Management Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Broadening Focus: Spillovers, Complementarities, and Specialization in the Hospital Industry

Jonathan R. Clark, Robert S. Huckman,

MANAGEMENT SCIENCE
Vol. 58, No. 4, April 2012, pp. 708–722
ISSN 0025-1909 (print) | ISSN 1526-5501 (online)

http://dx.doi.org/10.1287/mnsc.1110.1448

Broadening Focus: Spillovers, Complementarities, and Specialization in the Hospital Industry

Jonathan R. Clark
Health Policy and Administration, Pennsylvania State University, University Park, Pennsylvania 16802, jrc24@psu.edu

Robert S. Huckman
Technology and Operations Management, Harvard Business School, Harvard University, Boston, Massachusetts 02163; and National Bureau of Economic Research, Cambridge, Massachusetts 02138, rhuckman@hbs.edu

The long-standing argument that focused operations outperform others stands in contrast to claims about the benefits of broader operational scope. The performance benefits of focus are typically attributed to reduced complexity, lower uncertainty, and the development of specialized expertise; the benefits of greater breadth are linked to the economies of scope achieved by sharing common resources, such as advertising or production capacity, across activities. Within the literature on corporate strategy, this tension between focus and breadth is reconciled by the concept of related diversification (i.e., a firm with multiple operating units, each specializing in distinct but related activities). We consider whether there are similar benefits to related diversification *within* an operating unit and examine the mechanism that generates these benefits. Using the empirical context of cardiovascular care within hospitals, we first examine the relationship between a hospital's level of specialization in cardiovascular care and the quality of its clinical performance on cardiovascular patients. We find that, on average, focus has a positive effect on quality performance. We then distinguish between *positive spillovers* and *complementarities* to examine (1) the extent to which a hospital's specialization in areas related to cardiovascular care directly impacts performance on cardiovascular patients (positive spillovers) and (2) whether the marginal benefit of a hospital's focus in cardiovascular care depends on the degree to which the hospital "cospecializes" in related areas (complementarities). In our setting, we find evidence of such complementarities in specialization.

Key words: operational focus; spillovers; complementarities; healthcare; organizational studies; effectiveness–performance; productivity; hospitals
History: Received November 2, 2009; accepted July 5, 2011, by Christian Terwiesch, operations management. Published online in *Articles in Advance* December 22, 2011.

Introduction

A key tension facing many firms concerns the optimal scope of their operations. The benefits of operational specialization, or focus, in terms of lower cost or higher quality are widely discussed in both manufacturing (Skinner 1974) and service (Heskett 1986) settings. Leveraging operational focus has been offered as a rationale for decisions ranging from the use of contract manufacturers by consumer electronics companies to the use of a single type of aircraft by low-cost airlines or the dedication of an entire hospital to patients undergoing a single surgical procedure. In fact, the "law of factory focus" has been cited as a key component of received wisdom in the field of operations management (Schmenner and Swink 1998). Despite this broad support for operational focus, some observers have noted that seemingly unfocused operations perform at a high level (Ketokivi and Jokinen 2006) and that a broader range of activities may, in fact, increase firm value (Teece 1980, Panzar and Willig 1981, Villalonga 2004).

Some reconciliation of these views may be found in the concept of related diversification, which argues that expanding scope into *related* businesses increases firm value, whereas broader diversification into *unrelated* businesses may reduce it (Rumelt 1974). The implicit assumption in this literature is that related diversification yields a firm with multiple operating units—each specializing in a distinct set of activities—and that the specialties of these units are related to each other. In this paper, we consider whether the benefits of related diversification also exist *within operating units themselves*.[1] Specifically, we ask whether a focused operating unit can be "too focused." To the extent that there are benefits to related diversification within an operating unit, we offer an empirical approach for identifying the source of those benefits.

[1] Schilling et al. (2003), Boh et al. (2007), and Narayanan et al. (2009) consider whether there are benefits to engaging in related activities at the level of small groups and individuals. We discuss this work in greater detail below.

Studies of related diversification at the corporate level tend to attribute the benefits of diversification to *economies of scope*, which Panzar and Willig (1981, p. 268) define as occurring when "... it is less costly to combine two or more product lines in one firm than to produce them separately." Economies of scope, however, may emerge from two sources that we aim to isolate in this study: *positive spillovers* and *complementarities*. Roberts (2004, p. 73) defines these concepts by noting, "... complementarity is conceptually different from a positive spillover. A positive spillover occurs when the overall benefit from some activity (rather than the returns to increasing the activity) is increasing in the level of the other activity." Because of our interest in the effects of focus, our study tests for the presence of positive spillovers and complementarities based not on an operating unit's *absolute level* of specific activities but on its *level of specialization* in those activities. Despite this difference, the conceptual definitions and intuition provided by Roberts carry through to our setting.

A common type of positive spillover is what Markides and Williamson (1994) refer to synonymously as the "asset amortization" or "static economies of scope" benefit of related diversification. That is, positive spillovers may simply be economies of scale that exist across different activities rather than within a single activity. Such economies may appear as either reductions in average cost (from the amortization of fixed investments) or improvements in average quality (from leveraging intangible assets, such as know-how). In either case, a positive spillover occurs when increased specialization in a related business segment has a *direct* benefit on operational performance in a focal business segment that is *independent* of the operating unit's level of specialization in the focal segment.

Complementarities, on the other hand, exist if increased specialization in a related business segment has an *indirect* benefit on operational performance in a focal business segment by increasing the marginal benefit of specializing more in the focal activity (Milgrom and Roberts 1994, 1995). Complementarity thus implies that the benefits of related diversification may not be simply caused by sharing fixed assets but also by the fact that a related activity improves performance of the focal activity *at the margin*. In other words, complementarity suggests a positive interdependence between levels of specialization in focal and related activities.

To clarify further the distinction between these two sources of scope economies, we turn to an example from the setting we examine in this study—hospitals. Consider a hospital that only treats cardiovascular patients but faces declining demand for cardiovascular services. In the interest of amortizing fixed investments that it has made in assets such as hospital beds, operating rooms, and diagnostic services (e.g., radiology), the hospital may decide to add other clinical service lines outside cardiovascular care (e.g., endocrinology or respiratory medicine). To the extent that these other service lines directly improve the quality—or reduce the cost—of treating cardiovascular patients *regardless of the hospital's level of specialization in cardiovascular care*, they exert a positive spillover on cardiovascular care. For example, adding these new clinical services to a cardiovascular hospital may bring clinicians with general knowledge that can *directly* benefit the hospital's performance on cardiovascular patients (e.g., a new approach to reducing the rate of hospital-acquired infections that benefits many types of patients, including those with cardiovascular disease).

On the other hand, the addition of clinical specialists in these new service lines would exert a complementarity with respect to cardiovascular care to the extent that they give cardiovascular specialists access to new sources of knowledge and insight about related conditions (e.g., many patients with cardiovascular illness suffer from diabetes, a key area of focus for endocrinologists). This knowledge may help cardiovascular specialists interpret and encode their own specialized experiences with cardiovascular patients (Levitt and March 1988). The increased individual and organizational attention (Ocasio 1997) on these new service lines is likely to provide the context for greater formal and informal interaction among clinicians in related specialties (e.g., the "curbside consultations" described extensively in the medical literature Manian and Janssen 1996). To the extent that the presence of new service lines increases the performance associated with any given level of cardiovascular specialization, those services exert a complementarity with respect to cardiovascular care. In such cases, there are benefits to "cospecialization" in cardiovascular care and the new service lines.

The empirical literature on the impact of focus on performance has considered a range of performance measures including cost, productivity, customer satisfaction, and quality. In our context, a critical measure of performance—and that for which we have reliable information—is quality performance. Consistent with prior work examining focus in healthcare settings, we begin our inquiry by asking whether an operating unit that is more focused on a given activity achieves higher quality performance (i.e., higher output quality) with respect to that activity than a less-focused unit engaged in the same activity (e.g., Cram et al. 2005, Greenwald et al. 2006, KC and Terwiesch 2011). We continue by testing for the benefits of related diversification, that is, whether the composition of a unit's *other* activities (i.e., outside the focal area) impacts quality performance in the focal area. In so doing, we contribute to the literature on specialization and related diversification by separately measuring the extent of positive spillovers and complementarities. This latter line of inquiry allows us to examine whether and how the benefits of focusing on a particular activity depend on the degree to which an organization is also relatively specialized (i.e., "cospecialized") in *related* activities.

We consider these issues by examining the delivery of cardiovascular care within hospitals. We recognize that a hospital can be characterized as either an operating unit or a multi-unit firm. Nevertheless, as circumscribed facilities, most hospitals can be viewed as operating units, akin to plants in the manufacturing context. We have chosen our empirical setting for several reasons. First, hospitals tend to provide services across a range of clinical areas (i.e., business segments) such as cardiovascular care, cancer, orthopedics, and obstetrics. These segments appear in different proportions and combinations across facilities. For example, a given hospital may devote a substantial share of resources to cardiovascular care while allocating comparatively less attention or fewer resources to obstetrics. Conversely, another hospital may be characterized by a significant focus in obstetrics with relatively little cardiovascular care.

Second, hospital discharge data include information on every patient in a particular hospital. This characteristic of the data allows us to measure the degree to which a given hospital focuses on a clinical area (e.g., cardiovascular services) as a continuous variable based on the percentage of its total operational activity dedicated to that clinical area.[2] This continuity is particularly useful in testing for complementarities based on the degree to which the marginal benefit of a given level of focus in one business segment increases as the share of activity devoted to related segments increases. Third, there are clear and objective measures of quality performance, specifically a hospital's risk-adjusted mortality rate for cardiovascular patients.

Finally, specialization is particularly relevant in the hospital industry, where many observers have noted the value of delivering healthcare through organizations focused around the needs of patients with specific diseases (Herzlinger 1997; Porter and Teisberg 2006, 2007; Christensen et al. 2009). In fact, the rise of single-specialty hospitals—a large portion of which focus on cardiovascular care—has led to significant debate over the value of such facilities. This debate centers on whether such facilities outperform traditional "general" hospitals (Herzlinger 1997, Ginsburg 2000, Schneider et al. 2008). Consistent with the spirited nature of this debate, the empirical studies on this topic offer mixed findings (Greenwald et al. 2006, Barro et al. 2006, Hwang et al. 2007, Nallamothu et al. 2007, Carey et al. 2008). Overall, this stream of literature highlights the importance of determining how hospitals should balance specializing in a single clinical area with building expertise in other areas.

Theory and Hypotheses

The idea that specialization, or focus, improves performance by reducing complexity and leveraging task repetition dates back to Smith's (1776) example of the pin factory and is later captured in the work of Fayol (1916) and Taylor (1911). Though containing implications for operating units or entire organizations, these early arguments largely center on the performance of the individual worker. March and Simon (1958) note that lessons learned about individual specialization may not simply translate to a higher level of organization. Nevertheless, subsequent thinking about focus at the level of the operating unit (e.g., Skinner's 1974 concept of the focused factory) is consistent with earlier work on specialized labor.

Several studies provide empirical support for the benefits of focus in the context of manufacturing (Hayes and Wheelwright 1984, Brush and Karnani 1996, Bozarth and Edwards 1997, Fisher and Ittner 1999). Studies in service settings likewise support the benefits of focus at some level (Heskett 1986, Lapre and Tsikriktsis 2006, Tsikriktsis 2007, Huckman and Zinner 2008). Specific to the hospital context, Herzlinger (1997) identifies the benefits of applying Skinner's focused factory to healthcare delivery. Subsequent studies in the hospital industry find benefits of focus in terms of clinical outcomes (e.g., Greenwald et al. 2006) and financial performance (e.g., Hyer et al. 2009).

Nevertheless, support for the benefits of focus at the level of the operating unit is not unanimous.[3] Mukherjee et al. (2000) suggest that the impact of reducing focus depends on a manufacturing line's degree of absorptive capacity (Cohen and Levinthal 1990) with respect to changes in manufacturing tasks. In their study of automobile assembly plants, MacDuffie et al. (1996) find that a more complex mix of parts negatively affects productivity, whereas

[2] Measuring focus as a continuous, rather than discrete, variable implies that an operating unit need not be dedicated solely to one activity (or set of activities) to be considered "focused." For example, a unit that is 40% dedicated to a particular activity—with no other activity accounting for a similarly large portion of the unit's effort—is relatively focused on the first activity.

[3] Even at the level of the individual, support for the benefits of specialization is not unanimous. Recent work by both Boh et al. (2007) and Narayanan et al. (2009) highlights benefits of variety to some degree in individual work within software development contexts.

a more complex mix of models has no such effect. Further, the negative impact of parts complexity can be offset by the adoption of lean management principles. Other studies in manufacturing contexts suggest that more-focused operations perform no better than their less-focused counterparts (Kekre and Srinivasan 1990, Suarez et al. 1996, Ketokivi and Jokinen 2006). In the financial services industry, Siggelkow (2003) finds that mutual fund providers with a broader range of funds (i.e., less-focused providers) have higher cash inflows than more-focused providers, despite the fact that the specific funds managed by the latter outperform similar funds managed by the former. Finally, a few studies in the hospital industry find that hospitals that devote a majority of their activity and resources to cardiovascular patients perform at best no better in terms of patient outcomes on cardiovascular procedures (Cram et al. 2005, KC and Terwiesch 2011).

Despite these mixed results, the bulk of the empirical literature suggests a positive-to-neutral effect of focus on performance. We thus offer the following baseline hypothesis related to an operating unit's level of focus (i.e., specialization in a focal business segment):

Hypothesis 1. *Increasing an operating unit's level of specialization in a focal business segment improves quality performance in that segment.*

As noted earlier, several studies at the firm level have argued that increased scope, or diversification, may represent an efficient approach to corporate organization (Teece 1980, Panzar and Willig 1981). Nevertheless, like the previously noted literature on focus at the plant or operating-unit level, this firm-level literature offers mixed evidence regarding the impact of diversification on firm value (Lang and Stulz 1994, Berger and Ofek 1995, Campa and Kedia 2002, Villalonga 2004). The literature on related diversification provides insight into these conflicting results by striking a balance between claims about the benefits of focus on one hand and those of diversification on the other. Rumelt (1974) finds the highest levels of profitability among firms that diversify into areas that draw on some "common core skill or resource." Subsequent work suggests that some level of related diversification is beneficial but that evolving into an unfocused enterprise by diversifying into unrelated businesses may destroy value (Christensen and Montgomery 1981, Rumelt 1982, Palepu 1985).

As suggested by Markides and Williamson (1994), the assumption—either explicit or implicit—of this stream of literature is "…to equate the benefits of relatedness with the static exploitation of economies of scope" (p. 150). That is, the literature tends to attribute the benefits of related diversification to the simple amortization of investments in fixed assets—a positive spillover—rather than to complementarities. We note that positive spillovers have been observed at the level of small groups in knowledge-intensive settings. The analysis of Boh et al. (2007) of productivity in software teams established that a group's average experience with related activities has a greater positive impact on productivity than its average experience with a focal activity. This setup differs from ours in two ways beyond the obvious difference in empirical context. First, it measures the returns to absolute experience rather than to focus. Second, it tests for positive spillovers but not for the complementarities that we measure in our study.

In this study, we present an approach for unpacking the benefits of related diversification by determining the extent to which they emerge from either or both of these sources. To achieve this, we first define the "relatedness" of an activity based on the *potential* for positive spillovers or complementarities with a focal activity. Among hospital patients, disease categories that frequently co-occur in patients with cardiovascular disease represent areas with the highest such potential. In our setting, *positive spillovers* exist when the level of specialization in related segments (i.e., the share of an operating unit's activity in related segments) impacts performance in the focal segment, independent of the unit's level of specialization in the latter. For example, we would predict that a hospital that is more specialized in endocrinology would provide better outcomes for cardiovascular patients—regardless of its level of specialization in cardiovascular care—as diabetes tends to be a common co-occurring condition for cardiovascular patients. Our expectation here is that, in a knowledge-intensive setting such as a hospital and because "…repetition, experience, and homogeneity of tasks breed competence" (Skinner 1974), greater hospital specialization in endocrinology would produce deeper organizational know-how with respect to diabetes. This know-how could be *directly* applied to patients who are hospitalized for cardiovascular disease but who also have diabetes. As a result, the benefits of this know-how would accrue to cardiovascular patients regardless of how specialized the hospital is in cardiovascular care. This suggests the following hypothesis:

Hypothesis 2. *Increasing an operating unit's degree of specialization in related business segments improves quality performance in its focal business segment* (*i.e., specialization in related segments has a positive spillover on quality performance in the focal segment*).

In comparison to positive spillovers, complementarities suggest the presence of *interdependencies* between focal and related activities (Tanriverdi and Venkatraman 2005). Schilling et al. (2003) provide experimental evidence of complementarities by demonstrating that groups learn a focal task at a faster rate when group members are exposed to *related* (i.e., moderate) variety—as opposed to no variety or unrelated (i.e., broad) variety—in tasks over time. They note that, in their experimental setting of problem-solving games, groups exposed to variety did not exhibit subspecialization. That is, they did not have one member play all games of one type and another member play all games of another type. In our setting, related diversification typically occurs by having related specialists within the same organization (e.g., cardiologists working in proximity to endocrinologists), not by exposing individuals or groups to a range of related activities over time (e.g., individual physicians acting as cardiologist-endocrinologist combinations). Our study, therefore, examines whether the complementary benefits of relatedness identified by Schilling et al. (2003) *within* individuals or small groups can be extended to interactions that tend to occur *across* specialized individuals or groups. To the extent that complementarities exist in our setting, they suggest that some degree of interpersonal or intergroup coordination is taking place.

We test for complementarities across activities by considering whether the benefit of a given level of focus depends on how an operating unit's nonfocal activities are distributed in terms of their relatedness to the focal area. As noted earlier, Milgrom and Roberts' (1994) general definition states that two variables are complementary if "the marginal returns to one variable are increasing in the level of the other variable" (p. 5). In our setting, the variables are the degree of *specialization* in focal and related nonfocal activities, respectively. We expect that if nonfocal activities are disproportionately allocated to related (rather than unrelated) categories, the marginal benefit of a given level of specialization in the focal activity will be greater. In short, we expect that there are returns to cospecialization in related activities.

In the context of our earlier hospital example, complementarities in specialization would imply that the benefits of a hospital being relatively specialized in cardiovascular care would be greater if the hospital were also specialized in the related area of endocrinology. These complementarities could be caused by one or more of several factors. For example, cardiovascular physicians may develop better solutions to clinical problems to the extent that they are able to draw on the knowledge of stronger diabetes specialists through direct consultation on specific patients. That is, "cospecialized" hospitals might facilitate formal interactions among specialists (e.g., traditional consultations or "grand rounds") (Parrino and White 1990) or what the medical literature commonly refers to as informal "curbside consultations" (Manian and Janssen 1996).[4]

Beyond direct consultation, hospitals that cospecialize in cardiovascular disease and endocrinology may also be more likely to develop clinical centers that focus on the intersection of these two clinical areas. That is, such hospitals may direct more cognitive attention (Simon 1947, Ocasio 1997) to this intersection. This point is reflected in the concepts of focused attention (Kahneman 1973) and situated attention (Ross and Nisbett 1991), which collectively argue that individual behavior and social cognition are influenced by an organization's structures for allocating time, effort, and other resources (Ocasio 1997). In our setting, one might see a hospital develop a specialized program in cardiovascular endocrinology, which would be staffed by physicians and other clinicians (e.g., nurses, nutritionists) dedicated to this subspecialty. As this subspecialty expertise develops, one would expect cardiovascular specialists in the hospital—either physicians or other clinical staff—to interpret and encode more effectively the learning from their own specialized experience (Levitt and March 1988). In line with this logic, we propose the following hypothesis:

Hypothesis 3. *Increasing an operating unit's degree of specialization in related business segments increases the marginal benefit (in terms of quality performance) of specialization in the focal business segment (i.e., specialization in related segments complements specialization in the focal segment to improve quality performance).*

To illustrate the predictions of our three hypotheses, we present a simple formalization. Assume that a hospital is composed of three types of service lines: a focal service line f (in our case, cardiovascular care), related service lines r, and unrelated service lines. The quality of output in a focal service line, q_f, can be expressed as

$$q_f = g(x_f, x_r, Z), \tag{1}$$

where x_f and x_r are the shares of a hospital's activity dedicated to focal and related services, respectively. We note that the remaining portion of a hospital's activity (i.e., $1\text{-}x_f - x_r$) is assumed to be dedicated to unrelated services. The matrix Z includes other variables that might affect the quality of output in the focal service. Each of our predictions can be

[4] An example of the content of such a consultation would be the postoperative management of patient glucose levels following coronary artery bypass graft surgery on a diabetic patient. This is an area where both cardiovascular specialists and endocrinology specialists provide input into decisions and where there are nuances related to the intersection of these two specialties that are not clearly the domain of either. This example highlights the more general coordination challenges resulting from subspecialization in medicine (Gawande 2009).

expressed as a partial derivative of Equation (1). Hypothesis 1 predicts that the quality of output in the focal service is increasing in that service's share of a hospital's activity (i.e., $\partial q_f/\partial x_f > 0$). Similarly, Hypothesis 2 predicts the same relationship between focal service quality and the share of a hospital's activity attributed to related services (i.e., $\partial q_f/\partial x_r > 0$). Finally, Hypothesis 3 predicts a positive cross-partial derivative of focal-service quality with respect to the shares of both the focal service and related services (i.e., $\partial^2 q_f/(\partial x_f \partial x_r) > 0$).

Setting and Data

Our analysis considers patients receiving coronary artery bypass graft (CABG) surgery as their primary procedure. CABG treats blockages of the coronary arteries and is an open-heart procedure in which the patient is placed on a heart-lung machine while the heart is stopped. Access to the heart is gained through an incision in the chest, while a blood vessel taken from either the leg or chest is used to bypass the arterial blockage. Following surgery, patients typically spend one or two days in the intensive care unit and five or six days in total receiving postoperative care in the hospital.

We focus on CABG patients for several reasons. First, CABG patients are more homogeneous than the entire population of cardiovascular patients. Second, one of the more reliably tracked quality measures in hospital discharge data is in-hospital mortality—an outcome that occurs relatively frequently in patients receiving CABG surgery compared to other clinical areas. Third, CABG patients account for a significant portion of cardiovascular patients and, as a whole, cardiovascular patients are numerous and tend to have several "secondary" diagnoses in noncardiovascular areas. This tendency enables us to identify those clinical areas from which spillovers to cardiovascular patients are likely to be greatest.

Our empirical analysis draws on hospital discharge data from the Nationwide Inpatient Sample (NIS), a database maintained by the Agency for Healthcare Research and Quality. The NIS contains patient-level data on hospital stays for approximately 1,000 hospitals in the United States each year. These hospitals are sampled from state-level hospital discharge databases and approximate a 20% stratified random sample of acute-care hospitals in the United States. Data in the NIS are reported at the level of the patient, and *all* patients admitted to a sampled hospital are included for the year in question. These data include details about the hospital (e.g., urban versus rural location, teaching status, and region of the country), individual patient demographics, the status of the patient on discharge, and the patient's primary and secondary diagnoses and procedures. We estimate both hospital- and patient-level models based on individuals who underwent CABG surgery.

To develop our sample, we begin with the NIS for the years 1995 through 2004. During this period, there were 661,910 discharges at 774 hospitals in the NIS data with a primary procedure of CABG surgery. We exclude 996 observations that contain insufficient data. Additionally, to control for factors that influence in-hospital mortality and to ensure greater homogeneity and comparability across patients, we limit our sample to those patients who had one of three primary diagnoses consistent with a primary procedure of CABG: acute myocardial infarction, acute and chronic ischemic heart disease, and angina pectoris.[5] Of the 661,910 discharges, 16,540 had a primary diagnosis other than the three noted above and were therefore excluded from our data.

The number of states included in the NIS varies from 19 in 1995 to 37 in 2004. Given that the NIS is a stratified random sample, hospitals do not appear in the NIS every year. Our empirical specifications include one-year lags of certain variables, which require hospitals to appear in the data for pairs of consecutive years. Therefore, we limit our sample to hospitals performing CABG surgery with at least one pair of consecutive years in the NIS. Additionally, we exclude hospitals with very low volumes of CABG procedures, following the practice of several public and private reporting organizations by limiting our sample to facilities performing at least 30 procedures annually (e.g., Pennsylvania Health Care Cost Containment Council 2007). Following these exclusions, our base sample of discharges includes 283,003 patients receiving CABG surgery in 382 hospitals (807 hospital-years) between 1996 (because of our lagged variables) and 2004.

Dependent Variable

Our regression models capture quality performance using the dependent variable of in-hospital mortality. We note that in-hospital mortality—although a critical measure of quality performance—represents but one dimension of operational performance in hospitals. Unfortunately, we do not have access in our setting to other performance measures, such as cost or longer-term measures of clinical quality (e.g., patient quality of life or survival following hospital discharge).

Because of heterogeneity in patient characteristics, raw mortality rates may be biased measures of hospital performance that unfairly penalize (benefit) hospitals with a more- (less-) severe mix of patients.

[5] This group includes patients with a primary International Classification of Diseases, Clinical Modification (ICD-9-CM) diagnosis code between 410 and 414. The Centers for Disease Control and Prevention (2010) provides a description of the ICD-9-CM system.

We thus estimate the risk-adjusted mortality rate ($RAMR_{jt}$) for each hospital j in year t using a logistic regression. We pool all of the patient-level CABG observations in our database. The outcome variable in this regression is $MORT_{ijt}$, an indicator that equals 1 if patient i in hospital j in year t died in the hospital and 0 otherwise. The form of this regression is as follows:

$$\ln\left(\frac{pr(MORT_{ijt}=1 \mid x_i)}{1-pr(MORT_{ijt}=1 \mid x_i)}\right)=\alpha+\beta X_i, \qquad (2)$$

where X_i represents a vector of patient-level risk factors, including demographic characteristics of the patient, the patient's primary condition, coexisting conditions, and other procedures performed during the same hospitalization that may indicate a higher risk of death. We control for patient gender and age, with an interaction term to capture the possibility that the effects of age may differ across gender. We categorize the patient's primary condition by the first three digits of the primary diagnosis code (ICD-9-CM code). Additionally, we categorize patients with a primary diagnosis of acute myocardial infarction, or heart attack, by the location of the infarction (e.g., anterior, inferior, right ventricular). We measure coexisting conditions using the approach of Elixhauser et al. (1998), which captures the presence of approximately 30 comorbidities using indicator variables for each.[6] Finally, we include indicators for two procedures that, if occurring with CABG, represent complicating factors: angioplasty prior to CABG and valve replacement surgery. Though performed by a cardiologist rather than a cardiac surgeon, angioplasty represents a primary treatment for coronary artery disease; if angioplasty is not successful, CABG is often used as an alternative. Valve replacement surgery, like CABG, is an open-heart surgical procedure.

To calculate hospital j's risk-adjusted mortality rate in year t, $RAMR_{jt}$, we average the predicted values for each patient from Equation (2) for hospital j in year t to create the predicted mortality rate PMR_{jt}. We use this value, along with the observed mortality rate OMR_{jt}—defined as the total number of CABG deaths at hospital j in year t divided by the total number of CABG patients in the hospital over the same time period—to calculate $RAMR_{jt}$:

$$RAMR_{jt}=\frac{OMR_{jt}}{PMR_{jt}}\times AMR, \qquad (3)$$

where AMR represents the observed mortality rate across all hospitals for the study period and is included simply to normalize the risk-adjusted rate.

Independent Variables

Though our analysis focuses on CABG patients, the NIS includes data on *every* patient in a particular hospital in a given year. This feature allows us to observe a hospital's focus on a particular service area as a continuous variable based on the percentage of its total operational activity occurring in that area. We measure a hospital's focus in cardiovascular services ($FOCUS_{jt}$) as the percentage of patients at that hospital in a particular year whose primary diagnosis—the principal reason for hospitalization—falls in the area of cardiovascular disease.[7] Formally,

$$FOCUS_{jt}=\frac{\sum_{i=1}^{n_{jt}} CARDIO_{ijt}}{n_{jt}}, \qquad (4)$$

where $CARDIO_{ijt}$ is a binary indicator that equals 1 if patient i discharged from hospital j in year t had a primary diagnosis in cardiovascular disease and 0 otherwise. The denominator n_{jt} represents the total number of patients—cardiovascular or otherwise—discharged from hospital j during year t. We note that cardiovascular disease includes, but is not limited to, patients receiving CABG. It also includes other branches of cardiovascular care, such as diagnostic cardiology, interventional cardiology and angioplasty, valve surgery, other forms of treatment for heart failure, and treatments related to cardiac rhythm management. As a continuous, share-based measure, $FOCUS_{jt}$ captures operational specialization in a more nuanced manner than studies that measure focus in a discrete way, such as a simple count of the number of activities in which the organization participates or binary indicators for whether an organization is involved in a particular activity (Hayes and Wheelwright 1984, Kekre and Srinivasan 1990, Suarez et al. 1996, Huckman and Zinner 2008).

To define related services, we identify hospital service categories with the greatest potential for positive spillovers or complementarities with cardiovascular care. We do this by taking advantage of data detailing *secondary* diagnoses (i.e., conditions that are present

[6] These conditions include congestive heart failure, valvular disease, pulmonary circulation disorders, hypertension (uncomplicated and complicated), paralysis, other neurological disorders, chronic pulmonary disease, diabetes (uncomplicated and complicated), hypothyroidism, renal failure, liver disease, chronic peptic ulcer disease, HIV and AIDS, lymphoma, metastatic cancer, solid tumor without metastasis, rheumatoid arthritis/collagen vascular disease, coagulation deficiency, obesity, weight loss, fluid and electrolyte disorders, blood loss anemia, deficiency anemias, alcohol abuse, drug abuse, psychoses, and depression.

[7] We define patients with a primary diagnosis in cardiovascular disease as those with a primary diagnosis in major diagnostic category 5 (i.e., diseases and disorders of the circulatory system).

but not the primary reason for the patient's hospitalization) for each patient. We assume that the presence of these secondary conditions suggests the need for knowledge and experience specific to treating them. The NIS database includes information on up to 15 secondary diagnoses for each patient, which allows us to determine—across our entire sample of cardiovascular patients—the frequency of specific secondary diagnoses. We aggregate these secondary diagnoses into service groups using major diagnostic categories (MDCs). Each MDC corresponds to a single organ system or disease category. Table 1 summarizes the frequency with which other MDCs appear as *secondary* diagnosis categories in patients with a primary diagnosis in cardiovascular disease.

We define *related* service categories as those that appear as secondary diagnoses for at least 20% of primary cardiovascular patients. The implication is that at least two of every ten cardiovascular patients may benefit from access to expertise in these related areas through mechanisms such as knowledge sharing (Henderson and Cockburn 1996) among clinical specialists. Our analysis indicates that 4 of the 24 noncardiovascular MDCs meet this requirement: MDC 4 (diseases and disorders of the respiratory system), MDC 6 (diseases and disorders of the digestive system), MDC 10 (endocrine, nutritional, and metabolic diseases and disorders), and MDC 11 (diseases and disorders of the kidney and urinary tract). We define the degree to which hospitals are engaged in related service categories ($RELATED_{jt}$) as follows:

$$RELATED_{jt} = \frac{\sum_{i=1}^{n_{jt}} RELATED_{ijt}}{n_{jt}}, \quad (5)$$

where $RELATED_{ijt}$ is an indicator equal to 1 if the *primary* diagnosis for patient i discharged from hospital j in year t is in a service area that is related to cardiovascular care. Again, n_{jt} represents the total number of patients discharged from hospital j in year t. $RELATED_{jt}$ thus captures the extent to which a hospital concentrates on treating patients whose *primary* needs fall into those areas that most commonly appear as *secondary* needs for primary cardiovascular patients.

We recognize that our choice of 20% as a cutoff for including service categories in $RELATED_{jt}$ may seem arbitrary. Accordingly, we investigate the robustness of our results to relaxing this threshold. Moreover, in our base specification, $RELATED_{jt}$ is equivalent to a combination of variables representing the share of patients in each of several individual MDCs. To validate our decision to combine these categories, we employ factor analysis to determine the degree to which the individual MDCs load onto a common factor. Though we do not report the results of this analysis in detail here, we note that they suggest that the MDCs above the 20% threshold load onto the same factor, whereas those below it do not.[8]

Though we estimate a version of our model including $RELATED_{jt}$ as a continuous variable, most of our models categorize $RELATED_{jt}$ into discrete groups to facilitate the interpretation of interaction effects. We initially split $RELATED_{jt}$ at the median for each year, dividing it into $RELATEDBelowMedian_{jt}$ and $RELATEDAboveMedian_{jt}$. To allow additional flexibility in the specification of interaction effects, our base model further divides relatedness into three levels ($RELATED1_{jt}$, $RELATED2_{jt}$, and $RELATED3_{jt}$), with cutoffs defined at the 33rd and 66th percentiles of $RELATED_{jt}$ for each year. Hospitals in the *RELATED1* category thus have the lowest level of services that are related with cardiovascular care, and those in the *RELATED3* category have the highest.

Finally, we include a measure of the total volume of admissions at hospital j in year t, which allows us to control for the impact of a hospital's overall volume, or size, on mortality rates. In our robustness checks, we also run versions of our model that substitute cardiovascular volume or CABG volume for

Table 1 Frequency of Secondary Diagnoses in Patients with Primary Diagnosis in Cardiovascular Care (MDC = 5)

MDC	MDC description	Frequency (%)
10	Endocrine, nutritional, and metabolic diseases and disorders	64
4	Diseases and disorders of the respiratory system	31
6	Diseases and disorders of the digestive system	21
11	Diseases and disorders of the kidney and urinary tract	20
8	Diseases and disorders of the musculoskeletal system and connective tissue	19
20	Alcohol/drug use and alcohol/drug-induced organic mental conditions	18
23	Factors influencing health status	15
16	Diseases and disorders of blood, blood-forming organs, and immunological disorders	15
19	Mental diseases and disorders	14
1	Diseases and disorders of the nervous system	13
18	Infectious and parasitic diseases (systemic or unspecified sites)	10

Notes. There are 12 MDCs that appear as a secondary diagnosis for less than 10% of patients with a cardiovascular primary diagnosis. These MDCs are skin, subcutaneous tissue, and breast (MDC 9); male reproductive system (MDC 12); hepatobiliary system and pancreas (MDC 7); ear, nose, mouth, and throat (MDC 3); eye (MDC 2); injuries, poisoning, and toxic effects of drugs (MDC 21); neoplastic disorders (MDC 17); female reproductive system (MDC 13); human immunodeficiency virus (MDC 25); newborns and other neonates (MDC 15); burns (MDC 22); and pregnancy, childbirth, and the puerperium (MDC 14).

[8] Factor loadings for MDCs 4, 6, 10, and 11 meet a threshold of 0.70; those for MDCs 8 and 20 are closer to zero. Chronbach's alpha is 0.70 for the combination of MDCs 4, 6, 10, and 11. The removal of any one of these individual MDCs results in a slightly lower alpha.

Table 2 Summary Statistics and Correlations

($N = 807$)	Mean	SD	Min	Max	*RAMR*	*Focus*	*Volume*	*Related*
RAMR	0.028	0.018	0.000	0.244	1			
Focus	0.197	0.088	0.067	0.884	−0.092	1		
Volume	19,125	10,255	2,490	68,464	0.007	−0.168	1	
Related	0.220	0.043	0.073	0.387	−0.038	−0.003	−0.172	1

total volume. Table 2 presents summary statistics and correlations for the key variables in our analysis. We note that *FOCUS* and *RELATED* have a correlation of −0.003. This low correlation suggests that the effects of *FOCUS* and *RELATED* can be separately identified in our sample.[9]

Empirical Model

We estimate the following base model to test for the effects of focus and related service intensity on risk-adjusted mortality rates:

$$\begin{aligned} RAMR_{jt} = {} & \alpha_j + \lambda_t + \beta_1 RELATED2_{jt-1} \\ & + \beta_2 RELATED3_{jt-1} \\ & + \beta_3 \ln(FOCUS)_{jt-1} \times RELATED1_{jt-1} \\ & + \beta_4 \ln(FOCUS)_{jt-1} \times RELATED2_{jt-1} \\ & + \beta_5 \ln(FOCUS)_{jt-1} \times RELATED3_{jt-1} \\ & + \beta_6 \ln(VOLUME)_{jt-1} + \beta_7 X_{jt} + \varepsilon_{jt}. \end{aligned} \tag{6}$$

We include year fixed effects (λ_t) to control for unobserved factors that may drive the average trend in CABG mortality over time. We control for overall hospital size with $\ln(VOLUME)_{jt-1}$ and include X_{jt}, a vector of hospital characteristics including urban versus rural location, teaching status, and region of the country, to capture hospital-level factors that may be associated with mortality rates.

We take the natural log of focus to allow for a nonlinear relationship between *FOCUS* and *RAMR*. In doing so, we note that our data include some hospitals with high values of *FOCUS* (e.g., > 70% of discharges in cardiovascular care). For these hospitals, a change in *FOCUS* of, say, five percentage points is a less substantial shift (and is likely to have a smaller effect on *RAMR*) than for a hospital with a much lower initial value of *FOCUS*. To examine robustness, we also estimate versions of our base model in which *FOCUS* enters as a linear variable. We note, however, that the R^2 for our models using the log of *FOCUS* are consistently higher than those for otherwise similar models using *FOCUS* as a linear regressor.[10] Finally, we demean our measures of *FOCUS* to facilitate interpretation of interaction terms.

We lag *FOCUS*, *RELATED*, and *VOLUME* by one year to reduce concerns about reverse causality in the relationship between these variables and hospital performance. We do this because it is possible that hospitals with strong cardiovascular performance in one year may experience an increase in their cardiovascular focus in subsequent years. To the extent that hospitals gain or lose cardiovascular volume (and focus) based on their reputations as "good" or "bad" hospitals—reputations that plausibly remain relatively stable over the time period we consider—we aim to control for this potential reverse causality by including hospital random effects (α_j). To examine the appropriateness of using random effects, researchers generally employ a simple Hausman test. However, our panel data are clustered by hospital, a characteristic not permitted by the Hausman test, and thus we must rely on a Hausman-like test of fixed versus random effects—a test of overidentifying restrictions—implemented in Stata using the xtoverid command (Schaffer and Stillman 2006). In our case, the xtoverid procedure produces a test statistic that is not significant at conventional levels ($p = 0.203$), suggesting that random effects are both consistent and efficient. We also report the results of the fixed-effects model for comparison.

In our base regressions, we interact *FOCUS* with each of the categories of *RELATED* to determine the degree to which the returns to focus—in terms of mortality performance—depend on the intensity with which hospitals engage in related activities. Given the construction of our variables, the estimate of β_3 represents the total effect of focus for hospitals in *RELATED1*, and β_4 and β_5 represent similar total effects for hospitals in *RELATED2* and *RELATED3*, respectively. Based on our hypotheses, we expect to find that a greater level of *FOCUS* leads to lower mortality (i.e., $\beta_3 < 0$, $\beta_4 < 0$, and $\beta_5 < 0$ per Hypothesis 1), that a greater level of *RELATED* leads to lower mortality (i.e., $\beta_2 < \beta_1 < 0$ per Hypothesis 2), and that the marginal effect of *FOCUS* becomes greater in magnitude as hospitals move from *RELATED1* to *RELATED2* to *RELATED3* (i.e., $\beta_5 < \beta_4 < \beta_3 < 0$ per Hypothesis 3). Put differently, this final prediction suggests that the marginal benefit of focus in terms of quality performance should be increasing in the hospital's level of specialization in related activities.

[9] Some may find this surprising, as both *FOCUS* and *RELATED* are calculated by dividing hospital volume in certain clinical areas over total hospital volume. Thus, to the extent that *FOCUS* increases, one might expect *RELATED* to decrease. We note that this is not necessarily the case, because hospitals also engage in clinical activities, classified as *unrelated* nonfocal activities, that are not captured by either *FOCUS* or *RELATED*. In fact, given that the means of *FOCUS* and *RELATED* sum to roughly 0.40, unrelated nonfocal activities account for 60% of hospital activity on average.

[10] Except where explicitly noted in the remainder of this document, ln*(FOCUS)* and *FOCUS* are used synonymously.

Table 3 Regressions Testing the Effect of Focus and Relatedness on Mortality Rates

Coefficient	RAMR (1)	(2)	(3)	(4)	(5)	(6)
ln(*VOLUME*)	−0.0041 (0.0035)	−0.0043 (0.0035)	−0.0039 (0.0034)	−0.0040 (0.0033)	−0.0042 (0.0034)	0.0168 (0.0150)
ln(*FOCUS*)	−0.0116** (0.00411)	−0.0115** (0.0044)	−0.0136** (0.0050)			
ln(*RELATED*)		−0.0046 (0.0036)	−0.0011 (0.0042)			
ln(*FOCUS*) × ln(*RELATED*)			−0.0145* (0.0072)			
RELATED(*AboveMedian*)				0.0010 (0.0015)		
ln(*FOCUS*) × *RELATED*(*BelowMedian*)				−0.0056† (0.0030)		
ln(*FOCUS*) × *RELATED*(*AboveMedian*)				−0.0245** (0.0085)		
RELATED2					0.0002 (0.0015)	−0.0012 (0.0026)
RELATED3					−0.0015 (0.0021)	−0.0011 (0.0041)
ln(*FOCUS*) × *RELATED1*					−0.0042 (0.0032)	−0.0065 (0.0126)
ln(*FOCUS*) × *RELATED2*					−0.0200* (0.0086)	−0.0158 (0.0147)
ln(*FOCUS*) × *RELATED3*					−0.0210** (0.0071)	−0.0536** (0.0240)
Categories of related	None	None	None	Halves	Thirds	Thirds
Method	Random effects	Random effects	Random effects	Random effects	Random effects	Fixed effects
Observations	807	807	807	807	807	400
Number of hospitals	382	382	382	382	382	103
R-squared	0.051	0.054	0.055	0.056	0.066	0.130

Notes. Robust standard errors are clustered by hospital. Regressions include hospital random or fixed effects and year fixed effects. Random effects models also include indicators for the following hospital characteristics: urban location, teaching status, and geographic region. Standard errors are in parentheses.
$^{**}p < 0.01$; $^{*}p < 0.05$; $^{\dagger}p < 0.10$.

Results and Discussion

Base Results

Table 3 presents estimates for several versions of Equation (6). In column (1), we examine the average effect of focus alone. The data in column (1) suggest that, on average, focus has a negative effect on risk-adjusted mortality, a result that is significant at the 1% level. The estimate implies that a one-standard-deviation increase from the mean value of *FOCUS* results in a reduction in the average mortality rate of 0.4 percentage points (i.e., a 14% reduction). This translates to an additional life saved for every 250 patients treated. A similar estimate is reported in column (2), where the logarithmic form of *RELATED* is added to the model. These results support the beneficial average impact of focus on performance predicted in Hypothesis 1. Column (3) presents the results of a model in which the continuous versions of *FOCUS* and *RELATED* (both in logarithmic form) are interacted. Both variables have been demeaned to facilitate interpretation. We begin by noting that specialization in related activities in and of itself does not have a statistically significant effect on risk-adjusted mortality. That is, we do not find support for the positive spillovers predicted in Hypothesis 2. The estimate on the interaction term in column (3), however, is in the predicted direction and statistically significant at conventional levels, suggesting that the marginal benefit of specializing in cardiovascular care is amplified by greater specialization in related areas. Column (3) thus provides initial support for the complementarities predicted in Hypothesis 3.

In columns (4) and (5), we employ various categorical forms of *RELATED*—first split at the median and then into thirds—interacted with *FOCUS*. Our results again suggest that the marginal effect of focus on mortality depends on the level of relatedness. In column (4), the estimated coefficient on *FOCUS* is negative (but significant only at the 10% level) for hospitals in the *RELATEDBelowMedian* category. For hospitals in the *RELATEDAboveMedian* category, however, the estimated coefficient on *FOCUS* is negative and significant at the 1% level. We note that this latter estimate is significantly different from the estimate of *FOCUS* for the *RELATEDBelowMedian* category at the 1% level. Similarly, in column (5), the estimated effect of *FOCUS* is negative but insignificant for hospitals in *RELATED1* and negative and significant for hospitals in *RELATED2* and *RELATED3*. These estimates indicate that a one-standard-deviation increase from the mean value of *FOCUS* results in an overall reduction in mortality of 0.71 percentage points for hospitals in the *RELATED2* category and 0.74 percentage points for hospitals in the *RELATED3* category. These improvements correspond to an additional life saved for approximately every 135 patients treated. We note that although the estimate on *FOCUS* for hospitals in *RELATED3* is not significantly different from that for *RELATED2*, each of these estimates is significantly different from that for *RELATED1* at the 5% level. Overall, the results in Table 3 suggest that hospitals with the moderate to high levels of specialization in related services experience greater returns to focus (in terms of quality performance) than those with lower levels of specialization in related services.

A key implication of these findings is that, in the extreme, hospitals with 100% focus on cardiovascular care—which do exist in practice and fall, by definition, into the *RELATED1* category—may experience *lower* returns to focus than a hospital that maintains a substantial focus on cardiovascular care but also offers primary services in related areas. Thus, these results provide strong support for Hypothesis 3 and suggest the importance of complementarities in explaining the benefits of related diversification in this setting.

We acknowledge that any endogeneity in our key explanatory variables may lead to biased estimates. As noted earlier, we recognize that hospitals with higher-quality CABG programs may attract larger absolute volumes of CABG patients, thereby increasing their level of focus on cardiovascular care. Though we believe that the lagging of the focus variable and the inclusion of hospital random effects go a long way in addressing potential endogeneity concerns, we are able to directly test for reverse causality by running a reverse regression model, with the natural log of a hospital's current focus as the dependent variable and its lagged risk-adjusted mortality rate for CABG as the independent variable. The model includes hospital random effects and year fixed effects.[11] If focus is indeed endogenously related to performance, we would expect to find a negative and significant relationship between the lagged risk-adjusted mortality rate and the degree of focus in cardiovascular disease. Though we find that the coefficient on *RAMR* is negative, it does not approach conventional levels of statistical significance ($p = 0.878$). We note that a similar result is observed if hospital random effects are replaced by hospital fixed effects. These results are encouraging, as they mitigate concern that a hospital's level of focus is endogenously determined by its prior performance.

Robustness

Our results may be sensitive to the choices we have made in generating our sample, measuring our variables of interest, and constructing our base model. We conduct several robustness checks to examine the extent of this potential sensitivity.

First, our base model relies on hospital random effects, an approach supported by our test of overidentifying restrictions. We do, however, examine the robustness of our results to the inclusion of hospital fixed effects (Table 3, column (6)). To ensure sufficient precision in estimating hospital effects, the sample for our fixed-effects model includes only facilities with at least three annual observations in the sample. The results in column (6) are consistent with those reported in column (5) and suggest that our finding of greater benefits from focus at higher levels of specialization in related services is robust to using fixed effects.[12]

Second, our definition of related services includes the four MDCs that account for secondary diagnoses in at least 20% of cardiovascular patients. To examine alternative definitions of related services, we consider the impact of restricting and relaxing this threshold. Specifically, we begin by defining *RELATED* to include only the most frequently occurring secondary MDC (MDC 10) and then progressively add

[11] The model is specified as follows, where, as before, α_j and λ_t are hospital and year fixed effects, respectively:

$$\ln(FOCUS)_{jt} = \alpha_j + \lambda_t + \beta_1 RAMR_{jt-1} + \varepsilon_{jt}.$$

[12] One slight difference in these results is that in column (5), the impact of *FOCUS* for *RELATED2* and *RELATED3* are significantly different both from zero and from the impact of *FOCUS* for *RELATED1*. Yet the impacts of *FOCUS* for *RELATED2* and *RELATED3* are not significantly different from each other. In column (6), the impact of *FOCUS* for *RELATED3* is significantly different both from zero and from the impact of *FOCUS* for *RELATED1* and *RELATED2*. In addition, the impacts of *FOCUS* for *RELATED*1 and *RELATED*2 are not significantly different from each other. In both cases, however, the finding of complementarities in specialization is present.

Table 4 Regressions Testing Different Definitions of RELATED

	RAMR					
Coefficient	(1)	(2)	(3)	(4)	(5)	(6)
ln(*VOLUME*)	−0.0041	−0.0040	−0.0043	−0.0042	−0.0034	−0.0043
	(0.0033)	(0.0034)	(0.0036)	(0.0034)	(0.0032)	(0.0037)
RELATED2	−0.0015	0.0001	−0.0012	0.0002	−0.0007	0.0011
	(0.0015)	(0.0014)	(0.0014)	(0.0015)	(0.0013)	(0.0015)
RELATED3	−0.0006	0.0020	−0.0007	−0.0015	0.0019	−0.0004
	(0.0017)	(0.0019)	(0.0023)	(0.0021)	(0.0028)	(0.0022)
ln(*FOCUS*) × *RELATED1*	−0.0058	−0.0047	−0.0086	−0.0042	−0.0053†	−0.0085*
	(0.0032)	(0.0030)	(0.0052)	(0.0032)	(0.0031)	(0.0036)
ln(*FOCUS*) × *RELATED2*	−0.0075†	−0.0162†	−0.0108*	−0.0200*	−0.0098*	−0.0133
	(0.0041)	(0.0083)	(0.0047)	(0.0086)	(0.0042)	(0.0082)
ln(*FOCUS*) × *RELATED3*	−0.0299**	−0.0221**	−0.0198**	−0.0210**	−0.0279*	−0.0166**
	(0.0100)	(0.0071)	(0.0068)	(0.0071)	(0.0124)	(0.0060)
MDCs in related	10	4, 10	4, 6, 10	4, 6, 10, 11	4, 6, 10, 11, 8	4, 6, 10, 11, 8, 20
MDCs added					8	8, 20
Observations	807	807	807	807	807	807
Number of hospitals	382	382	382	382	382	382
R-squared	0.076	0.070	0.056	0.066	0.060	0.056

Notes. Robust standard errors are clustered by hospital. Regressions include hospital random effects, year fixed effects, and indicators for the following hospital characteristics: urban location, teaching status, and geographic region. Standard errors are in parentheses.
$^{**}p < 0.01$; $^{*}p < 0.05$; $^{\dagger}p < 0.10$.

the next most frequent MDC, working our way down the list in Table 1. The results of these models are presented in Table 4. The model specifications are the same as in Equation (6) except that *RELATED1*, *RELATED2*, and *RELATED3* have been defined using the MDCs specified in each column. Column (4) repeats our base results. The results in columns (1)–(3) suggest that as we make the threshold more restrictive, the complementarity we see in our base results continues to hold. Columns (5) and (6) suggest that as we relax the threshold, we initially see little or no effect on our results when adding MDC 8 but begin to see complementarity dissipate as we further relax the threshold by adding MDC 20. Specifically, a test of the difference between the estimates on *FOCUS* for hospitals in *RELATED1*, *RELATED2*, and *RELATED3* in column (6) suggests that they are statistically indistinguishable at conventional levels. These results are consistent with our predictions, as one would expect complementarities from related services to decline as the definition of relatedness is expanded to include clinical areas that are progressively less likely to appear as secondary diagnoses for cardiovascular patients.

Though not presented in detail here, we perform a number of additional robustness checks. These include (1) running our base models at the patient level rather than the hospital level;[13] (2) defining *FOCUS* at the procedure level (i.e., CABG cases as a share of total hospital volume) rather than the disease level (i.e., cardiovascular cases as a share of total hospital volume); (3) controlling for cardiovascular volume and CABG volume in place of total hospital volume; (4) including only patients who actually have secondary conditions in disease areas defined as *RELATED*; and (5) limiting the sample for our fixed-effects model to those hospitals with at least four (rather than at least three) observations in the data to improve the precision in estimating our hospital fixed effects. The results of each of these additional analyses are consistent with the results presented in Table 4. A few of these checks, however, merit additional discussion.

We begin by noting that our base models capture total hospital volume as part of two different variables: ln(*VOLUME*) and ln(*FOCUS*). The coefficient on ln(*FOCUS*) thus represents the marginal impact that variable has on mortality, holding ln(*VOLUME*) constant. An alternate specification would replace ln(*FOCUS*) with logged *cardiovascular* volume for the hospital. We do not use this approach for several reasons. First, we explicitly want to measure the impact of cardiovascular focus, or specialization, rather than absolute cardiovascular volume. Second, there is a high degree of comovement between the logged values of cardiovascular volume and total hospital volume (correlation = 0.806), so we are not able to observe independent variation in each measure. The same is not true for ln(*VOLUME*) and ln(*FOCUS*)

[13] These patient-level models are identical to the model presented in Equation (6), with the exception that they also include the patient-level covariates in the vector X_i from the regression used to risk adjust mortality (see Equation (2)).

(correlation = −0.192). Third, this alternate specification constrains the impact of a one-unit increase in logged cardiovascular volume to be the same, regardless of the level of logged total hospital volume. However, the change in ln(*FOCUS*) for a one-unit increase in cardiovascular volume would differ depending on the level of ln(*VOLUME*), and we want to capture this difference in testing our hypotheses.

We also note that our base model considers all CABG patients. However, one might expect the complementary effect of specialization in related areas to be particularly beneficial for patients who actually have secondary conditions in those areas. We thus run a version of our base model with the sample limited to the 83% of all CABG patients who had at least one secondary diagnosis in the four major diagnostic categories that define *RELATED* in our base regressions. This analysis produces estimates that are very similar to those presented in Table 3.

Conclusion

Our paper examines how managers can balance the benefits of focus and diversification within individual operating units. We begin by establishing within our setting that operational focus is, on average, associated with better quality performance. We then examine the extent to which specialization in related activities generates positive spillovers that impact the level of quality performance for a focal activity; we find no evidence of such spillovers. Finally, we investigate whether there are complementarities in specialization across related areas. We find that hospitals with greater specialization in related business segments experience a higher marginal benefit to specialization in a focal segment. That is, there are complementarities resulting from cospecialization in focal and related segments.

Our study contributes to the literature on specialization in several ways. First, we find that the benefits of related diversification—which have been identified *across* operating units within firms—also exist *within* operating units. Like studies conducted at the firm level, our results at the level of the operating unit suggest that related activities play an important role in the connection between focus and performance. Our findings, however, push this analysis deeper by offering evidence that complementarities—not just positive spillovers (e.g., simple economies of scale in shared resources)—play a role in explaining the benefits of related diversification. These results are robust to changes in the level of observation, definition of focus, and designation of related businesses.

In the context of the hospital industry, our work highlights the need for a broader conceptualization of what it means for a hospital to specialize. The model of the single-specialty hospital has become increasingly popular in areas such as cardiovascular care, orthopedics, and obstetrics. Nevertheless, our findings suggest that single-specialty hospitals—and multispecialty facilities interested in emphasizing a specific clinical service—need to look beyond their focal activity to build strong capabilities in complementary areas. This is consistent with the view that, to deliver value for patients with specific diseases, healthcare organizations should include "all needed specialties and the prevalent comorbidities" (Porter and Teisberg 2007, p. 1104).

Our study faces several potential limitations, and its results should be interpreted accordingly. First, we reiterate the empirical issues regarding specification and potential endogeneity that we have addressed with the robustness checks discussed above. Second, our study is limited to one technology (CABG surgery) and one industry, which may limit the generalizability of its findings. Nevertheless, the theoretical foundation of this paper has its roots in other industries. For example, the literature on focus has largely centered on manufacturing firms (Hayes and Wheelwright 1984, Brush and Karnani 1996, Bozarth and Edwards 1997), and the literature on related diversification includes large samples of firms representing a cross-section of industries (Christensen and Montgomery 1981, Rumelt 1982, Palepu 1985).

Third, we consider one measure of performance—quality as captured by risk-adjusted mortality—but are not able to consider other important operational metrics, such as cost. As a result, our paper cannot speak to the impact of focus on overall value (e.g., cost-adjusted quality). The data used in this study do not provide information on costs. What is available are data on hospital *charges*, which, because of the varied discounts offered across hospitals and across services within hospitals, are not representative of either actual prices or costs. Despite this limitation, quality—which we *are* able to study—remains a critical component in determining the value of healthcare provided. Examining the implications of related diversification for overall value represents an important topic for future study.

Fourth, our study considers the impact of focus and related diversification on the execution of an organization's current tasks, not on its innovative performance (i.e., its ability to develop new products or services). The work of several authors (e.g., Abernathy and Wayne 1974, March 1991, and O'Reilly and Tushman 2004) suggests that focused organizations may face significant challenges with respect to innovation. Examining whether our findings translate to innovation-based settings thus represents a fruitful avenue for future research.

Finally, we define related areas based on the frequency with which cardiovascular patients have secondary needs in those areas. We assume that related areas represent those most likely to generate positive spillovers or complementarities with cardiovascular care. Unfortunately, our data do not allow us to isolate the precise mechanism generating the complementarities we observe in our empirical results. For example, we cannot determine whether these complementarities are caused by physical proximity of related services, direct interactions among physicians in different specialties, or the transfer of information by specific individuals who span boundaries (Tushman and Scanlan 1981) across clinical specialties (e.g., nurses working with patients in both focal and related areas). Additionally, although interactions among individuals may be important in knowledge-intensive settings such as healthcare delivery, other mechanisms may be more important sources of complementarities in other environments. Additional work is required to investigate such mechanisms.

Despite these caveats, our study highlights the potential role of complementarities in enhancing the benefits of focus on performance. In so doing, it emphasizes that the benefits of related diversification may be derived from sources beyond the simple amortization or sharing of fixed assets. Specifically, our findings suggest that the returns to an operating unit specializing in a given line of business may depend on the degree to which the unit "cospecializes" in related activities. Ultimately, these results provide a potential explanation for why one might find decreasing returns to focusing an organization on a single operating activity (or narrow set of activities), especially when it is possible to invest in other activities that complement the organization's area of concentration.

Acknowledgments

The authors appreciate helpful comments from the department editor, an associate editor, three referees, Carliss Baldwin, David Chan, Rebecca Henderson, Andrew King, Gary Pisano, and seminar participants at the Academy of Management, the American Society of Health Economists, Emory University, Harvard Business School, Massachusetts Institute of Technology, the National Bureau of Economic Research, the University of Michigan, the University of Minnesota, and the University of Pennsylvania. The authors acknowledge support for this research from the Division of Research and Faculty Development at Harvard Business School.

References

Abernathy, W. J., K. Wayne. 1974. The limits of the learning curve. *Harvard Business Review* **52**(5) 109–118.

Barro, J. R., R. S. Huckman, D. P. Kessler. 2006. The effects of cardiac specialty hospitals on the cost and quality of medical care. *J. Health Econom.* **25**(4) 702–721.

Berger, P. G., E. Ofek. 1995. Diversification's effect on firm value. *J. Financial Econom.* **37**(1) 39–65.

Boh, W. F., S. A. Slaughter, J. A. Espinosa. 2007. Learning from experience in software development: A multilevel analysis. *Management Sci.* **53**(8) 1315–1331.

Bozarth, C., S. Edwards. 1997. The impact of market requirements focus and manufacturing characteristics focus on plant performance. *J. Oper. Management* **15**(3) 161–180.

Brush, T., A. Karnani. 1996. Impact of plant size and focus on productivity: An empirical study. *Management Sci.* **42**(7) 1065–1081.

Campa, J. M., S. Kedia. 2002. Explaining the diversification discount. *J. Finance* **57**(4) 1731–1762.

Carey, K., J. F. Burgess, G. J. Young. 2008. Specialty and full-service hospitals: A comparative cost analysis. *Health Services Res.* **43**(5) 1869–1887.

Centers for Disease Control and Prevention. 2010. Classificaiton of diseases, functioning, and disability. Report. Accessed June 8, http://www.cdc.gov/nchs/about/otheract/icd9/abticd9.htm.

Christensen, C. M., J. H. Grossman, J. Hwang. 2009. *The Innovator's Prescription: A Disruptive Solution for Health Care*. McGraw-Hill, New York.

Christensen, H. K., C. A. Montgomery. 1981. Corporate economic performance: Diversification strategy versus market structure. *Strategic Management J.* **2**(4) 327–343.

Cohen, W. M., D. A. Levinthal. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administ. Sci. Quart.* **35**(1) 128–152.

Cram, P., G. Rosenthal, M. Vaughan-Sarrazin. 2005. Cardiac revascularization in specialty and general hospitals. *New England J. Medicine* **352**(14) 1454–1462.

Elixhauser, A., C. Steiner, D. R. Harris, R. M. Coffey. 1998. Comorbidity measures for use with administrative data. *Medical Care* **36**(1) 8–27.

Fayol, H. 1916. *Administration Industrielle Generale*. Dunod, Paris.

Fisher, M. L., C. D. Ittner. 1999. The impact of product variety on automobile assembly operations: Empirical evidence and simulation analysis. *Management Sci.* **45**(6) 771–786.

Gawande, A. 2009. *The Checklist Manifesto*. Metroplitan Books, New York.

Ginsburg, P. B. 2000. Are focused factories the wave of the future? *Frontiers of Health Services Management* **16**(3) 41–46.

Greenwald, L., J. Cromwell, W. Adamache, S. Bernard, E. Drozd, E. Root, K. Devers. 2006. Specialty versus community hospitals: Referrals, quality, and community benefits. *Health Affairs* **25**(1) 106–118.

Hayes, R. H., S. C. Wheelwright. 1984. *Restoring Our Competitive Edge: Competing Through Manufacturing*. Wiley, New York.

Henderson, R., I. Cockburn. 1996. Scale, scope, and spillovers: The determinants of research productivity in drug discovery. *RAND J. Econom.* **27**(1) 32–59.

Herzlinger, R. E. 1997. *Market-Driven Health Care*. Addison-Wesley, Reading, MA.

Heskett, J. L. 1986. *Managing in the Service Economy*. Harvard Business School Press, Boston.

Huckman, R., D. Zinner. 2008. Does focus improve operational performance? Lessons from the management of clinical trials. *Strategic Management J.* **29**(2) 173–193.

Hwang, C. W., G. F. Anderson, M. Diener-West, N. R. Powe. 2007. Comorbidity and outcomes of coronary artery bypass graft surgery at cardiac specialty hospitals versus general hospitals. *Medical Care* **45**(8) 720–728.

Hyer, N. L., U. Wemmerlov, J. A. Morris. 2009. Performance analysis of a focused hospital unit: The case of an integrated trauma center. *J. Oper. Management* **27**(3) 203–219.

Kahneman, D. 1973. *Attention and Effort*. Prentice-Hall, Englewood Cliffs, NJ.

KC, D. S., C. Terwiesch. 2011. The effects of focus on performance: Evidence from California hospitals. *Management Sci.* **57**(11) 1897–1912.

Kekre, S., K. Srinivasan. 1990. Broader product line: A necessity to achieve success? *Management Sci.* **36**(10) 1216–1231.

Ketokivi, M., M. Jokinen. 2006. Strategy, uncertainty and the focused factory in international process manufacturing. *J. Oper. Management* **24**(3) 250–270.

Lang, L. H. P., R. M. Stulz. 1994. Tobin's q, corporate diversification, and firm performance. *J. Political Econom.* **102**(6) 1248–1280.

Lapre M. A., N. Tsikriktsis. 2006. Organizational learning curves for customer dissatisfaction: Heterogeneity across airlines. *Management Sci.* **52**(3) 352–366.

Levitt, B., J. March. 1988. Organizational learning. *Annual Rev. Sociol.* **14** 319–340.

MacDuffie, J. P., K. Sethuraman, M. L. Fisher. 1996. Product variety and manufacturing performance: Evidence from the international automotive assembly plant study. *Management Sci.* **42**(3) 350–369.

Manian, F., D. Janssen. 1996. Curbside consultations: A closer look at a common practice. *J. Amer. Medical Assoc.* **275**(2) 145–147.

March, J. G. 1991. Exploration and exploitation in organizational learning. *Organ. Sci.* **2**(1) 71–87.

March, J., H. Simon. 1958. *Organizations*. Wiley, New York.

Markides, C., P. J. Williamson. 1994. Related diversification, core competences and corporate performance. *Strategic Management J.* **15**(S2) 149–165.

Milgrom, P., J. Roberts. 1994. Complementarities and systems: Understanding Japanese economic organization. *Estudios Económicos* **9**(1) 3–42.

Milgrom, P., J. Roberts. 1995. Complementarities and fit strategy, structure, and organizational change in manufacturing. *J. Accounting Econom.* **19**(2–3) 179–208.

Mukherjee, A., W. Mitchell, F. B. Talbot. 2000. The impact of new manufacturing requirements on production line productivity and quality at a focused factory. *J. Oper. Management* **18**(2) 139–168.

Nallamothu, B. K., Y. Wang, P. Cram, J. D. Birkmeyer, J. S. Ross, S. T. Normand, H. M. Krumholz. 2007. Acute myocardial infarction and congestive heart failure outcomes at specialty cardiac hospitals. *Circulation* **116**(20) 2280–2287.

Narayanan, S., S. Balasubramanian, J. M. Swaminathan. 2009. A matter of balance: Specialization, task variety, and individual learning in a software maintenance environment. *Management Sci.* **55**(11) 1861–1876.

Ocasio, W. 1997. Towards an attention-based view of the firm. *Strategic Management J.* **18**(S1) 187–206.

O'Reilly, C. A., M. L. Tushman. 2004. The ambidextrous organization. *Harvard Bus. Rev.* **82**(4) 74–81.

Palepu, K. 1985. Diversification strategy, profit performance and the entropy measure. *Strategic Management J.* **6**(3) 239–255.

Panzar, J. C., R. D. Willig. 1981. Economies of scope. *Amer. Econom. Rev.* **71**(2) 268–272.

Parrino, T., A. White. 1990. Grand rounds revisited: Results of a survey of U.S. departments of medicine. *Amer. J. Medicine* **89**(4) 491–495.

Pennsylvania Health Care Cost Containment Council. 2007. *Technical Notes for PHC4's Report on CABG and Valve Surgery, Calendar Year 2005*. State of Pennsylvania, Harrisburg.

Porter, M. E., E. O. Teisberg. 2006. *Redefining Health Care: Creating Value-Based Competition on Results.* Harvard Business School Press, Boston.

Porter, M. E., E. O. Teisberg. 2007. How physicians can change the future of health care. *J. Amer. Medical Assoc.* **297**(10) 1103–1111.

Roberts, J. 2004. *The Modern Firm*. Oxford University Press, Oxford, UK.

Ross, L., R. Nisbett. 1991. *The Person and the Situation: Perspectives of Social Psychology*. McGraw-Hill, New York.

Rumelt, R. P. 1974. *Strategy, Structure, and Economic Performance*. Division of Research, Graduate School of Business Administration, Harvard University, Boston.

Rumelt, R. P. 1982. Diversification strategy and profitability. *Strategic Management J.* **3**(4) 359–369.

Schaffer, M. E., S. Stillman. 2006. "XTOVERID: Stata module to calculate tests of overidentifying restrictions after xtreg, xtivreg, xtivreg2 and xthtaylor." Statistical Software Components, Boson College Department of Economics, Chestnut Hill, MA. http://ideas.repec.org/c/boc/bocode/s456779.html.

Schilling, M., P. Vidal, R. Ployhart, A. Marangoni. 2003. Learning by doing something else: Variation, relatedness, and the learning curve. *Management Sci.* **49**(1) 39–56.

Schmenner, R. W., M. L. Swink. 1998. On theory in operations management. *J. Oper. Management* **17**(1) 97–113.

Schneider, J. E., T. R. Miller, R. L. Ohsfeldt, M. A. Morrisey, B. A. Zelner, P. Li. 2008. The economics of specialty hospitals. *Medical Care Res. Rev.* **65**(5) 531–553.

Siggelkow, N. 2003. Why focus? A study of intra-industry focus effects. *J. Indust. Econom.* **51**(2) 121–150.

Simon, H. 1947. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations.* Macmillan, Chicago.

Skinner, W. 1974. The focused factory. *Harvard Bus. Rev.* **52**(3) 113–121.

Smith, A. 1776. *An Inquiry Into the Nature and Causes of the Wealth of Nations*. W. Strahan and T. Cadell, London.

Suarez, F. F., M. A. Cusumano, C. H. Fine. 1996. An empirical study of manufacturing flexibility in printed circuit board assembly. *Oper. Res.* **44**(1) 223–240.

Tanriverdi, H., N. Venkatraman. 2005. Knowledge relatedness and the performance of multi-business firms. *Strategic Management J.* **26**(2) 97–119.

Taylor, F. W. 1911. *The Principles of Scientific Management*. Harper & Brothers, New York.

Teece, D. J. 1980. Economies of scope and the scope of the enterprise. *J. Econom. Behav. Organ.* **1**(3) 223–247.

Tsikriktsis, N. 2007. The effect of operational performance and focus on profitability: A longitudinal study of the U.S. airline industry. *Manufacturing Service Oper. Management* **9**(4) 506–517.

Tushman, M. L., T. J. Scanlan. 1981. Boundary spanning individuals: Their role in information transfer and their antecedents. *Acad. Management J.* **24**(2) 289–305.

Villalonga, B. 2004. Diversification discount or premium? New evidence from the business information tracking series. *J. Finance* **59**(2) 479–506.