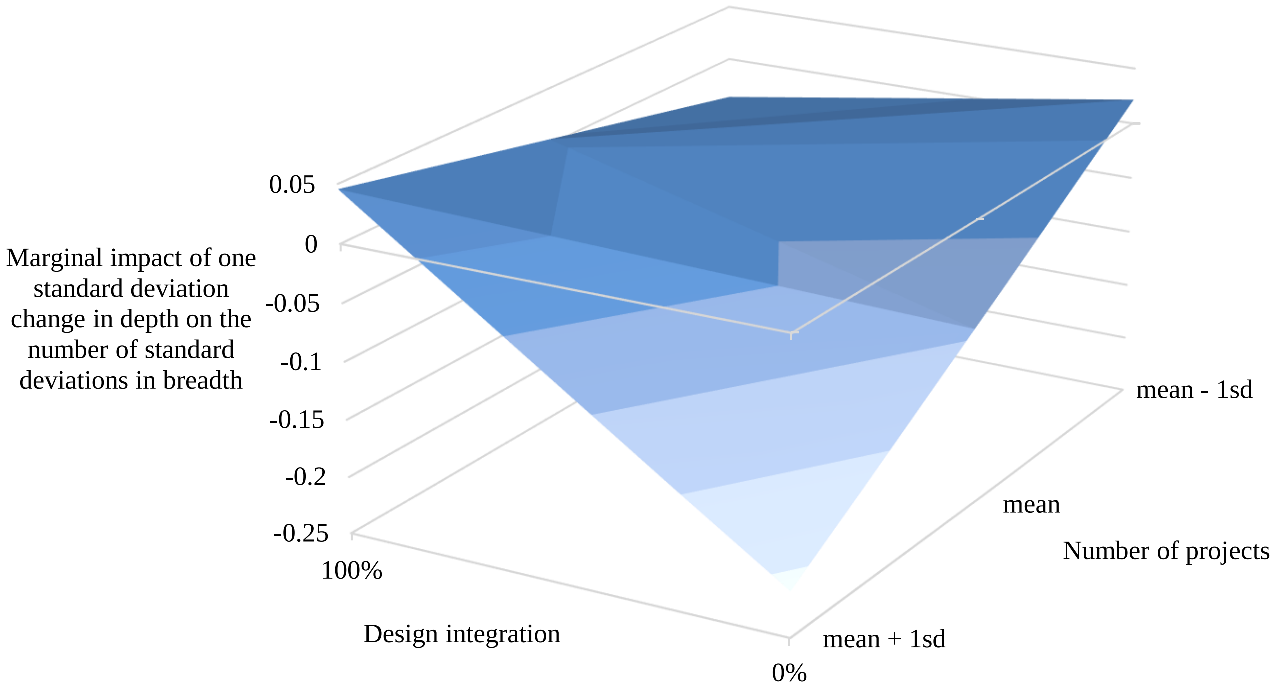


Figure 8

Moderating effect of procurement centralization on the impact of distance between projects

Notes: (1) in this graph we plot the following derivative d(breadth)/d(depth), (2) for improved presentation, the changed the directions of both axes (as compared to the Figures 5 and 6)



APPENDIX: DESCRIPTION OF CONTROL VARIABLES

Contractor Size. The natural logarithm of the total square meters built by contractor by year.
Uncertainty in the contractor's focal type of project. Uncertainty in the contractor's focal type of project can affect diversification through the "risk mitigation" logic (Wang & Barney, 2006). The focal type of project is based on the greatest percentage of square meters built in the current and prior year. Based on Leiblein and Miller (2003), we measure uncertainty as the squared sum of errors for a linear regression of the monthly building permits for each type and each region for the past ten years. Due to seasonality, the data were adjusted using the Arima X-12 procedure.
Demand imbalance across project types. Since firms may tend to diversify away from stagnant markets into growing ones, we controlled for this demand imbalance. We computed the yearly growth of the building permits for each contractor's focal project type for all other types and computed the ratio of the former on the later. If this ratio is lower than one, diversification might be required to maintain a given sales volume.
Contractor market share. A contractor with market power might possess the ability to influence the behavior of suppliers and thus not need to vertically integrate. In construction, market power appears to exist at the geographical level (Ball, 2003; Somerville, 1999). We measure market share by contractor by comparing its total square meters built to that built by all contractors in their region, using a weighted average.
Geographic dispersion. The geographic dispersion of the contractor might affect its monitoring ability and thus, its vertical and horizontal scope. The geographic dispersion is computed by the HHI index, using the square meters built by contractor by year in the different regions.
Metropolitan region focus. Chile is divided in 15 regions, with the main metropolitan region accounting for roughly half of the economic activity and having thicker supplier markets. For each contractor-year, we computed the percentage of square meters built in this region.
Housing sector focus. In the construction industry, there is a natural segmentation and specialization between housing and infrastructure/commercial sectors, with horizontal diversification being easier within versus between sectors. To control for this, we computed the percentage of square meters built in housing for each contractor-year.
Market size. The size of regional markets is measured as the square meters in building permits approved in each region of Chile. This information is supplied yearly by the Chilean Ministry of Statistics. To measure of market size at the contractor, we sum the sizes of the markets in which a contractor is executing a project, and then take the natural logarithm of this measure.
Time fixed effects. We include time dummies to control for time-varying unobserved heterogeneity. For example, during 2009 and 2010 there was an important downturn in the construction industry, which may bias our results if not accounted for.