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ARE THERE ALWAYS SYNERGIES BETWEEN PRODUCTIVE RESOURCES AND RESOURCE DEPLOYMENT CAPABILITIES?

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While the independent impacts of particular firm resources and deployment capabilities on firm performance are unambiguous cornerstones of the strategy field, it is commonly assumed that their joint impacts are synergistic. This article seeks to understand whether this common misconception of resource-based theory can be refuted empirically. Using data from hospitals conducting specialist surgery, I find hospital performance improves independently through better surgical resource quality and from more use of a streamlined form of resource management in which overall patient team leadership and operating team leadership are held by the same physician. Generally the interaction of these two firm activities had no impact on performance. These results contribute to the strategy field's understanding of whether and when internal fit affects performance, clarifying an incorrect inference commonly made about resource-based theory.

INTRODUCTION

Firm performance hinges on the efficient and effective management of productive resources using knowledge-based routines. Do these resource management capabilities *interact positively* with resource quality and, thus, *synergistically* determine performance? A common perception is that there must be complementarities to be harnessed among resources and that by identifying and exploiting these, managers can add value to the firm. There is, however, no strong theoretical basis for this view. Indeed, while the independent effects of resources and resource management might be positive, there may be no synergies, or worse, such interactions might be negative.

The antecedents to this view are deep and help explain its persistence. Strategy and economics scholars have long reasoned that resources and capabilities are strongly synergistic or complements in firm performance (Penrose, 1959; Chandler, 1962; Alchian and Demsetz, 1972; Porter, 1996; Milgrom and Roberts, 1995; Rivkin, 2000). In the resource-based (RBT) theory, for example, resource management capabilities allow predictions about future values of firm resources (Barney, 1986, 1991; Peteraf, 1993; Wernerfelt, 1984). Building on RBT, the capabilities-building mechanism of firm rent creation (Makadok, 2001; Lippman and Rumelt, 2003) also sees effective

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exploitation of valuable and complementary resource-capability combinations as a firm's chief strategic imperative (Amit and Schoemaker, 1993; Collis and Montgomery, 1995; Teece, Pisano, and Shuen, 1997; Eisenhardt and Martin, 2000; Peteraf and Reed, 2007; Hoopes and Madsen, 2008).

Yet even the RBT does not require such synergies between resources and capabilities: for example, a highly productive and innovative R&D team may suffice as long as it is not actively mismanaged (Barney, 1991; Peteraf, 1993). Nevertheless, a stream of empirical results buttresses the persistent notion that interdependencies among firm activities generally yield positive interactions on firm performance (Carmeli and Tishler, 2004; Danneels, 2007; Ethiraj *et al.*, 2005; Morgan,Vorhies, and Mason, 2009; Novak and Stern, 2009; Parmigiani and Mitchell, 2009).

However, it is not clear that interactions among firm activities should always be positive or even neutral (Siggelkow, 2001) or that no boundary conditions on such interactions exist (Newbert, 2008). In theory, for example, firm capabilities could generate a competitive advantage even when combined with less valuable productive resources (Maritan and Brush, 2003; Lippman and Rumelt, 2003; Hansen, Perry, and Reese, 2004), since a firm's processes and capabilities may alter firm resource bases (Eisenhardt and Martin, 2000; Miller, 2003). In practice, a study of Indian software firms found the marginal benefits to different complementary capabilities changed magnitude or sign as certain critical thresholds were reached (Ethiraj *et al.*, 2005). Studying Major League Baseball teams, Sirmon, Gove, and Hitt (2008) find the benefits of managerial ability to matter more under conditions of resource parity in dyadic competition contexts. In a related sports context, Holcomb, Holmes, and Connelly (2009) found that the benefits of sports team managerial ability appear strongest at lowest levels of resource quality and less evident in firms with already superior resources.

If present, the accurate identification of synergies between resources and resource management matters to firms and their investment and operational decisions (Siggelkow, 2002). Thus, the present article seeks to shed light on the value of resource-capability combinations. I identify a critical set of interdependent productive resources and an organizational capability to deploy these resources in a particular streamlined configuration (Sirmon, Hitt, and Ireland, 2007), which may plausibly be combined to yield greater value (Holcomb *et al.*, 2009). I test the key question mentioned earlier as to the independent and joint effect of these resources and the associated resource management capability on firms' performance in the context of 75 hospitals providing specialized surgical services in one state over nine years, examining hypothesized effects on hospital performance metrics such as market share, quality, and cost containment.

This study has both conceptual and empirical contributions. Conceptually, I seek to straighten out a common misperception as to the necessary presence of synergies among firm activities. This misperception arose both before RBT and since RBT, but misconstrues the RBT as it was originally intended. Empirical work that tests implications and constructs of the RBT also addresses acknowledged weaknesses and underexploration and strengthens the role of this theory (Priem and Butler, 2001; Newbert, 2007, 2008). For strategy scholars and practitioners, these findings may help inform strategic trade-offs between the acquisition of enhanced productive resources and the honing of improved administrative resources. In practice, hospital performance summarizes lives gained or lost and careful or wasteful stewardship of finite health care budgets.

THEORETICAL BACKGROUND

Internal 'fit'

Scholars have long understood that strategy, structure, and processes must fit together (Chandler, 1962; Nadler and Tushman, 1980; Porter, 1996).The ready intuition is that the whole may be greater than the sum of well-fitting parts. Intuitively, firm activities, be they resources, capabilities, processes, or culture (Barney, 1991; Barney 2001) are at least somewhat interdependent by virtue of being included within a firm's tangible or intangible boundaries. The managerial implications of such fit fall into broad categories.

The first considers the ability of a firm's competitors to understand and replicate a firm's activities (Lippman and Rumelt, 1982; Teece, 1986; Dierickx and Cool, 1989). To the extent that firm activity linkages fit together tightly, opaquely,

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or ambiguously, they may only be observed and imitated with difficulty or with uncertainty (Eisenhardt and Tabrizi, 1995; Levinthal, 1997; Rivkin, 2000; Miner, Bassoff, and Moorman, 2001;; Bingham and Eisenhardt, 2008).

The second managerial implication considers the ability of a firm's managers to capture the performance advantage that may emerge from an interdependent set of activities. Changes in one activity may affect the benefits or costs accruing to the firm from another activity (Alchian and Demsetz, 1972; Penrose, 1959; Lenox, Rockart, and Lewin , 2006; Lenox, Rockart,and Lewin, 2007). Such activities are complements if 'doing (more of) any one of them increases the returns to doing (more of) the others' (Milgrom and Roberts, 1995: 181). Managers must then internally optimize combinations of firm activities to achieve a new, higher performing firm (Milgrom and Roberts, 1990; Topkis, 1995a, 1995b), although fit may change dynamically over time (Siggelkow, 2001).

An emerging third managerial implication of fit is that excessive credulity concerning the value and sign of interactions among firm activities is fraught with its own risks. Interdependencies with substantively negative interactions imply a need for an adjustment of the levels or presence of particular firm elements, while interdependencies with significant complementarities suggest coordinated firm action and investment to increase the levels of such elements. In this light, mistaking substitutes for complements may have an asymmetrically worse firm performance impact than the converse error (Siggelkow, 2002), highlighting the importance of straightening out the common misperception at the root of this study. In Figures 1 and 2, I preview in very broad strokes the relationships and the hypotheses between two critical firm activities and tasks and then ultimate firm performance.

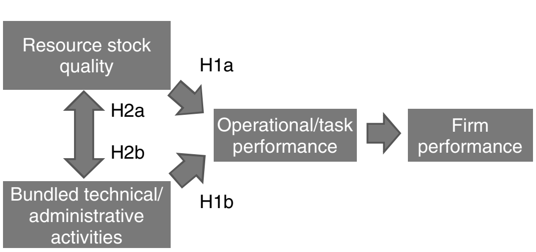

Figure 1. Expected relationships and hypotheses

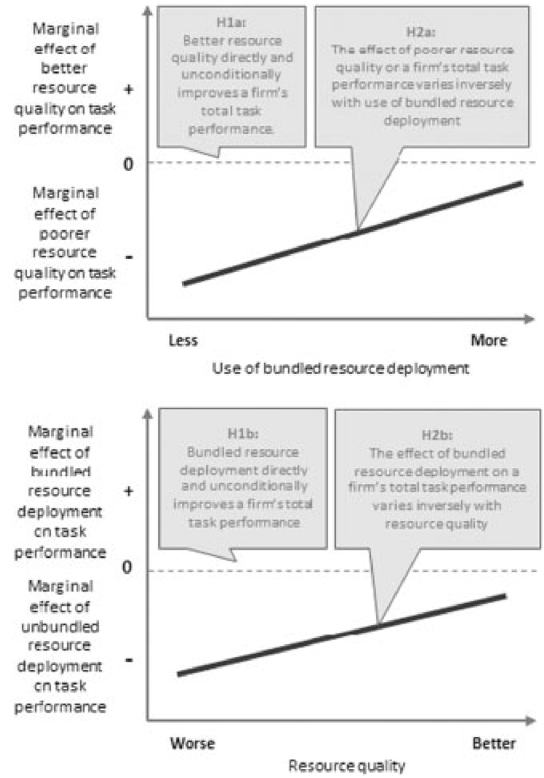

Figure 2. Expected magnitudes, signs, and dependence of hypotheses

Conceptualizing productive resources' independent value

Resource-based theory explicates the potential value of resources resides in their immobility, scarcity, nontransferability, and inimitability (Barney, 1986; 1991; Peteraf, 1993). However, these four 'VRIN' characteristics matter only if the resources are successfully deployed to increase consumer willingness to pay or reduce a firm's costs to produce and serve those customers or both (Peteraf and Barney, 2003). The value of productive resources is realized through the technical, managerial, and intuitive skills of individual knowledge workers and the teams in which they increasingly deliver services to customers. Although such individuals may have similar training, experience, and credentials, their human capital differs across and within firms (Becker, 1962; Castanias and Helfat, 1991).

Depending on individuals' backgrounds, experience, and learning, they may acquire both 'technical skills' and 'knowledge' (Nass, 1994), as well as 'intuition' (Simon, 1987) as a consequence of solving execution problems and perfecting delivery. Technical skills correlated with firm-specific assets remain critical in many industries where knowledge-based production demands intimate familiarity with supporting tools such as software and hardware. Intuition on the part of a knowledge worker reflects uncodified knowledge that is difficult to articulate, teach, or vicariously acquire. Other differences in development may be due to a broader or narrower exposure to variation in inputs to production or processes of production or team assignments, rendering technical skills nonuniform. These on-the-job differences in experience combine and lead to a distribution in the quality of individual resources. A central and logically primary component of resource management is, then, the correct structuring of a firm's resource portfolio by adding to or deleting from the pool of resources controlled by the firm (Sirmon *et al.*, 2008). Unless an individual's performance can be associated with some element of a firm's balanced scorecard, resource management is ineffectual.

Focused on the sample in this study, the productive resources are specialist surgeons working on care teams in a hospital. In other industries, these resources would closely mirror the highly technical specialists such as bench scientists in pharmaceutical firms or software engineers in computing services firms. For the surgeons I study, the most valuable resource skill is performing a specialist surgical service with minimal patient mortality and postoperative complications. Leading surgeons acknowledge 'differences in surgical skill among surgeons are something that we all know . . . but never discuss publicly' (Bonchek, 2002: 433). Components of this skill include technical ability[1] as well as judgment skills which yield high quality surgical outcomes.[2,3] A high grade on these outcome quality metrics leads to more word of mouth, more volume, a higher market share, and a stronger bargaining position with payors and insurers, all driving a larger revenue line.[4] Conversely, a low grade on mortality rates also drives costs up, mainly through longer and more complex postoperative stays that, in turn, decrease capacity and lower incremental revenue. Therefore, I hypothesize that:

Hypothesis 1a: Better resource quality directly and unconditionally improves a firm's total task performance.

Independent impact of resource management

Organizational theorists view the firm as a bundle of knowledge-based routines (Cyert and March, 1963; Nelson and Winter, 1982). The efficient and effective deployment of productive resources is a key routine that turns such resources into services (Ethiraj *et al.*, 2005; Hansen *et al.*, 2004; Sirmon *et al.*, 2007) and may form a basis for rent generation (Lippman and Rumelt, 2003). Managers who are able to build and use relational capital to integrate multiple capabilities into a configuration and use organizational routines and their tacit knowledge to deploy these configurations to enact the leveraging strategy are most likely to create value for customers (Sirmon *et al.*, 2007). In modern knowledge-based industries, productive resources are harnessed in cross-disciplinary teams and *ad hoc* committees comprising technical specialists and nontechnical generalists. While much of the literature conceptualizes complementary, horizontal activities (Milgrom and Roberts, 1995; Rivkin, 2000; Ethiraj *et al.*, 2005), in this study I focus entirely on potentially complementary vertical ones of the sort featured in a related stream of the literature (Argyres 1996; Brusoni, Prencipe, and Pavit, 2001; Jacobides and Hitt, 2005).

The design and constitution of such structural mechanisms is an important aspect of building and sustaining routines (Miller, 2003; Zollo and Winter, 2002). One of many important design features is that of the team's type of leadership: is team leadership *focused* within a single individual or *distributed* across two or more individuals (Gibb, 1954)? In the former design, leadership and execution responsibility is combined within a

[1] Direct technical errors (e.g., graft bleeds or aortic or ventricular rupture) are a relatively minor cause of cardiac inpatient mortality, compared to patient selection decisions (Rastan *et al.*, 2005).

[2] 'Great surgery is often much more about decisions than incisions' (Tribble and Newburg, 1998: 1).

[3] Preoperative decision making and case selection drives remarkable runs of successes such as those at Emory where only one of 1,400 consecutive patients died instead of the expected 30 to 40 (ACC/AHA Task Force on Practice Guidelines, 2004).

[4] Adding a typical cardiac surgery increases a hospital's return on assets to 5 percent from 3 percent, and to 15 percent for a specialist hospital (Hayes, Pettengill, and Stensland, 2007).

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single individual. This design feature is independent of other important structural mechanisms that seek to acquire, train, and develop firm resources. My focus on a team leadership design feature nevertheless attempts to capture the tactical (not the strategic [Teece, 2007]) orchestration of firm resources.

Depending on the team's deliverables, overall leadership may be concentrated and held by the technical specialist or by a nontechnical generalist or administrative specialist. However, responsibilities may be shared or structured so that one or more team members or committee chairs are responsible for the final outcome while others are responsible for subtasks or subcommittee deliverables, especially if these are of a very technical or specialized nature. These organizational decisions bear many of the same hallmarks as firm strategic decisions on whether a firm's CEO should simultaneously fill the board chairman's role (Iyengar and Zampelli, 2009) and the impact of heterogeneity among team members (Hambrick, Cho, and Chen, 1996). While at the firm level this is a binary and persisting decision, at the level of the individual team, these decisions may vary over teams and time. For instance, shared team leadership may comprise a series of overlapping key individuals over time as they rotate in and out of leadership positions or in and out of the team itself (Carson, Tesluk, and Marrone, 2007).

At the institutional level, this decision may be made based on considerations of accountability by the team to the organization as a whole. Governance may be simpler and more effective if one individual is identified as having sole final responsibility for all of the tasks of the team. Such governance advantages of focused leadership may also interact with competence (Makadok, 2003). If the nature of the technical task is so specialized that an administrative leader cannot reasonably understand, influence, or direct the technical specialist, then it may be more effective to split these two roles and permit distributed leadership. Such splitting of leadership between technical and administrative specialists may also be advisable when firm performance hinges on leveraging knowledge assets. Optimal use of such assets calls for effective and efficient knowledge management processes that are applied to accumulate, articulate, codify, and use knowledge assets to create value and enhance performance over time. If the relevant information or knowledge is not well codified in the institution, then it is optimal to give the worker with ownership or access to such specialized knowledge the decision rights to make optimal decisions (Kim and Mahoney, 2006).

At the level of team-institutional interfaces, co-location of the overall team leadership role with that of the technical specialist role may address more general property rights issues (Coase, 1937). For example, parochial concerns in technical functional silos for engineering reputation may be at odds with more prosaic accounting concerns. In particular, the actions of a specialist leader may be biased toward delivering technically superior solutions and away from regard for firm-wide concerns such as higher maintenance or warranty costs, more difficult customer support, and higher marketing costs. Bundling leadership and management of the team's resource management together under one specialist leader can ensure a better balance by making nontechnical matters more salient. In this manner, team resources are managed in line with firm overall imperatives under unitary team leadership.

Finally, at the level of the team itself, shared team leadership may improve trust and member commitment and better align efforts toward the common goal (Marks, Mathieu, and Zaccaro, 2001; Carson *et al.*, 2007). However, communication, coordination, and simplification of the team structure under one formal leader may ensure fewer, quicker, and clearer handoffs among team members.[5] Balancing these advantages of focused leadership is the cost of potentially burdening a specialist with ill-suited administrative responsibilities. A related cost in deploying teams in which such roles are bundled is that beneficial redundancy is reduced and slack or friction in the team structure is curtailed (Capron and Mitchell, 2009).[6]

[5] In our study setting, the specialist surgical literature documents adverse patient and hospital outcomes associated with increased handoffs and blurring of responsibility in multispecialty teams (Williams *et al.*, 2007). Greenberg *et al.* (2007) identify serious communications breakdowns as typically involving verbal communication between a dyad comprising the senior surgical staff and another caregiver.

[6] I am grateful for an anonymous referee's point that apart from a team leadership rationale for the differences in focused versus distributed teams, there may be a deeper rationale. In such a view, cost efficiencies, information transmission, and other drivers of vertical integration of complementary activities may, in turn, drive a strategic asset orchestration at the firm level (Teece 2007; Helfat *et al.*, 2007; Peteraf and Barney, 2003). In

In non-health care-related settings, an analogous decision problem on team structure would be the extent to which, say, a bench scientist performing highly technical tasks in a wet lab could or should simultaneously act as the team leader. His/her leadership of the team involves taking responsibility for a complex joint product spanning his/her own lab as well as other labs within the firm, requiring the mobilization of firm-wide resources and other administrative tasks. Focused on the sample in this study, resource management at the service delivery level is the deployment of specialist medical and hospital resources in care teams that are constituted for each patient from admission through discharge.

An attending physician (surgeon or nonsurgeon) is the overall team leader with formal and legal responsibilities for the patient and the final outcome. In particular, the attending medical officer is charged with the appropriate marshalling and mobilization of hospital resources throughout the admission and, thus, is empowered to ensure the best possible outcome is achieved for the patient. The other most important role is that of the operating surgeon, who carries out the initial operation after admission and is responsible for postoperative surgical management through discharge and thereafter. The operating surgeon leads the care team while the patient is in the operating room and has unrestricted decision-making authority while in the operating room.

In this study, I focus on the patient-by-patient decisions that are made on how to constitute the care team: is the operating surgeon simultaneously the attending physician (a 'bundled deployment' hereafter) or are these two roles split and leadership distributed across two different physicians (an 'unbundled deployment' hereafter) with one responsible for only the operative, technical part and the other responsible more globally for the entire team's end result. Based on the preceding considerations, on balance, I expect the following relationship to hold:

Hypothesis 1b: Bundled resource deployment directly and unconditionally improves a firm's total task performance.

my empirical setting and with my secondary data, distinguishing between these and other rationales is unfortunately not possible for data reasons and because the team level unit of analysis rolls up neatly to the firm level of analysis (Hitt *et al.*, 2007).

Joint impact of productive resources and resource management

Independent impacts of resources and resource management do not by themselves imply an additional joint impact. However, firm capabilities may still condition the value brought by resources (Collis, 1994; Collis and Montgomery, 1995). It has long been argued that valuable productive resources may remain unused if firms fail to deploy them appropriately or merely fail to deploy them (Penrose, 1959). Deployment ability may then be just as or more important than the value of the firm's resources (Alchian and Demsetz, 1972).

This positive interaction of capabilities with resources is definitively formalized in the dynamic capabilities stream of the resource-based view literature (Teece *et al.*, 1997; Barney, 2001; Helfat and Peteraf, 2003). Makadok (2001) diagnoses the importance of understanding positive interactions between rent creation due to the selection of productive resources and rent creation due to the building of effective capabilities. Capability building can create rents, it is argued, only if the necessary productive resources have already been acquired, while resource picking can create rents even if it only prevents the acquisition of poor resources. Makadok (2001) proposes that the marginal benefits of both of these rent-creation mechanisms are strictly positive, that there are increasing returns to capability building, and that the mixed partial derivatives are also typically positive. In the microeconomics and resource-based view literatures, the joint interaction effect of firm resources and capabilities can significantly contribute to the mean firm's performance (Milgrom and Roberts, 1995; Rivkin, 2000; Ethiraj *et al.*, 2005).

A stream of empirical results buttresses the notion that interdependencies among firm activities are generally positive interactions (Ichniowski, Shaw, and Prennushi, 1997; Carmeli and Tishler, 2004; Danneels, 2007; Ethiraj *et al.*, 2005; Morgan *et al.*, 2009; Novak and Stern, 2009; Parmigiani and Mitchell, 2009). Far less evidence has emerged to disconfirm or challenge the presence of strategic complementarities. In a study of Indian software firms, the marginal benefits to different complementary capabilities were found to change magnitude or sign as certain critical thresholds were reached (Ethiraj *et al.*, 2005). In two separate studies of sports teams, nuanced evidence of strategic complementarities has emerged. The benefits of managerial ability appear strongest at lowest levels of resource quality and less evident in firms with already superior resources (Holcomb *et al.*, 2009), but matter more under conditions of resource parity in dyadic competition contexts (Sirmon *et al.*, 2008).

In this study's empirical setting, surgeons exclusively operate inside the boundaries of a complex firm, while hospitals offer nonsurgical substitute remedies (angioplasties) to the same patients. Surgeons supply a cardiac surgical services industry with low barriers to hospital entry and substantial growth in programs. New demand for such surgical programs is met by surgeons working across multiple hospitals in a county.[7] This challenges the core resource-based view assumptions of immobility, scarcity, nontransferability, and inimitability.[8] In the sense of Miller (2003), surgical resources that were attainable by any firm were generally no longer sustainable.

These considerations inform the hypothesized joint impacts of resources and resource management. They favor position logic (Bingham and Eisenhardt, 2008) as the most promising strategic logic for sustained hospital competitive advantage. This logic does not require VRIN resources as much as the existence of interdependent, tightly linked activity systems. The stability of the cardiac surgical services market also supports the slow and deliberate fleshing out of such activity systems. Best results may accrue to technically excellent surgeons building patient care teams under their unitary control in a focused leadership form.

As shown in Figure 2, I expect the interaction of these firm activities to be complementary: the *direct* effect of one activity is higher as the level of the other activity changes. However, I do not expect that bundling technical and overall team leadership roles together can completely compensate for poor surgical skill sets. Similarly, it is unlikely that even surgical skills that are excellent at the hospital average level can compensate completely for unbundled resource deployment. The *direct* effects of interest are shown to remain under the zero line in Figure 2, regardless of the other activity's level, and my main hypotheses are, thus:

Hypothesis 2a: The effect of poorer resource quality on a firm's total task performance varies inversely with the use of bundled resource deployment.

Hypothesis 2b: The effect of bundled resource deployment on a firm's total task performance varies inversely with resource quality.

METHODS

Empirical setting

I study a specialist surgical service line—coronary artery bypass graft surgery (CABG) for the relief of blocked coronary arteries. This is the most common major surgical intervention in the U.S., while the underlying ischemic heart disease is the leading cause of death in the United States today (ACC/AHA Task Force on Practice Guidelines, 2004). A patient who requires such surgery will be admitted to a hospital under the care of an 'attending' physician. This physician—who may or may not be the operating surgeon—has staff or admitting privileges at the facility which formally allow the mobilization and coordination of hospital resources in support of the patient's treatment. The operation itself involves a team consisting of a cardiac anesthesiologist, a cardiac perfusionist, an operating cardiac surgeon, and ancillary support staff. Postoperatively the patient is cared for by the operating surgeon (providing critical care services postoperatively), an intensivist (in the intensive care unit or in a dedicated cardiothoracic intensive care unit), cardiologists, and hospitalists on the general wards in concert with nursing and ancillary service providers.

In the market for cardiac surgical services in Florida, most services are rendered by a local tertiary care center competing with approximately four other hospitals within a Hospital Referral Region (Wennberg, 1999) spanning approximately three counties. Cardiac surgical services are economically profitable service lines for hospitals and

[7] Of 306 national hospital regions, 40 percent added cardiac surgical programs from 1992 to 2003, while only 6 percent lost such programs (Wilson *et al.*, 2007). A further 30 percent of all hospitals intended to add them (Hayes *et al.*, 2007).

[8] These surgical resources are exogenously valuable to hospitals due to demand-side market imperfections. Government administered payments to hospitals in this service line are higher than average cost (Hayes *et al.*, 2007).

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they contribute to a higher general hospital reputation (Wilson *et al.*, 2007). The ratio of payments received to costs incurred is estimated at around 1.10 based on Medicare insured patients (Hayes *et al.*, 2007).

Physicians, acting as agents for their patients, select the hospital that the patient will be admitted to, moderated by patient preferences. Patients rarely pay for their services directly and their preferences are for well-known and well-regarded hospitals close to home. Clinical excellence (patient-level outcomes of admissions and interventions) drives local and regional competition for potential patients; costs drive contractual negotiations with third-party payors.

Sample

The firms studied in the present article are the 75 state-regulated hospitals performing cardiac surgery in Florida from the first quarter of 1998 to the last quarter of 2006. Federally regulated (e.g., Veteran's Affairs) and prison hospitals are not observed. Ownership and management of these hospitals falls into four main categories. Large national corporate chains operate 26 hospitals on a for-profit basis, including 20 operated by national leader HCA and 4 by Tenet.

The remaining 49 non-profit hospitals comprise community, religious, and government-operated hospitals. There are 28 community hospitals operated on a not-for-profit basis by standalone or small, local networks. Typically these hospitals arose out of local community needs in the middle of the last century and include players such as Shands Healthcare, Mt. Sinai Medical Center, and the Wuesthoff Medical Centers. I distinguish 12 hospitals managed and owned by non-profit foundations with an explicit religious mission. These include the Catholic mission hospitals of Catholic Health East, the Baptist mission hospitals of Baptist Health South, and the Adventist religious hospitals. Finally, nine non-for-profit hospitals are operated by a city, county, or state authority. In total, my panel data contains 2,262 observations on hospital*quarter dyads, which represent the aggregation of a total of 165,596 observed nonvalve, primary coronary artery bypass graft operations performed by 341 surgeons. A series of exclusion restrictions and data validation leading to that set of admissions and surgeons is further described in the Appendix.

Dependent variables

Performance heterogeneity in this industry is well documented by regulators, patients, and payors. Competition is well defined in relatively small geographical areas, due to patient preferences and the underlying medical condition. Customers seek out hospitals and their surgeons based on non-price attributes (e.g., historical in-hospital outcomes, skills, distance), while payors negotiate prospectively with hospitals. The financial leverage inherent in these payment structures concentrates attention on in-hospital costs and market share, while hospitals' outcomes are proxies for reputation. All firm performance metrics are calculated at hospital*quarter level and are chosen to best reflect the appropriate dependent variable (Ray, Barney, and Muhanna, 2004).

Patient outcomes

I also measure three aggregated patient outcomes at the hospital level. Since the proxies for surgical resource quality are recovered from patient-level mortality models, I mitigate the risk of specifying a tautological relationship by not using mortality as a hospital performance dependent variable (Priem and Butler, 2001).

First, I include the *patient-weighted average length of stay*, since this directly affects both patient experience and hospital costs and minimizing the length of stay is a key hospital objective. I then use two variables that are related to the substantial risk of nonfatal complications in this operation and which, thus, contribute to a hospital's reputation as well as indirectly increase hospital costs. As many as 3 percent of patients suffer strokes (possibly due to aortic plaque dislodged during surgery) and around 2 percent experience kidney damage (possibly as a result of perfusion inflammation) severe enough to require dialysis. A further 3 percent survive a prolonged chest wall wound site infection (ACC/AHA Task Force on Practice Guidelines, 2004).

Accordingly, I compute the *average proportion of live discharges who were not allowed home under self-care*. Live discharges may be transferred to a subacute hospital or skilled nursing facility for extended convalescence or rehabilitation. They may also be allowed to go home, conditional on receiving skilled nursing help at home or visitations for injections of intravenous

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medicines. I also calculate the *average proportion of patients who required prolonged mechanical ventilation* exceeding 96 hours in intensive care. This is usually the result of complications (e.g., strokes) sustained intraoperatively or postoperatively or illness severity preoperatively (e.g., severe heart attack).

I also measure *market share in cardiac surgical services* by computing the volume of patients admitted as a fraction of the volume performed by all hospitals in the 18 local HRRs in Florida. The HRR dimensions are computed from extensive analysis of Medicare travel patterns for tertiary health care. In my data, three of 18 HRRs had only one hospital throughout the entire nine-year panel,[9] while the mean number of competing hospitals within a HRR was nearly 5. To understand whether share changes were due to competitor effects or own effects, I also use *CABG patient volumes* as an ancillary dependent variable.

Finally, I additionally measure average claimed hospital charges which are deterministically related to actual costs for admitted cardiac surgery patients. Regardless of government entitlement payor (e.g., Medicare) or commercial payor (e.g., Blue Cross HMO), or a blend such as the Medicare managed care plans, reimbursements are almost always prospectively negotiated contractual payments. This enforces rigorous cost control and process efficiency at hospitals. Direct hospitals costs typically contribute 62 percent of these costs in the form of patient care labor and patient care materials (Eisenberg *et al.*, 2005), suggesting variable decisions made during an admission have a meaningful impact on total charges.

I do not measure profitability from the service line since competitive advantage may not be manifested in better firm financial performance (Coff, 1999). For example, in physician-owned hospitals, it is especially likely that unobserved rent appropriation by above-average surgeons may prevent analysts from observing sustained above-average hospital financial performance.

Independent variables

Surgical resource quality proxies for *productive resource quality* and is operationalized by risk-adjusting actual surgeon outcomes for preexisting patient risk, following Huckman and Pisano (2006). In this approach, the number of observed deaths and total cases is used to first calculate the observed mortality rate over the prior quarter for each surgeon. Subsequently a probit regression on each patient's discharge status (alive or dead) is used to estimate each patients' expected mortality, taking into account demographics (age, gender, race) and preexisting health factors (diagnosis covariates) and other procedures undertaken during the patient's admission (procedure covariates, see Controls section later), and year of admission. The fitted values from this risk model are then aggregated for each surgeon, allowing computation of an expected mortality rate.

Finally, again following Huckman and Pisano (2006), the quotient of the observed and expected mortality rates is standardized by multiplying by the quarter's overall panel average mortality. This risk-adjusted mortality rate (RAMR) is computed for each surgeon for the preceding quarter and then the patient-weighted average of each hospital's surgeons is computed as the focal independent variable of surgical resource quality for the prior quarter. This percentage mortality figure ranges from 0 to more than 10 percent for high-risk cases. In line with H1a, higher values of mortality are expected to be associated with poorer hospital performance.

I operationalize *bundled deployment capability*, the resource management capability of interest, by observing for each patient admitted for cardiac surgery the type of patient care team that was constituted by the hospital. I observe whether the team had focused (bundled resource deployment) or distributed (unbundled) leadership, as each patient record documents attending and operating physician identifiers. This binary variable at the patient admission level aggregates up to a fraction at the hospital level. Specifically, at the hospital level I compute patient-weighted average utilization of the bundled deployment form for each hospital*quarter. This proportion ranges from 0 to 1. I then use the complement of this proportion in the analyses of hospital performance (i.e., the proportion of unbundled teams). In line with H1b, higher values of the proportion of unbundled deployment care teams are expected to be associated with worse performance. Together with the measure of

[9] These hospitals contribute to a conservative bias toward the null in models with market share as dependent.

resource quality, higher values of their multiplicative interaction effect are expected to be worse for performance, in line with H2a and H2b. Aggregating binary decisions in this way has important implications and limitations. In interpreting regression coefficients based on aggregates, it is not always clear what changes at the individual level correspond to the unit changes at the aggregate level. Well-known limitations of such aggregation include the ecological fallacy (Robinson, 1950), which consists of assuming that an observed relationship at the group (i.e., hospitals) level necessarily holds for particular individuals (i.e., particular surgical teams). To accommodate these limitations in this study, I restrict inference to the group level, rather than seek to attribute results to particular individuals.

Control variables

Substantial patient heterogeneity includes differing degrees of illness severity (e.g., elective versus emergent presentations to hospital) and varying preexisting health status that can independently affect outcomes. To control for these, I used comorbidity classification software from the Agency for Healthcare Research and Quality. There is also substantial surgical process heterogeneity, and I coded differences in the techniques used to revascularize blocked arteries (e.g., use of arterial or venous material for bypass grafts), as well as differences in the techniques used to support the patient's vital systems intraoperatively (e.g., on-pump perfusion versus off-pump). Finally, hospital characteristics included as control covariates were 'teaching hospital' and 'adult open heart hospital' designations, dummies for ownership status, proxies for CABG focus (proportion of all admissions that were CABG related, and ratio of surgical CABG admissions to medical PTCA admissions), proportion of patients insured by Medicare or commercial managed care (health maintenance organizations and preferred provider organizations) and proxies for hospital scale (beds number and yearly admissions) that plausibly drive hospital performance independent of resource quality or manner of deployment.[10]

[10] Standard tests for multicollinearity in ordinary least squares regressions did not reveal variance inflation factors (VIF) greater than 4 (mean VIF 1.41, maximum VIF 3.96).

Model specification and estimation

I construct a time series cross-sectional panel data set with the hospital, h, as the panel unit and the calendar quarter as time unit, t. I specify firm performance, y, as a function of the focal independent variables and their multiplicative interaction. Included are aggregated control variables and calendar year dummies (1998 being the omitted variable). In preliminary analyses, the Durbin-Wu-Hausman test was nonsignificant. Accordingly, I specify a random effects panel regression: $y_{h,t} = \alpha + \beta X_{h,t} + \mu R_{h,t} + \nu B_{h,t} + \theta R_{h,t}{*}B_{h,t} + \eta\mu_t + \varepsilon_{h,t}$

The hospital-level control variables $X_{h,t}$ represent time-invariant hospital-specific factors, such as hospital type, ownership type (not-for-profit being the omitted variable), and specialization in CABG surgery, as well as time-varying aggregates of patient characteristics (demographics, risk, types of insurance status) and time-varying variables indicating scale (e.g., beds, yearly admissions).

Independent variables are the hospital's average surgical resource quality variable, $R_{h,t}$, as measured by average quarter-lagged risk-adjusted mortality, and the average proportion of admissions served in the unbundled care team form, $D_{h,t}$, and their multiplicative interaction effect. For the favorable dependent variable (market share), the signs of the to be estimated parameters μ, ν, and θ are expected to be negative (e.g., the marginal effect of worse quality reduces market share).

Conversely, for unfavorable dependent variables (charges, complications), the signs are expected to be positive (e.g., the marginal effect of worse quality increases complications). I use Stata v11's *xtreg, re* command to estimate the panel model, specifying robust standard errors clustered by treating hospital in all models to account for potential correlation of patient outcomes within hospital units.

Direct effect plotting

Regression estimates of the parameters for the focal variables of interest present two interpretation difficulties. First, the true marginal effect on y of B, say, comes from a direct effect captured in the estimated coefficient ν, as well as an indirect effect through its role in the multiplicative interaction R*B. Thus, the parameter ν is equivalent

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to the total marginal effect only if the interaction effect is zero.

Second, the indirect effect of B through the interaction will vary with different levels of R, yet the regression estimate of θ is at the means of all covariates, including at the mean of R. Thus, the estimated marginal effect of the independent variable B does not reveal its change with changes in the level of the other focal independent variable, R.

To address these problems, I report both the regression estimates of μ, ν, and θ at the means of all covariates as well as the average marginal effects. The latter are first calculated for each hospital*quarter observation using the particular values of B and R for that record, then averaged across all records using Stata's *margins* command. Each of these average marginal effects, thus, better incorporates the direct and indirect effects of the independent variable of interest. Additionally, for ease of interpretation, I plot the marginal effect of each focal variable as a continuous line over the range of the other variable (Brambor, Clark, and Golder, 2006). The point estimates of dy/dB at each level of R are calculated using the parameter estimates $dy/dB|_R = \nu + \theta R$, while in an analogous manner, I compute the point estimates of dy/dR at each level of B. I also compute and plot the 95 percent confidence intervals for these point estimates in a similar fashion. The 95 percent confidence limits for the marginal effect dy/dB at each level of R, for example, use the estimated variance as follows: $dy/dB|_R \pm 1.96*[var(\nu) + (R^2)*var(\theta) + 2R*cov(\nu,\theta)]^{1/2}$. Only point estimates whose 95 percent confidence limits lie entirely below or entirely above the zero line represent a marginal effect statistically significantly different from zero.

RESULTS

From January 1, 1998 to December 31, 2006, a total of 165,596 nonvalve, primary coronary artery bypass graft cases were performed at 75 state-regulated facilities in Florida by 341 surgeons completing residency before 1998. The average in-hospital mortality rate across facilities, surgeons and time was 2.85 percent, and 2.49 percent of all patients were mechanically ventilated for longer than 96 hours. The average patient spent 9.6 days in hospital, with 15.6 percent of live discharges to destinations elsewhere than home. Table 1 contains summary statistics and pairwise correlations for key firm-level dependent, independent, and control variables.

I turn to the hypotheses of independent effects first. In H1a and H1b, it was predicted that worse quality surgical productive resources and higher utilization of an unbundled resource deployment model would each independently negatively impact hospital performance.

Table 2 reports results from the regression on hospital market share. Focal variables of interest are entered sequentially and model fit and explanatory power appear adequate. In the row labeled 'marginal effect at the means of covariates' and the central column, the coefficient of −0.11 ($p < 0.05$) on resource quality has the following interpretation: a one-unit change in the weighted average lagged surgical quality of the surgeons employed in a hospital from 0 to 1 reduces market share by 11 percentage points. In terms of plausible changes in resource quality, a one standard deviation rise in mortality of 3 percentage points from the mean mortality of 2.9 percent (Table 1) is estimated to be associated with a 0.3 percent fall in market share. Similarly, the coefficient of −0.05 ($p < 0.05$) on the resource management variable implies that a one standard deviation increase of 33 percentage points in the proportion of unbundled care teams is estimated to be associated with a fall of 1.7 percentage points in CABG patient market share. After the interaction term is added, however, the marginal effect of resource quality at the means of all covariates loses significance.

As I have discussed, these regression estimates are unsatisfactory if substantial interaction effects exist (especially if these are asymmetric around the covariate means). Averaging each record's estimated marginal effect is the more informative estimate, and in the row labeled 'marginal effects averaged over all obs,' the average marginal effects are of the expected sign and significant at $p < 0.05$.

To test H2a and H2b on the joint effects of resource quality and resource management, I turn to the coefficient on the interaction term. The point estimate has an unexpectedly positive sign of +0.05, but is statistically indistinguishable from 0. This unexpected finding suggests that the two firm activities do not interact to affect performance. However, this conclusion is again based on averaged marginal effects. To understand

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Table 1. Descriptive statistics and correlations (selected variables)

Variable	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Mkt share	0.29	0.26													
2 Length of stay (days)	10.4	7.4	(0.17)												
3 Ventilated > 96 hr	0.03	0.08	(0.12)	0.56											
4 Not discharged home	0.21	0.17	(0.10)	0.34	0.33										
5 Total charges ($)	101,283	67,235	(0.24)	0.79	0.49	0.32									
6 Unbundled deployment	0.54	0.33	(0.36)	0.21	0.12	0.05	0.33								
7 Patient mortality by surgeon (%)	2.9%	3.0%	0.03	0.00	0.00	(0.04)	(0.07)	(0.02)							
8 Interaction of above two	0.02	0.02	(0.14)	0.09	0.04	(0.03)	0.09	0.47	0.69						
9 Not for profit	0.34	n.m.	(0.01)	0.09	0.10	0.19	(0.08)	(0.22)	(0.02)	(0.12)					
10 Government	0.13	n.m.	0.14	(0.02)	(0.04)	(0.13)	(0.09)	(0.26)	(0.04)	(0.15)	(0.27)				
11 Religious	0.18	n.m.	(0.03)	(0.04)	(0.03)	(0.17)	(0.10)	0.11	0.09	0.14	(0.33)	(0.18)			
12 For-profit	0.36	n.m.	(0.06)	(0.04)	(0.05)	0.04	0.22	0.31	(0.02)	0.11	(0.53)	(0.29)	(0.35)		
13 Facility volume (CABG patients)	101	78	0.38	(0.13)	(0.14)	(0.17)	(0.26)	(0.03)	(0.03)	(0.03)	(0.03)	0.08	0.16	(0.15)	
14 Surgeon cases (CABG patients)	38	16	0.08	(0.01)	0.02	(0.07)	(0.17)	0.08	0.05	0.09	(0.12)	(0.01)	0.19	(0.03)	0.43

n = 2,262 hospital*quarter observations for all variables
Patient-weighted pooled statistics; proportions (unless otherwise indicated)
|correlation— > 0.04 significant at $p < 0.05$; —correlation— > 0.06 significant at $p < 0.01$

Table 2. Panel hospital-level analyses: independent and joint impact of surgical resource quality and unbundled resource deployment on hospital CABG market share

		Hospital quarterly performance: CABG market share			
Intercept		0.26	0.26	0.29	0.29
		(0.23)	(0.23)	(0.22)	(0.22)
Calendar year dummy variables		Included in all models			
Patient characteristics	Unstable angina	0.02	0.02	0.01	0.01
		(0.02)	(0.02)	(0.02)	(0.02)
	Acute myocardial infarction (ratio)	0.01	0.00	0.00	0.00
		(0.03)	(0.03)	(0.02)	(0.02)
	On-pump operation (ratio)	−0.02	−0.01	−0.01	−0.01
		(0.02)	(0.02)	(0.02)	(0.02)
	Double mammary artery use (ratio)	0.00	−0.01	−0.01	−0.01
		(0.05)	(0.05)	(0.05)	(0.05)
	Single mammary artery use (ratio)	0.01	0.01	0.02	0.02
		(0.03)	(0.03)	(0.03)	(0.03)
	Medicare (ratio)	−0.03	−0.03	−0.03	−0.03
		(0.03)	(0.03)	(0.03)	(0.03)
	Managed care (ratio)	0.00	0.00	−0.01	−0.01
		(0.03)	(0.03)	(0.03)	(0.03)
Hospital controls	Government ownership (1/0)	−0.03	−0.03	−0.04	−0.04
		(0.13)	(0.13)	(0.13)	(0.13)
	Religious not-for-profit (1/0)	−0.09	−0.09	−0.08	−0.08
		(0.11)	(0.11)	(0.11)	(0.11)
	Corporate for-profit (1/0)	−0.05	−0.05	−0.03	−0.03
		(0.10)	(0.10)	(0.09)	(0.09)
	Teaching hospital (1/0)	−0.11	−0.11	−0.12	−0.12
		(0.17)	(0.17)	(0.16)	(0.16)
	'Adult openheart hospital' (1/0)	0.03	0.04	0.04	0.04
		(0.19)	(0.19)	(0.18)	(0.18)
	Facility beds (#)	0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)
	CABG to all admissions (ratio)	4.09	4.08	3.75	3.75
		(5.38)	(5.38)	(5.28)	(5.28)
	PTCA to CABG admissions (ratio)	−0.03	−0.03	−0.03	−0.03
		(0.03)	(0.03)	(0.03)	(0.03)
	Total yearly admissions ('00,000s)	0.71	0.72	0.65	0.65
		(0.66)	−0.66	−0.64	−0.64
Marginal effects (at covariate means)	Resource quality: patient mortality by surgeon (ratio)		−0.11*	−0.11*	−0.13
			(0.05)	(0.05)	(0.10)
	Resource deployment: unbundled teams (ratio)			−0.05*	−0.05*
				(0.03)	(0.03)
	Resource quality X resource deployment				0.05
					(0.16)
Marginal effects (averaged over all obs)	Resource quality: surgeons' mortality (ratio)		−0.11*	−0.11*	−0.10*
			(0.05)	(0.05)	(0.05)
	Resource deployment: unbundled teams (ratio)			−0.05*	−0.05*
				(0.03)	(0.03)
Model fit	R^2 (overall)	11%	11%	17%	17%
	Wald test	41.7***	50.8***	65.3***	66.3***

Panel random effects using GLS with robust s.e. clustered by hospital. (¶)p < 0.10. (*) p < 0.05, (**) p < 0.01), and (***) p < 0.001 estimated significance. 2,262 firm*quarter observations, 75 hospitals. Negative coefficients imply unfavorable effect.

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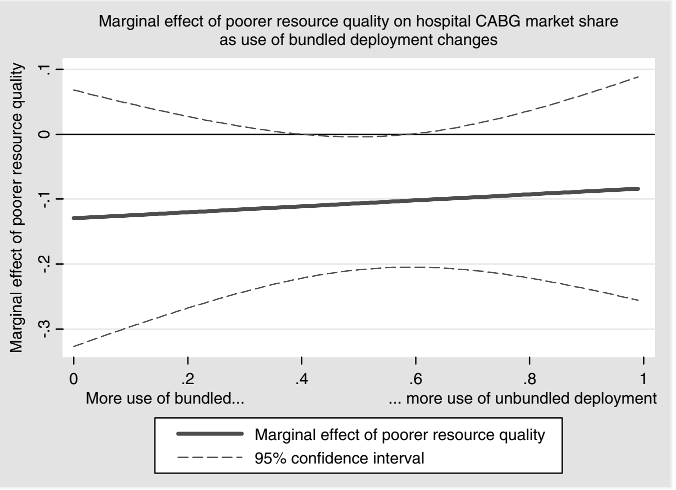

Figure 3. As hospitals deployed < 40 percent or > 60 percent teams bundling surgicaland leadership resources, the negative impact of poorer surgical resource quality on market share became indistinguishable from zero

and visualize these marginal effects better as a response surface rather than as point estimates requires the effects to be plotted.

In Figure 3, I plot the estimated negative marginal effect of poorer resource quality on hospital market share as the extent of the use of bundled resource deployment changes over its range from 0 to 1. Confirmation of H1a is again seen in that the point estimates of the marginal effects of poorer resource quality are uniformly negative regardless of the extent of use of the bundled resource deployment model.

I had hypothesized in H2a that the combination of poorer surgical resource quality and a care team with a less streamlined, more distributed leadership would be unambiguously *more* negative for hospital performance. Graphically, a strongly downward sloping curve was expected. However, reflecting the insignificant regression estimate of the coefficient θ on the interaction term, a flat marginal effect was found over the range of different values for the use of the bundled deployment model. This again suggests that rather than being complements, resource quality and bundled deployment are neutral with respect to each other's effect on hospital performance.

The other key finding in Figure 3 is that the 95 percent confidence limits around the point estimates of resource quality marginal effects are only entirely below the zero line in a central critical area. To reconcile this with the significant point estimates at the mean, note (see Table 1) that the mean proportion of unbundled deployment team is around 0.53 and, thus, in the central critical area. The marginal effect of resource quality is indistinguishable from zero for hospitals that deploy fewer than ~40 percent or more than ~60 percent of patient care teams using the focused leadership model in which the surgeon is both operating room leader and overall team leader. This finding is unlikely to be due to a low number of observations inflating confidence intervals: Appendix Figure A5 reports a large mass of observations in both tails of range of the empirical distribution. This suggests instead the following *post hoc* interpretations based on boundary conditions: for hospitals that are not consistently using one or the other resource deployment model, the marginal effect of poor resource quality appears negative and precisely estimated. But for hospitals that are predominantly using one of the two resource deployment models, the actual impact of resource quality is small and imprecisely estimated.

Figure 4 show the analogous plot of the changes in estimated marginal effect of unbundled resource deployment on hospital market share with changes in resource quality. Once again, visual confirmation of H1b and the independent negative impact of using unbundled resource deployment is evident. H2b was not confirmed, as the expected negative slope of this line was not found.

As with the previous estimates in Figure 3, there appear to be boundary conditions on the marginal effect in Figure 4. For values of (worse)

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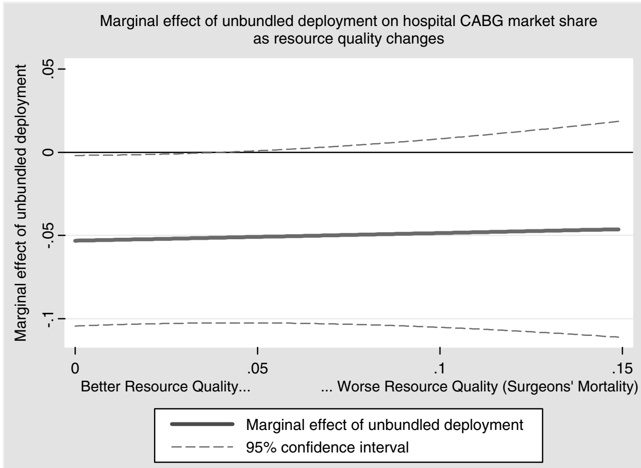

Figure 4. As surgical resource quality worsens beyond a critical value of resource quality (inpatient mortality > 5 percent), the negative impact of unbundled resource deployment on market share became statistically indistinguishable from zero

resource quality that exceed a inpatient mortality of 5 percent in the prior quarter as a patient-weighted average across all surgeons in the hospital, the marginal effect of unbundled resource deployment is indistinguishable from zero. A similar interpretation is that once resource quality deteriorates beyond a certain critical value, the extent of use of a particular resource deployment model becomes irrelevant. The first set of findings has focused exclusively on hospital cardiac surgery market share.[11]

I now turn to another key determinant of hospital success: cost control. Most reimbursements or payments to hospitals are prenegotiated (by private insurers) or predetermined (by Medicare) based in large part on a particular type of procedure (e.g., cardiac surgery on two vessels). The financial leverage implicit in fixed payments and highly variable costs makes cost control vital. In Table 3, I examine the impact of the two variables of interest on claimed charges, which are deterministically linked to actual resource use (e.g., bed days, consumables, injectables, nursing services., etc., in the operating room and on the wards).

These results support H1b only: there was strong evidence for an independent impact of the extent of use of unbundled resource deployment. Unexpectedly, no evidence was found that poor resource quality impacted hospital costs nor of any interaction between surgical skill set quality and the particular manner of deploying the patient care teams. Figures 5 and 6 confirm this graphically. I note that unlike in the previous measure of hospital performance, there were no boundary conditions on the marginal effects.

I relegate to the Appendix Table A1 analogous results for the dependent variables of patient length of stay, patient volumes, prolonged mechanical ventilation, discharge destination, and length of stay. I summarize all hospital performance metrics in Table 4.

This overview shows that in this empirical setting there is reasonably consistent evidence for the independent value of a particular resource deployment model, only inconsistent evidence for such value in terms of resource quality, and no formal evidence at all for interaction effects between resource quality and resource management models. As with, for example, market share, additional but inconsistent evidence for boundary conditions on the marginal effects of one independent variable at the extreme(s) of the other were also found (see Appendix figures for additional graphical detail).

DISCUSSION

This article's results drive several conceptual and practical conclusions. My overriding objective was

[11] Market share findings are supplemented with hospital patient volume analysis (later). This takes into account the differing implications of a change in share based on overall market growth or relative market share.

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Table 3. Panel hospital-level analyses: independent and joint impact of surgical resource quality and unbundled resource deployment on ||hospital CABG charges (costs)

		Hospital quarterly performance: CABG charges ($)			
Intercept		35,202 (42,365)	37,068 (42,822)	26,653 (38,884)	26,583 (38,989)
Calendar year dummy variables		Included in all models			
Patient characteristics	Unstable angina	10,941 (8,511)	10,665 (8,374)	11,667 (7,966)	11,658 (7,875)
	Acute myocardial infarction (ratio)	62,714 * (27,073)	63,948* (27,191)	64,065* (27,479)	64,047 (27,537)
	On-pump operation (ratio)	−6,204 (17,865)	−6,970 (18,163)	−8,830 (18,089)	−8,773 (18,168)
	Double mammary artery use (ratio)	−49,844 (47,429)	−50,311 (49,349)	−52,152 (49,044)	−52,370 (49,031)
	Single mammary artery use (ratio)	1,833 (20,366)	2,554 (20,830)	1,864 (20,479)	1,702 (20,764)
	Medicare (ratio)	37,383 (32,381)	37,542 (32,420)	36,921 (32,264)	36,762 (32,671)
	Managed care (ratio)	16,012 (22,662)	15,272 (22,747)	14,101 (22,332)	13,920 (22,629)
Hospital controls	Government ownership (1/0)	15,269¶ (8,798)	15,067¶ (8,813)	22,485** (8,073)	22,480** (8,074)
	Religious not-for-profit (1/0)	18,634¶ (10,136)	18,686¶ (10,388)	16,019¶ (8,730)	16,068¶ (8,749)
	Corporate for-profit (1/0)	51,391*** (6,826)	51,917*** (6,906)	45,238*** (7,705)	45,240*** (7,703)
	Teaching hospital (1/0)	17,273 (11,973)	17,376 (12,181)	24,657* (12,013)	24,631 (12,025)
	'Adult openheart hospital' (1/0)	−45,032 (41,726)	−46,004 (42,340)	−46,909 (36,968)	−46,989 (36,951)
	Facility beds (#)	49 (42)	49 (42)	19 (38)	19 (38)
	CABG to all admissions (ratio)	−564,630 (405,258)	−562,349 (413,837)	−411,265 (406,833)	−411,252 (406,153)
	PTCA to CABG admissions (ratio)	1,883 (3,814)	1,923 (3,893)	2,507 (3,715)	2,500 (3,711)
	Total yearly admissions ('00,000s)	−0.6 (0.6)	−0.6 (0.7)	−0.2 (0.6)	−0.2 (0.6)
Marginal effects (at covariate means)	Resource quality: patient mortality by surgeon (ratio)		−13,269 (19,080)	−14,711 (18,524)	−1,010 (36,080)
	Resource deployment: unbundled teams (ratio)			29,465*** (8,532)	30,285*** (8,328)
	Resource quality X resource deployment				−30,805 (71,268)
Marginal effects (averaged over all obs)	Resource quality: surgeons' mortality (ratio)		−13,269 (19,080)	−14,711 (18,524)	−17,652 (19,639)
	Resource deployment: unbundled teams (ratio)			29,465*** (8,532)	29,374*** (8,600)
R^2 (overall)		49%	49%	53%	53%
Wald test		655***	664***	780***	807***

Panel random effects using GLS with robust s.e. clustered by hospital. (¶)p < 0.10. (*) p < 0.05, (**) p < 0.01), and (***) p < 0.001 estimated significance. 2,262 firm* quarter observations, 75 hospitals. Negative coefficients imply unfavorable effect.

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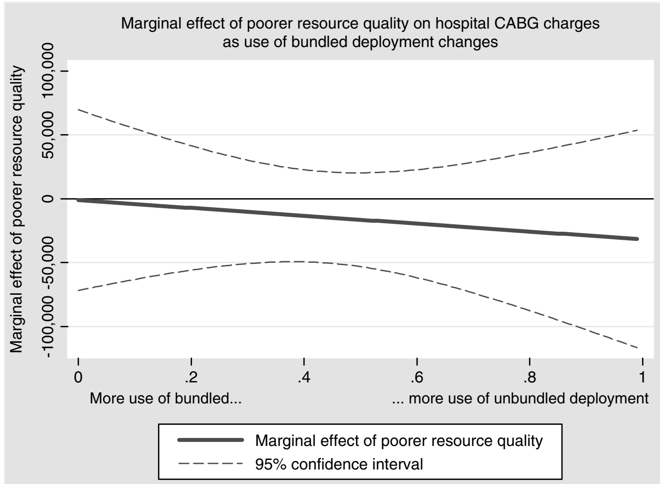

Figure 5. The effect of resource quality on hospital CABG patient costs was indistinguishable from zero regardless of the extent of use of bundled care teams.

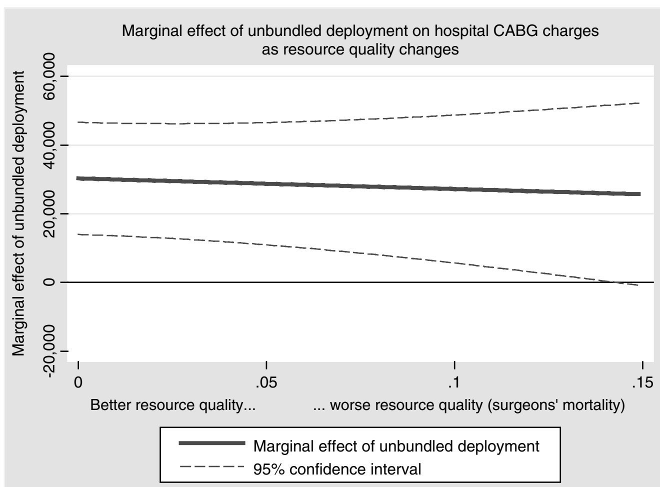

Figure 6. Over almost the entire range of surgical resource quality, use of the unbundled team model was associated with higher costs

to understand whether a common misconception of resource-based theory could be refuted empirically. Although the *independent* impacts of particular firm resources and deployment capabilities on firm performance is an unambiguous cornerstone of the strategy field, it is commonly assumed that their *joint* impacts are also positive or synergistic.

Empirically, this study provides partial confirmation of these key constructs in the resource-based view, partly addressing the concerns of Newbert (2008) and Priem and Butler (2001). Although the plausible assumption was made of some degree of positive association between hospital performance and hospital productive resource quality or between hospital performance and hospital resource deployment model, the empirical evidence summarized in Table 4 shows far more nuanced findings. In particular, results for the independent impacts of firm activities on firm performance were sensitive to the particular measure of hospital performance evaluated. *Ex ante* I expected both care team resource quality and the manner of care team deployment to strongly affect each measure of hospital performance. While the particular form of patient care team deployment under a focused, unitary leadership appeared most consistently associated with better performance, there was no impact on the directly unfavorable

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Table 4. Summary of independent and joint impacts of surgical resource quality and bundled resource deployment on hospital ||performance measures

CABG-related hospital performance	Direct effect of poorer resource quality	Direct effect of poorer resource deployment	Multiplicative interaction effect	Boundary conditions
Market share	Unfavorable	Unfavorable	n.s.	Resource quality n.s. at extremes of resource deployment styles; resource deployment n.s. at very poor resource quality
Patient volume	Unfavorable	Unfavorable	n.s.	Resource quality n.s. at extremes of resource deployment styles
Claimed charges	n.s.	Unfavorable	n.s.	None
Length of stay	n.s.	Unfavorable	n.s.	Resource deployment n.s. at very poor resource quality
Prolonged post-op ventilation	Unfavorable	n.s.	n.s.	Resource quality n.s. at extremes of resource deployment styles
Discharged, not home	n.s.	n.s.	n.s.	None

Direct effects are marginal effects averaged over all observations; 'unfavorable' indicates decreased share and volume, increased claimed costs, longer length of stay and a higher likelihood of prolonged ventilation and discharge elsewhere than home under self-care. In all cells, estimated significance at $p < 0.05$ or better, unless not significant (n.s.)

patient outcomes of prolonged mechanical ventilation or discharge to convalescent homes or hospice care instead of straight home.

However, this study conclusively failed to find evidence for a *joint* impact of firm resources and resource deployment models on firm performance. My prespecified hypothesis was that resource quality and manner of deployment would interact synergistically and both would significantly and positively affect hospital performance. The present study failed to document such formal complementarities. For the average firm in this particular industry setting, there were no synergies at all between controlling high quality resources and implementing and maintaining focused leadership in the patient care teams that included such resources. Whether this absence was due directly to the presence or absence of particular firm activities or whether these results were obtained through more indirect mechanisms is not distinguishable in this study. The particular mechanism(s) underpinning the different results summarized in Table 4 are manifold, but not further discussed for lack of clear support and space.

While I failed to find such formal complementarities, some results suggested that at very poor levels of resource quality, the marginal effect of differing levels of use of the better deployment method was insignificant. Similarly, at the extremes of use of the better deployment method, some results showed that the marginal effect of poor resource quality was less significant. These boundary conditions should not be considered true interactions and may simply represent local limitations on feasible combinations of resource quality and deployment models in this industry.

Taken together, this study supports the conclusion that it is an erroneous inference that firm activities tend to be synergistic and that managers may add value by identifying and exploiting such synergies. This misconception appears to have predated the RBT and may have arisen in works as early as those of Penrose (1959), Chandler (1962), and Alchian and Demsetz (1972), but has also been echoed in research (Amit and Schoemaker, 1993; Collis and Montgomery, 1995; Teece *et al.*, 1997; Eisenhardt and Martin, 2000; Peteraf and Reed, 2007) built on the seminal RBT works (Barney, 1986, 1991; Peteraf, 1993; Wernerfelt, 1984).

Thus, this study adds concerns raised by a small, emerging body of research that interactions among firm activities may not always be positive or even neutral, and that boundary conditions on such interactions may exist (Newbert, 2008). Ethiraj *et al.* (2005) examined Indian software firms and found the marginal benefits to different, seemingly complementary capabilities were found to change magnitude or sign as certain critical thresholds were reached. Using different methods, Sirmon *et al.* (2008) investigated similar phenomena in sporting teams, finding the benefits of managerial ability to matter more under conditions

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of resource parity in dyadic competition contexts. Further, caveats on the complementarities between resources and capabilities were found by Holcomb *et al.* (2009). They found that the benefits of sports team managerial ability appear strongest at lowest levels of resource quality and less evident in firms with already superior resources. This study's findings complement these empirical investigations, albeit at different levels of analysis, and with the additional strong caveat of the uniqueness of the empirical setting here.

The practical implications for managers of the average firm center on optimal configuration of firm activities. This study finds that widespread anecdotal assumptions on the value of a hospital's productive resources and the value of particular resource deployment in a focused leadership care team cannot be objectively and consistently established in robust analyses.

Similar assumptions on the synergy between better caregivers and better care processes are widespread in the health care industry. For example, the use of preoperative checklists in surgery has been widely held up as an example of ensuring that all team members are aligned with patient care goals (Gawande, 2007; Hales and Pronovost, 2006).[12] Checklists are thought to be able to compensate for lower quality or fewer productive resources, especially in resource-poor contexts (Lingard *et al.*, 2008). Managers in the tertiary health care services industry anecdotally hold such assumptions to be plausible and justify organizational changes by appeals to such synergy.

If managerial assumptions on independent and joint impacts of particular firm activities do not generally survive empirical confirmation, then firm strategy may be flawed in conception and not achieve the desired results in execution. Investments in either strengthening resource quality and refining resource deployment capabilities are very likely characterized by diminishing returns. If investments in such a capabilities production function are justified by claimed synergies when none actually exist, then firms are not allocating investments optimally in a technical efficiency sense.

A related conceptual problem was raised by Siggelkow (2002) who discusses the costs to a manager of misidentifying negative interactions between firm activities for positive ones. This present study suggests that mistaking mere interdependencies (i.e., neutral interactions) for complementarities interactions may entail similar strategic costs. Such costs arise because a firm with well-fitting and interdependent firm activities but without strong evidence for positive interactions cannot receive unambiguous advice on optimal configurations of firm activities.

Note that monotone comparative statics techniques reward the assumption of positive interactions or complementarities with the powerful ability to sign the firm impact of a change in a key input (Milgrom and Roberts, 1990; Topkis, 1995a, 1995b). Unfortunately, these results hinge on knife-edge assumptions. They form the weakest set of assumptions that allow monotone results (Rivkin, 2000), but require all inputs to be pairwise strategically complementary with all other inputs to ensure that the effect of increases in a key input can be signed.[13]

Since a firm's production function is unobserved, understanding of the relationships between inputs and firm objective functions depends almost completely on empirical observation. Even plausible assumptions of positive independent effects and complementarity between firm activities require confirmation. Such confirmation is not often attempted and, as the present study finds, the results may neither be obvious nor anticipated.

Limitations

External validity may be limited, although I have argued that this setting is analogous in general to other industries in which strong technical skills, team production, and choices of roles are germane. For example, biopharmaceutical R&D teams have similar decision problems in team leadership. Plausible candidates include bench scientists performing highly technical skills in a wet lab, but also with the potential ability and right to lead the larger team and provide additional administrative leadership in a bundled deployment role. Internal validity is limited by the lack of data on other team members (e.g., cardiologist,

[12] Specifically, that the right operation is being performed at the right site of the right patient.

[13] The firm's base demand function must also be supermodular in all its arguments for monotone comparative statics techniques. Thus, for example, 'at higher quality levels, the quantity demanded is more sensitive to price changes' (Milgrom and Roberts, 1995: 521), an assumption that anecdotally does not seem to be uniformly valid.

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anesthesiologist, intensivist) involved in pre- and postoperative care.

More generally, I have specified and estimated models assuming a causal relationship between firm activities and firm performance. These models are robust to time-invariant, but not to time-varying, omitted variable biases. The latter could be the result of underlying unmeasured confounders (e.g., learning) driving both hospital performance and choices of resource quality or resourced deployment. An example of such a limitation of the models employed in this study is the implicit lack of strategic decision making on the part of the key productive resources of interest in hospitals.[14] Cardiac surgeons clearly have options to affiliate with particular hospitals, and hospitals may select a particular deployment method for the patient care teams of a particular surgeon to take into account the preferences of that surgeon. In this study, controlling for ownership type may have limited such unobserved selection effects.

CONCLUSIONS

Resource-based theory as originally conceived does not require resources and resource management to be highly complementary. This has become an inference that is commonly made, despite the views of Peteraf (1993) and Barney (1991) that resources alone (such as a highly productive R&D team) may have the potential to meet the VRIN conditions on their own, so long as they are not mismanaged. The contribution of this article is to clarify the original intent of the authors and demonstrate by empirical example that resource and resource management capabilities are not necessarily complementary. In the particular empirical setting used here, assumptions on the synergy between better caregivers and better care processes are widespread and deserve to be reassessed by managers and regulators.

Going forward, further empirical research into the presence or absence of strategic complementarity among firm activities is warranted. Given the clear imperatives for optimal configuration of firm activities, work should also continue to address the econometric biases that may arise in estimating positive interactions (Athey and Stern, 2003; Novak and Stern, 2009). The question of which resource/capability combinations in which firm and industrial settings are more synergistic than others remains an open one. The selection element involved in studying realized combinations of resources and capabilities complicates these potential analyses (Capron and Mitchell, 2009), but may also explain the lack of synergies found here. One potential explanation could, therefore, be a firm or managerial incentive failure to reap such synergies; another could be a failure in codevelopment and cospecialization of resources to firm capabilities. Progress on these fronts will strengthen the field's conceptual understanding of how strategy, structure, and firm activities fit together to drive superior firm performance.

[14] I am grateful to a referee for pointing out this limitation and highlighting a more general need for two-sided matching models between labor suppliers and labor demanders (Rothaermel and Hess, 2007; Mindruta, 2008).

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REFERENCES

ACC/AHA Task Force on Practice Guidelines. 2004. ACC/AHA 2004 guideline update for coronary artery bypass graft surgery. Available at: http://circ.ahajournals.org/content/110/9/1168.full (accessed 21 January 2013).

Alchian AA, Demsetz H. 1972. Production, information costs, and economic organization. *American Economic Review* **62**(5): 777–795.

Amit R, Schoemaker PJH. 1993. Strategic assets and organizational rent. *Strategic Management Journal* **14**(1): 33–46.

Argyres NS. 1996. Evidence on the role of firm capabilities in vertical integration decisions. *Strategic Management Journal* **17**(2): 129–150.

Athey S, Stern S. 2003. An empirical framework for testing theories about complementarity in organizational design. Working paper, National Bureau of Economic Research, Cambridge, MA. Available at: http://www.nber.org/papers/w6600 (accessed 12 March 2012).

Barney JB. 1986. Strategic factor markets: expectations, luck, and business strategy. *Management Science* **32**: 1231–1241.

Barney JB. 1991. Firm resources and sustained competitive advantage. *Journal of Management* **17**(1): 99–120.

Barney JB. 2001. Resource-based theories of competitive advantage: a ten-year retrospective on the resource-based view. *Journal of Management* **27**: 643–650.

Becker GS. 1962. Investment in human capital. *Journal of Political Economy* **70**(5): 9–49.

Bingham CB, Eisenhardt KM. 2008. Position, leverage, and opportunity: a typology of strategic logics linking resources with competitive advantage. *Managerial and Decision Economics* **29**: 241–256.

Bonchek LI. 2002. Off-pump coronary bypass: is it for everyone? *Journal of Thoracic and Cardiovascular Surgery* **124**: 431–434.

Brambor T, Clark W, Golder M. 2006. Understanding interaction models: improving empirical analyses. *Political Analysis* **14**: 63–82.

Brusoni S, Prencipe A, Pavitt K. 2001. Knowledge specialization, organizational coupling, and the boundaries of the firm: why do firms know more than they make? *Administrative Science Quarterly* **46**: 597–621.

Capron L, Mitchell WG. 2009. Selection capability: internal and external strategic renewal through managerial assessment of capability gaps and internal social frictions. *Organization Science* **20**: 294–312.

Carmeli A, Tishler A. 2004. The relationships between intangible organizational elements and organizational performance. *Strategic Management Journal* **25**(13): 1257–1278.

Carson JB, Tesluk PE, Marrone JA. 2007. Shared leadership in teams: an investigation of antecedent conditions and performance. *Academy of Management Journal* **50**: 1217–1234.

Castanias RP, Helfat CE. 1991. Managerial resources and rents. *Journal of Management* **17**(1): 155–171.

Chandler AD. 1962. *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. MIT Press: Cambridge, MA.

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

Coff RW. 1999. When competitive advantage doesn't lead to performance: the resource-based view and stakeholder bargaining power. *Organization Science* **10**(2): 119–133.

Collis DJ. 1994. How valuable are organizational capabilities? *Strategic Management Journal, Winter Special Issue* **15**: 143–152.

Collis DJ, Montgomery CA. 1995. Competing on resources: strategy in the 1990s. *Harvard Business Review* **73**: 118–128.

Cyert R, March JG. 1963. *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ: Prentice Hall.

Danneels E. 2007. The process of technological competence leveraging. *Strategic Management Journal* **28**(5): 511–533.

Dierickx I, Cool K. 1989. Asset stock accumulation and sustainability of competitive advantage. *Management Science* **35**: 1504–1511.

Eisenberg MJ, Filion KB, Azoulay A, Brox AC, Haider S, Pilote L. 2005. Outcomes and cost of coronary artery bypass graft surgery in the United States and Canada. *Archives of Internal Medicine* **165**: 1506–1513.

Eisenhardt KM, Tabrizi BN. 1995. Accelerating adaptive processes: product innovation in the global computer industry. *Administrative Science Quarterly* **40**(1): 84–110.

Eisenhardt KM, Martin JA. 2000. Dynamic capabilities: what are they? *Strategic Management Journal* **21**(10/11): 1105–1121.

Ethiraj SK, Kale P, Krishnan MS, Singh JV. 2005. Where do capabilities come from and how do they matter? A study in the software services industry. *Strategic Management Journal* **26**(1): 25–45.

Gawande A. 2007. The checklist: if something so simple can transform intensive care, what else can it do? *The New Yorker, December* **10**: 86–101.

Gibb CA. 1954. Leadership. In *Handbook of Social Psychology* (Vol. **2**), Lindzey G (ed). Addison-Wesley: Reading, MA; 877–917.

Greenberg CC, Regenbogen SE, Studdert DM, Lipsitz SR, Rogers SO, Zinner MJ, Gawande AA. 2007. Patterns of communications breakdowns resulting in injury to surgical patients. *Journal of the American College of Surgeons* **204**: 533–540.

Hales BM, Pronovost PJ. 2006. The checklist: a tool for error management and performance tracking. *Journal of Critical Care* **21**(3): 231–235.

Hambrick DC, Cho TS, Chen M-J. 1996. The influence of top management team heterogeneity on firms' competitive moves. *Administrative Science Quarterly* **41**(4): 659–684.

Hansen MH, Perry LT, Reese CS. 2004. A Bayesian operationalization of the resource-based view. *Strategic Management Journal* **25**(13): 1279–1295.

Hayes KJ, Pettengill J, Stensland J. 2007. Getting the price right: Medicare payment rates for cardiovascular services. *Health Affairs* **26**(1): 124–136.

Helfat CE, Finkelstein S, Mitchell W, Peteraf MA, Singh H, Teece DJ, Winter SG. 2007. *Dynamic Capabilities: Understanding Strategic Change in Organizations*. Blackwell Publishing: Malden, MA.

Helfat CE, Peteraf MA. 2003. The dynamic resource-based view: capability lifecycles. *Strategic Management Journal* **24**(10): 997–1010.

Hitt MA, Beamish PW, Jackson SE, Mathieu JE. 2007. Building theoretical and empirical bridges across levels: multilevel research in management. *Academy of Management Journal* **56**: 1385–1399.

Holcomb TR, Holmes TR, Connelly BL. 2009. Making the most of what you have: managerial ability as a source of resource creation. *Strategic Management Journal* **30**(5): 457–485.

Hoopes DG, Madsen TL. 2008. A capability-based view of competitive heterogeneity. *Industrial and Corporate Change* **17**: 393–426.

Huckman R, Pisano G. 2006. The firm-specificity of individual performance: evidence from cardiac surgery. *Management Science* **52**(4): 473–488.

Ichniowski C, Shaw K, Prennushi G. 1997. The effects of human resource management practices on productivity. *American Economic Review* **87**(3): 291–313.

Iyengar RJ, Zampelli EM. 2009. Self-selection, endogeneity, and the relationship between CEO duality and firm performance. *Strategic Management Journal* **30**(10): 1092–1112.

Jacobides MG, Hitt LM. 2005. Losing sight of the forest for the trees? Productive capabilities and gains from trade as drivers of vertical scope. *Strategic Management Journal* **26**(13): 1209–1228.

Kim J, Mahoney JT. 2006. Mutual commitment to support exchange: relation-specific IT system as a substitute for managerial hierarchy. *Strategic Management Journal* **27**(5): 401–423.

Lenox MJ, Rockart SF, Lewin AY. 2006. Interdependency, competition, and the distribution of firm and industry profits. *Management Science* **52**(5): 757–772.

Lenox MJ, Rockart SF, Lewin AY. 2007. Interdependency, competition, and industry dynamics. *Management Science* **53**: 599–615.

Levinthal DA. 1997. Adaptation on rugged landscapes. *Management Science* **43**: 934–950.

Lingard L, Regehr G, Orser B, Reznick R, Baker GR, Doran D, Espin S, Bohnen J, Whyte S. 2008. Evaluation of a preoperative checklist and team briefing among surgeons, nurses, and anesthesiologists to reduce failures in communication. *Archives of Surgery* **143**: 12–17.

Lippman S, Rumelt R. 1982. Uncertain imitability: an analysis of interfirm differences in efficiency under competition. *Bell Journal of Economics* **13**: 418–438.

Lippman S, Rumelt R. 2003. The payments perspective: micro-foundations of resource analysis. *Strategic Management Journal* **24**(10): 903–927.

Makadok R. 2001. Toward a synthesis of the resource-based and dynamic-capability views of rent creation. *Strategic Management Journal* **22**(5): 387–401.

Makadok R. 2003. Doing the right thing and knowing the right thing to do: why the whole is greater than the sum of the parts. *Strategic Management Journal* **24**(10): 1043–1055.

Maritan CA, Brush TH. 2003. Heterogeneity and transferring practices: implementing flow manufacturing in multiple plants. *Strategic Management Journal* **24**(10): 945–959.

Marks MA, Mathieu JE, Zaccaro SJ. 2001. A temporally based framework and taxonomy of team processes. *Academy of Management Review* **26**: 356–376.

Milgrom P, Roberts J. 1990. The economics of modern manufacturing: technology, strategy, and organization. *American Economic Review* **80**(3): 511–528.

Milgrom P, Roberts J. 1995. Complementarities and fit: strategy, structure, and organizational change in manufacturing. *Journal of Accounting and Economics* **19**: 179–208.

Miller D. 2003. An asymmetry-based view of advantage: towards an attainable sustainability. *Strategic Management Journal* **24**(10): 961–976.

Mindruta D. 2008. Value creation in university-firm research collaborations: a matching approach. In *Academy of Management Meeting: Best Papers Proceedings*, Grant RM, Baden-Fuller C (eds). Academy of Management: Briarcliff Manor, NY.

Miner AS, Bassoff P, Moorman C. 2001. Organizational improvisation and learning: a field study. *Administrative Science Quarterly* **46**: 304–337.

Morgan NA, Vorhies DW, Mason CH. 2009. Market orientation, marketing capabilities, and firm performance. *Strategic Management Journal* **30**(8): 909–920.

Nadler D, Tushman M. 1980. A model for diagnosing organizational behavior. *Organizational Dynamics* **9**(2): 35–51.

Nass C. 1994. Knowledge or skills: which do administrators learn from experience? *Organization Science* **5**(1): 38–50.

Nelson RR, Winter SG. 1982. *An Evolutionary Theory of Economic Change*. Harvard University Press: Cambridge, MA.

Newbert SL. 2007. Empirical research on the resource-based view of the firm: an assessment and suggestions for future research. *Strategic Management Journal* **28**(2): 121–146.

Newbert SL. 2008. Value, rareness, competitive advantage, and performance: a conceptual-level empirical investigation of the resource-based view of the firm. *Strategic Management Journal* **29**(7): 745–768.

Novak S, Stern S. 2009. Complementarity among vertical integration decisions: evidence from automobile product development. *Management Science* **55**: 311–332.

Parmigiani A, Mitchell W. 2009. Complementarity, capabilities, and the boundaries of the firm: the impact of within-firm and interfirm expertise on concurrent sourcing of complementary components. *Strategic Management Journal* **30**(10): 1065–1091.

Penrose E. 1959. *The Theory and Growth of the Firm*. Oxford University Press: New York.

Peteraf MA. 1993. The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal* **14**(3): 179–191.

Peteraf MA, Barney JB. 2003. Unraveling the resource-based tangle. *Managerial and Decision Economics* **24**: 309–323.

Peteraf MA, Reed R. 2007. Managerial discretion and internal alignment under regulatory constraints and change. *Strategic Management Journal* **28**(11): 1089–1112.

Porter ME. 1996. What is strategy? *Harvard Business Review* **74**(6): 61–78.

Priem RL, Butler JE. 2001. Is the resource-based 'view' a useful perspective for strategic management research? *Academy of Management Journal* **26**(1): 22–41.

Rastan AJ, Gummert JF, Lachmann N, Walther T, Schmitt DV, Falk V, Doll N, Caffier P, Richter MM, Wittekind C, Mohr FW. 2005. Significant value of autopsy for quality management in cardiac surgery. *The Journal of Thoracic and Cardiovascular Surgery* **129**: 1292–1300.

Ray G, Barney JB, Muhanna WA. 2004. Capabilities, business processes, and competitive advantage: choosing the dependent variable in empirical tests of the resource-based view. *Strategic Management Journal* **25**(1): 23–37.

Rivkin JW. 2000. Imitation of complex strategies. *Management Science* **46**: 824–844.
Robinson WS. 1950. Ecological correlations and the behavior of individuals. *American Sociological Review* **15**: 351–357.
Rothaermel FT, Hess A. 2007. Building dynamic capabilities: innovation driven by individual-, firm-, and network-level effects. *Organization Science* **18**: 898–921.
Shahian DM, Edwards FH, Ferraris VA, Haan CK, Rich JB, Normand SL, DeLong ER, O'Brien SM, Shewan CM, Dokholyan RS, Peterson ED, Society of Thoracic Surgeons Quality Measurement Task Force. 2007. Quality measurement in adult cardiac surgery. *Annals of Thoracic Surgery* **83**(4): S3–S12.
Siggelkow N. 2001. Change in the presence of fit: the rise, the fall, and the renaissance of Liz Claiborne. *Academy of Management Journal* **44**(4): 838–857.
Siggelkow N. 2002. Misperceiving interactions among complements and substitutes: organizational consequences. *Management Science* **48**: 900–916.
Simon HA. 1987. Making management decisions: the role of intuition and emotion. *Academy of Management Executive* **1**(1): 57–64.
Sirmon DG, Hitt MA, Ireland RD. 2007. Managing firm resources in dynamic environments to create value: looking inside the black box. *Academy of Management Review* **32**(1): 273–292.
Sirmon DG, Gove S, Hitt MA. 2008. Resource management in dyadic competitive rivalry: the effects of resource bundling and deployment. *Academy of Management Journal* **51**(5): 919–935.
Teece DJ. 1986. Capturing value from technological innovation: implications for integration, collaboration, licensing, and public policy. *Research Policy* **15**(6): 285–305.
Teece DJ. 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal* **28**(13): 1319–1350.
Teece DJ, Pisano G, Shuen A. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal* **18**(7): 509–533.
Thompson P. 2007. How much did the Liberty shipbuilders forget? *Management Science* **53**: 908–918.
Topkis DM. 1995a. Comparative statics of the firm. *Journal of Economic Theory* **67**: 370–401.
Topkis DM. 1995b. The economics of modern manufacturing: comment. *American Economic Review* **85**(4): 991–996.
Tribble C, Newburg D. 1998. Learning to fly: Teaching mental strategies to future surgeons. Available at www.zoneofexcellence.ca/Journal/Issue01/Learning_to_Fly.pdf (accessed 21 January 2013).
Wennberg DE. 1999. *The Dartmouth Atlas of Cardiovascular Health Care*. AHA Press: Chicago, IL.
Wernerfelt B. 1984. A resource-based view of the firm. *Strategic Management Journal* **5**(2): 171–180.
Williams RG, Silverman R, Schwind C, Fortune JB, Sutyak J, Horvath KD, Van Eaton EG, Azzie G, Potts JR III, Boehler M, Dunnington GL. 2007. Surgeon information transfer and communication factors affecting quality and efficiency of inpatient care. *Annals of Surgery* **245**: 159–169.
Wilson C, Fisher ES, Welch HG, Siewers AE, Lucas FL. 2007. U.S. trends in CABG hospital volume: the effect of adding cardiac surgery programs. *Health Affairs* **26**(1): 162–168.
Zollo M, Winter S. 2002. Deliberate learning and the evolution of dynamic capabilities. *Organization Science* **13**(3): 339–351.

APPENDIX

Data source, validation, and exclusions: description of data set construction

Panel hospital-level analyses: independent and joint impact of surgical resource quality and unbundled resource deployment on hospital coronary artery bypass graft surgery (CABG) length of stay

Marginal effect plots: marginal effects at differing values of focal independent variables for additional dependent variables reported in Table 4

Empirical distributions: resource quality and use of resource management histograms

Appendix: Data source, validation. and exclusion restrictions

The Florida Department of Health's Agency for Health Care Administration provided the study with administrative CABG discharge data. The data set comprises repeated, quarterly cross-sectional observations of all CABG-related admissions (isolated CABG, CABG + valve, and CABG + other) in all state-regulated hospitals from January 1, 1998 to December 31, 2006. Data was neither clinically audited nor contained clinical chart data (e.g., biochemical or biomechanical data summarizing kidney, lung, or heart function). It included in-hospital outcomes, demographic data, comorbidities, procedures undertaken, sites, and medical license numbers for operating surgeons.

I excluded patients under 19 years of age and patient records missing operating surgeon identifiers. There was substantial heterogeneity in patients spanning their prior medical and surgical history, as well as the particular surgery they required and the process of performing the surgery. Some CABG surgery is for first-time patients, while other CABG admissions involve repeat surgery with an additional valve or other surgery. The empirical problem is that these represent different outputs, or different products in the

Table A1. Panel hospital-level analyses: independent and joint impact of surgical resource quality and unbundled resource deployment on hospital coronary artery bypass graft surgery (CABG) length of stay

		Hospital quarterly performance: length of stay (days)			
Intercept		11.03	10.86	11.41*	9.94
		(6.10)	(6.31)	(5.72)	(5.74)
Calendar year dummy variables		Included in all models			
Patient characteristics	Unstable angina	0.27	0.24	0.16	0.20
		(0.57)	(0.60)	(0.58)	(0.57)
	Acute myocardial infarction (ratio)	9.73	9.88	9.72	9.74
		(6.11)	(6.17)	(6.21)	(6.22)
	On-pump operation (ratio)	−3.61	−3.66	−3.93	−3.93
		(3.84)	(3.90)	(3.94)	(3.95)
	Double mammary artery use (ratio)	−12.08	−12.63	−12.85	−12.90
		(9.06)	(9.42)	(9.45)	(9.44)
	Single mammary artery use (ratio)	1.11	1.16	0.77	0.82
		(3.31)	(3.42)	(3.30)	(3.36)
	Medicare (ratio)	6.86	6.87	6.87	6.93
		(5.70)	(5.69)	(5.70)	(5.77)
	Managed care (ratio)	4.80	4.83	4.33	4.37
		(4.27)	(4.32)	(4.13)	(4.19)
Hospital controls	Government ownership (1/0)	−0.70	−0.65	−1.43	−1.44
		(0.73)	(0.73)	(0.75)	(0.76)
	Religious not-for-profit (1/0)	−0.29	−0.31	−1.34	−1.09
		(0.86)	(0.89)	(1.08)	(0.81)
	Corporate for-profit (1/0)	0.02	0.03	−1.38	0.05
		(0.90)	(0.91)	(1.27)	(0.90)
	Teaching hospital (1/0)	1.77	1.73	2.42*	2.43*
		(1.17)	(1.19)	(1.24)	(1.25)
	'Adult openheart hospital' (1/0)	−7.90	−8.08	−8.20	−8.19
		(6.46)	(6.65)	(6.09)	(6.09)
	Facility beds (#)	0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)
	CABG to all admissions (ratio)	−21.55	−21.76	−5.69	−6.01
		(42.82)	(43.95)	(43.90)	(43.88)
	PTCA to CABG admissions (ratio)	0.34	0.34	0.42	0.42
		(0.43)	(0.44)	(0.44)	(0.44)
	Total yearly admissions ('00,000s)	−0.05	−0.05	−0.01	−0.01
		(0.04)	(0.04)	(0.04)	(0.04)
Marginal effects (at covariate means)	Resource quality: patient mortality by surgeon (ratio)		0.47	0.68	−1.50
			(1.57)	(1.52)	(4.56)
	Resource deployment: unbundled teams (ratio)			2.90**	2.76***
				(1.12)	(0.93)
	Resource quality X resource deployment				4.87
					(9.64)
R^2 (overall)		0.15	0.15	0.18	0.17
Wald test		129***	133***	164***	164***

Panel random effects using GLS with robust s.e. clustered by hospital. (¶)p < 0.10. (*) p < 0.05, (**) p < 0.01), and (***) p < 0.001 estimated significance. 2,262 firm* quarter observations, 75 hospitals. Negative coefficients imply unfavorable effect.

sense of Thompson (2007), and have different *ex ante* expectations over cost, mortality, and complications. Following the specialist literature (Shahian *et al.*, 2007), the main analyses use only patient records conforming to a relatively homogenous risk profile: no prior CABG and/or no ancillary valve operation. Thus, I excluded patients with CABG + valve (29,371 records) and patients with a prior CABG (9,351), based on ICD9 coding, because these cohorts of patients have very different risk profiles than isolated nonvalve primary CABG patients. The remaining data overestimates the true primary CABG population, since ICD-9 codes for repeat procedures in a

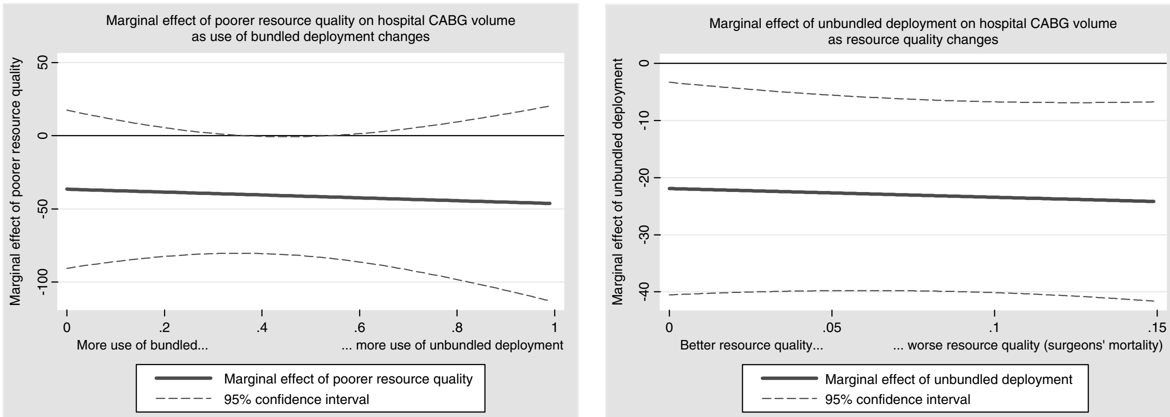

Figure A1. Marginal effects on hospital CABG patient volumes

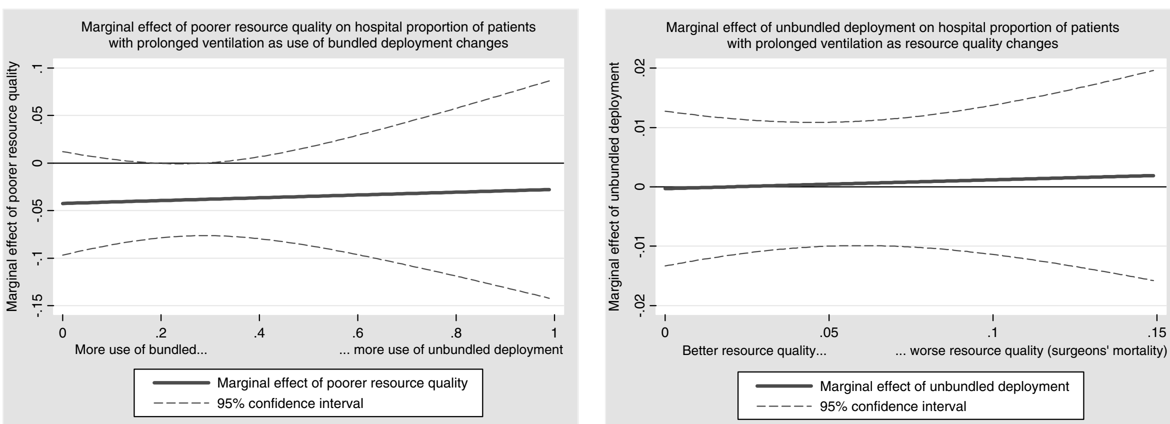

Figure A2. Marginal effects on proportion of hospital CABG patients receiving prolonged mechanical ventilation > 96 hours postoperatively

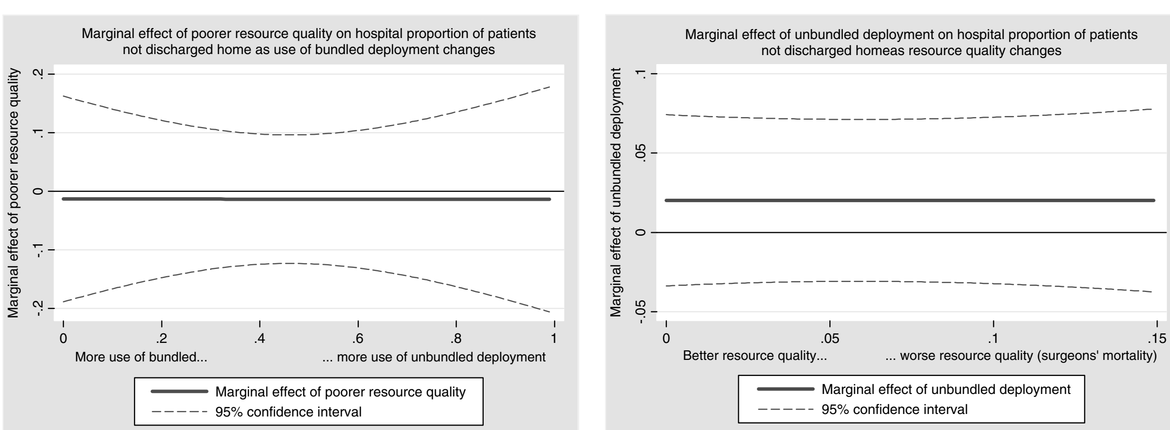

Figure A3. Marginal effects on proportion of hospital CABG patients not discharged directly home under self-care (i.e., discharged to convalescent hospital, skilled nursing facility, hospice, or home health care)

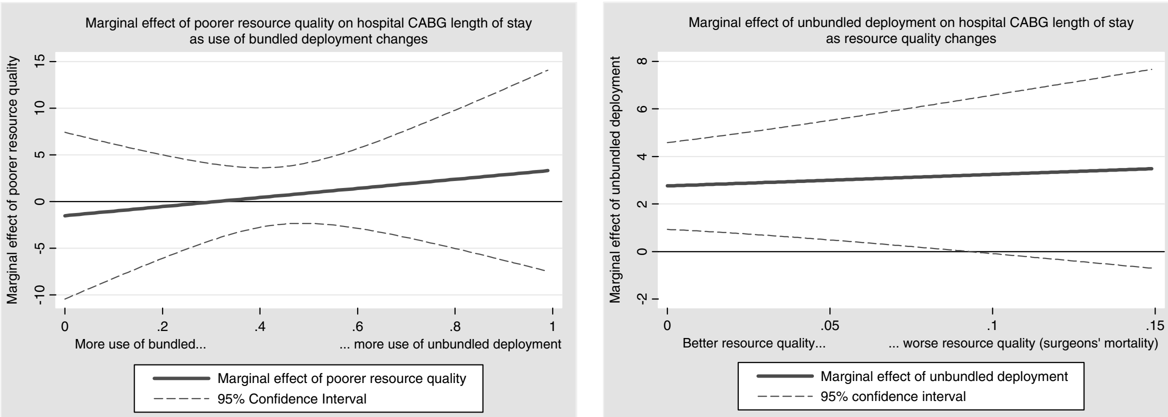

Figure A4. Marginal effects on hospital CABG length of stay

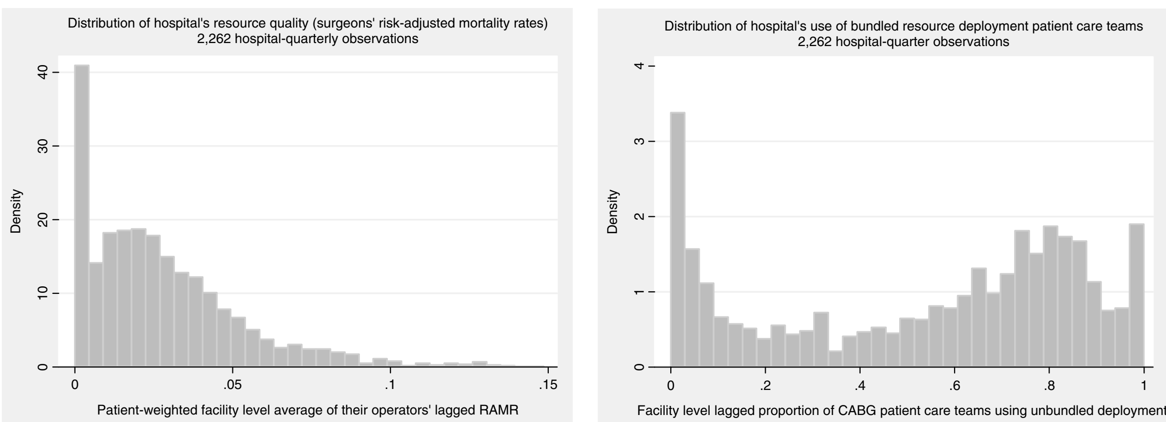

Figure A5. Empirical distributions of resource quality and use of the bundled resource deployment model, pooled over all 2,262 hospital*quarter observations

nonnative vessel. I also excluded records from a total of 57 surgeons whose final residency training was completed after the start of the panel in 1998 (17,009). These new cardiac surgeons are potentially at the steepest part of any experience curve and also have unrepresentative variation in practice scale. These may yield unrepresentative mortality statistics in the measures of surgical resource quality.

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