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Broadening Focus: Spillovers and the Benefits of Specialization in the Hospital Industry

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BROADENING FOCUS: SPILLOVERS AND THE BENEFITS OF SPECIALIZATION IN THE HOSPITAL INDUSTRY

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ABSTRACT

The long-standing argument that focused operations outperform others stands in contrast to theory and evidence supporting a broader scope for organizations. The literature on related diversification at the level of the firm provides some reconciliation of these conflicting observations by suggesting that multi-unit firms with a portfolio of related businesses outperform both single-unit firms and multi-unit firms composed of unrelated businesses. Explanations for this relationship between focus and firm performance have largely centered on economies of scope achieved by sharing common resources, such as advertising or production capacity. We consider whether there are similar benefits to relatedness at an operating unit level and whether such benefits stem from spillovers between operating activities. Using data from the hospital industry, we first examine the relationship between focus and performance in cardiovascular care. Then, distinguishing between *direct* and *complementary* spillovers, we examine: (1) the extent to which a hospital's specialization in areas related to cardiovascular care directly impacts performance in cardiovascular care (direct spillovers) and (2) whether the marginal benefit of a hospital's focus in cardiovascular care depends on the degree to which the hospital "co-specializes" in related areas (complementary spillovers). We find evidence of complementarities in specialization between cardiovascular care and related service areas.

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A key tension facing many firms concerns the optimal scope of their operations. Skinner's (1974) argument that narrowing an organization's set of activities improves its operational efficiency has endured for decades (Schmenner and Swink, 1998).[1] Nevertheless, others 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; Teece *et al*., 1994).

A potentially moderating view can be found in the literature on related diversification at the level of the firm. This work suggests that expanding scope into *related* businesses improves firm value, while further diversifying into *unrelated* businesses can reduce value (Rumelt, 1974). One explanation of the identified benefits of related diversification may be that these studies tend to be conducted at the level of the firm rather than at the level of its individual operating units.[2] As such, it is possible for a firm to be composed of several related but distinct operating units, each of which is highly focused on a particular activity or set of activities. That is, diversification could simultaneously exist at the corporate level but not at the level of the operating unit.

In this paper, we consider whether the benefits of related diversification identified at the level of the firm also exist at the level of the operating unit.[3] Further, we aim to shed light on the explicit mechanism generating these benefits. Because prior studies of related diversification tend to use overall firm value or performance as their outcome measure, they often are silent about the specific mechanisms underlying the benefits they observe, typically noting that such benefits are due to "economies of scope". Scope economies, however, can be generated via two broad mechanisms. The first is economies of scale due to the sharing of common resources across the firm's business units. Examples of such resources include fixed or semi-fixed investments in advertising, information systems, buildings, or administrative infrastructure. Markides and Williamson (1994) refer to these scope economies as being the result of

[1] At the level of the individual worker, the benefits of operational focus were highlighted much earlier in Smith's (1776) example of pin manufacturing.
[2] We define an operating unit as a division of a firm that supplies a specified product or circumscribed group of products. This definition applies equally to organizations that manufacture physical products and those that provide services. Given this definition, it is reasonable to use the terms operating unit and business unit interchangeably.
[3] Schilling *et al*. (2003) 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.

"asset amortization". The second is positive spillovers (Markides and Williamson, 1994; Henderson and Cockburn, 1996), which can be further decomposed into two types: *direct spillovers* and *complementary spillovers*. Direct spillovers exist when engaging in one activity directly improves the performance of another activity. Complementary spillovers exist if the *returns* to doing more of one are increasing in the level or intensity of the other (Milgrom and Roberts 1990, 1994, and 1995).

We investigate these spillovers by examining the performance benefits of specialization in an operating unit's activities. Our purpose is not simply to ask whether an operating unit that is focused in a given activity performs better with respect to that activity (e.g., Siggelkow, 2003; Cram, Rosenthal, and Vaughn-Sarrazin, 2005; Young, Foster, and Heller, 2005; Greenwald et al., 2006; Huckman and Zinner, 2008), but to examine whether the composition of that unit's *other* activities (i.e., outside of the focal area) impacts performance in the focal area through either direct or complementary spillovers.[4] 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., "co-specialized") in *related* activities.

We consider these issues in the context of the hospital industry in the United States, with a specific emphasis on the treatment of cardiovascular disease. We recognize that a hospital could be characterized as either an operating unit or a firm. Nevertheless, as circumscribed facilities, we view most hospitals as operating units, akin to plants in the manufacturing context. We have chosen the hospital setting for several reasons. First, hospitals tend to provide services across a range of clinical areas (e.g., cardiovascular, cancer, orthopedics, and obstetrics) that appear in different proportions and combinations across facilities. For example, some hospitals may devote a substantial share of resources to cardiovascular care while allocating comparatively less attention or fewer resources to obstetrics.

[4] We emphasize that we view an operating unit's level of focus as a continuous, rather than discrete, characteristic. As such, 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—as being relatively focused on the first activity.

Conversely, another hospital may be characterized by a significant focus in obstetrics with relatively little cardiovascular care.

Second, hospital discharge data includes information on every patient in a particular hospital. This characteristic of the data allows us to observe 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 area. This continuity is particularly useful if one aims to test for the presence of complementary spillovers based on the degree to which the marginal return to a given level focus in one activity increases as the share of activity devoted to related areas increases.

Finally, understanding the effects of focus and spillovers has particular relevance in the hospital industry. Industry scholars have noted the value of delivering health care through focused factories (Herzlinger, 1997) and organizing around “medical conditions and care cycles” (Porter and Teisberg, 2006, 2007). Christensen *et al.* (2009) note the need to organize hospital care into either “solution shops” (to diagnose specific conditions) or “value-added process clinics” (to treat problems once diagnosed). Additionally, the rise of single-specialty hospitals—a large portion of which focus on cardiovascular care—has led to a significant debate over the value of such facilities. This debate centers on whether such facilities outperform traditional “general” hospitals (Herzlinger, 1997, 2000; Dwyer, 2000; Ginsburg, 2000). Perhaps consistent with the spirited nature of this debate, however, the empirical studies on this topic offer mixed findings (Cram, Rosenthal, and Vaughn-Sarrazin, 2005; Young, Foster, and Heller, 2005; Greenwald et al., 2006; Barro, Huckman and Kessler, 2006). Overall, this stream of literature highlights the importance of determining how hospitals should balance focusing in a single clinical area with building expertise in related areas.

Literature Review and Hypotheses

The idea that specialization improves performance by introducing simplicity and repetition into the individual worker’s routine dates back to Adam Smith’s (1776) example of the pin factory. Later theory likewise gives special consideration to the performance benefits of specialized work. In laying out his fourteen principles of management, Fayol (1916) proposes that "specialization belongs to the natural order", arguing for specialization as a fundamental scientific principle. Specialization is likewise implicit in Taylor's (1911) description of scientific management and the importance of matching workers to specific tasks. He maintains that organizing work in this manner allows for improved productivity and innovation.

These early arguments, though containing implications for operating units or entire organizations, largely center on the performance of the individual worker. March and Simon note that the problems of individual specialization and specialization of "organizational units" may not "have the same answers" (March and Simon, 1958). Nevertheless, subsequent thinking about focus at the level of the operating unit is consistent with earlier work on specialized labor. Skinner (1974), in particular, offered a well-known argument in favor of operational focus as a competitive weapon in his conception of the "focused factory". Translating Smith's observations from the individual level to that of the plant, Skinner notes of the focused factory: "repetition and concentration in one area allow its work force and managers to become effective and experienced in the task required for success (Skinner, 1974, p. 115)."

Several studies provide empirical support for Skinner's argument. Studies of manufacturing plants find that the number of products (Hayes and Wheelwright, 1984), day-to-day variation in product mix (Fisher and Ittner, 1999), the share of business attributed to a plant's largest product line (Brush and Karnani, 1996), and the degree of "manufacturing characteristics focus" (e.g., consistent processes across products) or "market requirements focus" (e.g., a limited set of customer demands) (Bozarth and Edwards, 1997) each bears on performance, with more focused operations outperforming others. Anderson (2001) finds evidence of a negative impact of product mix on performance even after accounting for the fact that many managers anticipate—and attempt to adjust capacity to mitigate—these effects.

Studies in service contexts likewise support the benefits of focus at some level (Heskett, 1986; Johnston, 1996; Lapre and Tsikriktsis, 2006; Tsikriktsis, 2007). In health care, Herzlinger (1997) identified the benefits of applying Skinner's focused factory to health care delivery. Greenwald *et al.*

(2006) found that hospitals devoting more than 45 percent of their business to cardiovascular care achieve lower mortality rates for cardiovascular patients. Examining a non-hospital setting in health care, Huckman and Zinner (2008) note that clinical trial sites focused exclusively on clinical trials perform better than sites that split their resources between clinical trials and traditional patient care.

Nevertheless, support for the benefits of focus at the level of the operating unit is not unanimous. 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 while 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. Ketokivi and Jokinen (2006) observe that many manufacturing plants remain unfocused while performing at a high level. In their study of the printed circuit board industry, Suarez *et al*. (1996) find no demonstrable effect of product line breadth on manufacturing cost and product quality. Kekre and Srinivasan (1990) find that product line breadth has a positive effect on market share, with no accompanying effect on production costs. In the financial services industry, Siggelkow (2003) finds that cash inflows to mutual funds are positively related to product line breadth despite the fact that individual mutual funds managed by more focused organizations outperform similar funds managed by firms with broader product portfolios. Finally, two studies in the hospital industry find that after controlling for procedure volume, hospitals that devote a majority of their business to cardiovascular patients perform no better in terms of patient outcomes on cardiovascular procedures (Young, Foster, and Heller, 2005; Cram, Rosenthal, and Vaughn-Sarrazin, 2005).[5]

Despite the mixed results highlighted above, the empirical literature has only rarely suggested *negative* returns to focus. We thus offer the following baseline hypothesis:

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[5] We note that these papers—and our study—consider the impact of focus on the performance 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.

Hypothesis 1: An operating unit's level of specialization in a focal business segment (i.e., the share of its activity generated by that segment) is positively related to its operational 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 organization (Teece, 1980; Panzar and Willig, 1981). The idea resonates broadly in practice, as multi-product firms seem to be the rule rather than the exception (Montgomery, 1994). Nevertheless, like the previously noted literature on focus at the plant or operating-unit level, this firm-level literature offers mixed evidence. Some studies have documented benefits of focus in the form of a diversification discount (Rhoades, 1974; Lang and Stulz, 1994; Berger and Ofek, 1995; Servaes, 1996), while others report no discount (Campa and Kedia, 2002) or even a premium (Villalonga, 2004).

The strategy literature on *related* diversification at the firm level 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. The argument begins with the contention that not all diversification decisions are equivalent. Rumelt (1974) observes that diversification by U.S. firms during the middle of the 20th century was characterized by variation in how firms established "different patterns of relationships…among different lines of business." In the same study, 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 has replicated these findings (Christensen and Montgomery, 1981; Rumelt, 1982). Using an alternate definition of related diversification, Palepu (1985) finds that more focused firms do not outperform diversified firms on average and that related diversifiers outperform unrelated diversifiers, particularly in terms of profitability growth. Overall, these results suggest that some level of related diversification is beneficial, but that evolving into an unfocused enterprise by diversifying into unrelated businesses can destroy value.

Explanations for this "inverted U-shaped" relationship between diversification and firm performance largely center on economies of scope achieved through the sharing of resources. These arguments can be tied to Coase's (1937) contention that multiple activities should be conducted within the firm only if the cost of doing so is exceeded by the cost of conducting those activities separately, and to Penrose (1959), who positions the firm as a pool of resources, the maximum utilization of which may allow for growth into diverse businesses. Further, Panzar and Willig (1981) argue for the "equivalence between economies of scope and the existence of sharable inputs." Where resources or strategic capabilities are common across businesses, be they tangible (e.g., manufacturing facilities) or intangible (e.g., brands), firms can experience economies of scope (Davis and Thomas, 1993; Tanriverdi and Venkatraman, 2005). Teece (1980) argues more specifically that when such common, sharable resources are indivisible, diversification represents an "efficient way of organizing economic activity".

The assumption, either explicit or implicit, in the above studies is that the economies of scope resulting from related diversification are essentially economies of *scale* with respect to resources that are shared across operating units. Markides and Williamson (1994) refer to such economies of scope as being due to "asset amortization". They note, however, that scope may confer other benefits as competencies developed in one business unit may in fact be used to improve the *quality* of performance in another. Similarly, Henderson and Cockburn (1996) identify "internal knowledge spillovers" as being distinct from economies of scope. They argue that knowledge spillovers are characterized by the interaction of knowledge developed in one area with the conduct of business in another and an associated positive effect on output.

As noted above, one of our objectives is to determine whether the benefits of related diversification within an operating unit can be attributed to spillovers rather than pure asset amortization. Further, we decompose these spillovers between related and focal activities into two components: direct spillovers and complementary spillovers. To our knowledge, such a decomposition of spillovers has not been conducted in prior empirical studies. In our setting, direct spillovers exist when the intensity of related activities impacts performance in the focal activity independent of the firm's level of focus on the latter. This suggests the following hypothesis:

Hypothesis 2: For a given level of specialization in the focal business segment, the degree of specialization in related business segments is positively associated with operational performance in the focal business segment.

In comparison to direct spillovers, complementary spillovers suggest the presence of *interdependencies* between focal and related activities. The theory of complementarities states these interdependent activities generate value "if doing more of any subset of them increases the returns to doing more of any subset of the remaining activities" (Milgrom and Roberts, 1994). Roberts (2004) provides clarity regarding the distinction between complementarities and what we have termed direct spillovers. "Note that 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." (p. 73)

Schilling *et al*. (2003) provide experimental evidence of complementary spillovers by demonstrating that groups learn a particular task at a faster rate when group members are exposed to a set of related tasks over time. In their setting (i.e., problem-solving games), they consider outcomes for small groups exposed to one of three conditions: no variety, related variety, or unrelated variety. They note that in their experimental setting, groups did not exhibit sub-specialization (i.e., 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 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 benefits of relatedness identified by Schilling *et al*. (2003) *within* individuals or small groups, can be extended to a higher level of the organization where task variation is distributed *across* specialized individuals or groups. To the extent that complementary spillovers are observed in our setting, it suggests that some degree of interpersonal or intergroup coordination is taking place.[6]

We test for complementary spillovers across activities by considering whether the benefit of a given level of focus depends upon how an operating unit's non-focal activities are distributed in terms of their relatedness to the focal area. 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" (Milgrom and Roberts, 1994, p. 5). In our setting, the variables are the degree of *specialization* in focal and related non-focal activities. We expect that if non-focal activities are disproportionately allocated to related categories (i.e., those with a high potential for spillovers or interaction with the focal area) the marginal returns to a given level of specialization in the focal activity will be greater. Consistent with theory and our own expectations, we propose the following hypothesis:

Hypothesis 3: The returns to specialization in the focal business segment are positively related to an operating unit's level of specialization (i.e. "co-specialization") in related business segments.

Hypotheses 2 and 3 offer an important implication. As we note later, we define the degree of focus (or specialization) based on the share of a unit's activity dedicated to a particular business segment. Given this share-based measure, if 100% of a unit's activity was dedicated to a focal segment, there would, by definition, be no room for related activities. Thus, to the extent that either direct or complementary spillovers exist, they provide a potential explanation for why one might observe decreasing benefits to focus within an operating unit. In short, dedicating resources to a focal activity may be helpful to a point but not if doing so prevents an adequate level of investment in activities that generate benefits in terms of either direct or complementary spillovers.

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[6] See Lawrence and Lorsch (1967), Galbraith (1973), and Argyres (1996) for discussions of the challenges associated with interdivisional coordination.

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 is taken from either the leg or chest and used to bypass an arterial blockage. Following surgery, patients typically spend one or two days in the intensive care unit and five or six days in total receiving post-operative care in the hospital.[7]

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 outcome measures in hospital discharge data is in-hospital mortality—an outcome that occurs relatively frequently in patients receiving CABG surgery relative 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 non-cardiovascular 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).[8] The NIS contains patient-level data on hospital stays for approximately 1,000 hospitals annually. These hospitals are sampled from state-level hospital discharge databases and approximate a 20 percent 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, primary and secondary procedures performed, individual patient demographics, the status of the patient upon discharge from the hospital, and the patient's primary and secondary diagnoses. We estimate both hospital- and patient-level models based on individuals who underwent CABG surgery.

[7] This length of stay estimate is based on data from the Pennsylvania Health Care Cost Containment Council (PHC4).

[8] Maintained by the Healthcare Cost and Utilization Project (HCUP), a federal, state and industry partnership supported by the Agency for Healthcare Research and Quality (AHRQ)

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 several primary diagnoses consistent with a primary procedure of CABG. These primary diagnoses include acute myocardial infarction (AMI), acute and chronic ischemic heart disease, and angina pectoris.[9] Of the 661,910 discharges, 16,540 had a primary diagnosis of something other than cardiovascular disease 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 pairs of consecutive years. Therefore, we limit our sample to hospitals performing CABG surgery with at least three pairs of consecutive years in the NIS. The result is a minimum of three observations for each hospital in our sample.[10] Additionally, we exclude hospitals with very low volumes of CABG procedures; we follow the practice of several public and private reporting organizations by limiting our sample to facilities performing at least 30 procedures annually.[11] Following these exclusions, our final sample of discharges includes 145,415 patients receiving CABG surgery in 103 hospitals (400 hospital-years) between 1996 (due to our lagged variables) and 2004. Tables 1a and 1b present summaries of our sample.

[Tables 1a and 1b here]

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[9] This group includes patients with a primary ICD-9-CM diagnosis code between 410 and 414.

[10] To illustrate, a hospital meeting this minimum criteria could have a minimum of four consecutive years in the data (which combine to form three consecutive pairs) or a maximum of six years in the data consisting of three non-overlapping sets of paired consecutive years. Though we limit our main sample to hospitals with a minimum of three pairs of consecutive years, we examine the sensitivity of our results to changes in these criteria.

[11] For example, HealthGrades, a private company that publishes performance data for hospitals, does not report mortality or complication rates if a hospital had fewer than 30 annual cases in a particular area, including CABG surgery. Similarly, the states of Massachusetts and Pennsylvania publicly report mortality rates for CABG surgery, but do not do so for hospitals with fewer than 30 cases.

Dependent Variable

Our regression models capture operational performance using the dependent variable of in-hospital mortality. Due to heterogeneity in patient characteristics associated with the risk of death, raw mortality rates may be biased measures of hospital performance that unfairly penalize (benefit) hospitals with a more- (less-) severe mix of patients. 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 $MORT_{\text{ijt}}$, an indicator that equals one if patient *i* in hospital *j* in year *t* died in the hospital, and zero otherwise. The form of this regression is as follows:

$$\ln\left(\frac{\mathrm{pr}(\mathrm{MORT}_{ijt}=1|x_i)}{1-\mathrm{pr}(\mathrm{MORT}_{ijt}=1|x_i)}\right)=\alpha+\beta X_i+\varepsilon_{ijt} \tag{1}$$

X_i represents a vector of patient-level risk factors, including demographic characteristics of the patient, the patient's primary condition, co-existing conditions independent of the primary condition, 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 (AMI), or heart attack, by the location of the infarction.[12] We measure co-existing conditions using the approach of Elixhauser *et al.* (1998), which captures the presence of 30 comorbidities using indicator variables for each.[13] Finally, we include indicators for two procedures that,

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[12] Depending on the location of the obstruction of cardiac circulation, different parts of the heart may be affected. Medical classifications define these locations anatomically using terms such as anterior, inferior, right-ventricular, etc. As an example, an occlusion of the left anterior descending artery will result in an *anterior wall* infarction.

[13] 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, Druge Abuse, Psychoses, and Depression.

if occurring with CABG, represent complicating factors: angioplasty prior to CABG and valve replacement surgery.[14]

To calculate hospital *j*'s risk-adjusted mortality rate in year *t*, $RAMR_{jt}$, we average the predicted values for each patient from (1) 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 $RAMR_{jt}$:

$$\text{RAMR}_{\text{jt}} = \frac{\text{OMR}_{\text{jt}}}{\text{PMR}_{\text{jt}}} * \text{AMR} \quad \textbf{(2)}$$

AMR represents the observed mortality rate across all hospitals for the study period and is included simply to normalize the risk-adjusted rate. Figure 1 provides temporal trends in *RAMR* between 1996 and 2004. Consistent with prior studies using other data sources (e.g., Cutler *et al.*, 2004), our data illustrate a decline in average risk-adjusted mortality during our study period.

[Figure 1 here]

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 allows us to observe the degree to which a hospital focuses 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 degree of focus in cardiovascular services ($FOCUS_{jt}$) as the percentage of patients in a particular hospital in a particular year whose primary diagnosis—the principal reason for hospitalization—falls in the area of cardiovascular disease.[15] We note that each patient receives only one primary diagnosis. We define $FOCUS_{jt}$ as,

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[14] PTCA, like CABG surgery, also treats coronary atherosclerosis and can be performed with or without the placement of a stent in the affected artery. If this method of treating atherosclerosis is ineffective, CABG is usually the alternative. Valve replacement surgery, like CABG, is a procedure for which the patient's chest cavity is opened.

[15] We define patients with cardiovascular disease as those with a primary diagnosis in Major Diagnostic Category 5: Diseases and Disorders of the Circulatory System

$$FOCUS_{jt} = \frac{\sum_{i=1}^{n_{jt}} CARDIO_{ijt}}{n_{jt}} \quad \textbf{(3)}$$

where $CARDIO_{ijt}$ is a binary indicator that equals one if patient *i* discharged from hospital *j* in year *t* had a primary diagnosis in cardiovascular disease, and zero otherwise. The denominator n_{jt} represents the total number of patients 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 aspects of cardiovascular care (e.g., 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 (Bozarth & Edwards, 1997; Hayes & Wheelwright, 1984; Kekre & Srinivasan, 1990; Suarez & Cusumano, 1996; Villalonga, 2004, Huckman and Zinner, 2008).

Beyond testing for returns to an operating unit's focus on a given business segment, we also aim to determine whether the composition of that unit's *other* activities affects these returns. Specifically, our purpose is to examine whether the impact of focus on performance depends on the existence and intensity of related services. To define related services, we identify hospital service categories with the greatest potential for knowledge spillovers with cardiovascular care. We do this by taking advantage of data detailing *secondary* diagnoses (i.e., conditions that are present 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 (MDC). Each MDC corresponds to a single organ system or disease category. For example, patients with cardiovascular disease diagnoses combine to form MDC 5. Table 2 summarizes the frequency with which other MDCs appear as *secondary* diagnosis categories in cardiovascular patients (i.e., those with a *primary* diagnosis in MDC 5).

[Table 2 here]

We define *related* service categories as those that appear as secondary diagnoses for at least 20% of cardiovascular patients. The implication is that at least two of every ten cardiovascular patients may benefit from expertise, or spillovers, from these related areas. Our analysis indicates that four of the 24 non-cardiovascular MDCs meet this requirement.[16] Based on this analysis, we define the degree to which hospitals are engaged in related service categories ($RELATED_j$) as follows:

$$RELATED_{jt} = \frac{\sum_{i=1}^{n_t} RELATED_{ijt}}{n_{jt}} \tag{4}$$

$RELATED_{ijt}$ is an indicator equal to one 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. In this case, 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 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. 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

[16] These include MDCs 4 (Diseases and disorders of the respiratory system), 6 (Diseases and disorders of the digestive system), 10 (Endocrine, nutritional and metabolic diseases and disorders) and 11 (Diseases and disorders of the kidney and urinary tract).

analysis in detail here, we note that they suggest that the MDCs above the 20% threshold load onto the same factor, while those below do not.[17]

To facilitate the interpretation of interaction effects, we additionally categorize $RELATED_j$ into discrete groups.[18] We initially split related at the median, 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 $RELATED_{jt}$. Hospitals in the *RELATED1* category thus have the lowest level of services that are related with cardiovascular care while those in the *RELATED3* category have the highest.

Finally, we include the total volume of admissions at hospital *j* in year *t* ($VOLUME_{jt}$), which allows us to control for the impact of a hospital's overall volume, or size, on mortality rates.[19] Table 3 presents summary statistics and correlations for the key variables in our analysis. We note that *FOCUS* and *RELATED* have a correlation of -0.173. This modest correlation suggests that the effects of *FOCUS* and *RELATED* can be separately identified in our sample.[20]

[Table 3 here]

Empirical Model

We estimate the following base model to test for the effects of focus and related services on in-hospital, risk adjusted mortality rates:

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[17] Factor loadings for MDCs 4, 6, 10, and 11 exceed a threshold of 0.70, while those for MDCs 8 and 20 are closer to zero. Chronbach's alpha is 0.6995 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.

[18] Though our base specification relies on the discrete forms of *RELATED*, we also estimate and report the results of a model in which *FOCUS* is interacted with the continuous form of *RELATED*.

[19] *VOLUME* represents the denominator of *FOCUS*. We note that the results we show below are robust to substituting the hospital's total volume of *cardiovascular* admissions—the numerator of *FOCUS*—for *VOLUME*.

[20] 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* non-focal 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 non-focal activities account for 60% of hospital activity on average.

$$RAMR_{jt} = \alpha_j + \lambda_t + \beta_1 RELATED2_{jt} + \beta_2 RELATED3_{jt} + \beta_3 ln(FOCUS)_{jt-1} * RELATED1_{jt} + \beta_4 ln(FOCUS)_{jt-1} * RELATED2_{jt} + \beta_5 ln(FOCUS)_{jt-1} * RELATED3_{jt} + \beta_6 VOLUME_{jt-1} + \varepsilon_{jt} \quad \textbf{(5)}$$

Our model includes fixed effects for each hospital (α_j), which allow us to control for time-invariant characteristics of hospitals that may affect in-hospital mortality rates and otherwise bias our results. We also include year fixed effects (λ_t) to control for unobserved factors that are driving the average trend in CABG mortality over time (Figure 1). We take the natural log of focus to allow for a non-linear 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. Finally, in our base specification we demean *FOCUS* to facilitate interpretation of its interaction with categories of *RELATED*.

We lag *FOCUS* and *VOLUME* by one year to reduce concerns about reverse causality in the relationship between these variables and hospital performance. To further address these concerns, we also run a reverse regression to test the effect of prior performance on focus. Specifically, we model the current level of focus as a function of risk-adjusted mortality rates, lagged one year. The results of this analysis are discussed in more detail in the results section.

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 (Hypothesis 1), that a greater level of *RELATED* leads to lower mortality (Hypothesis 2), and that the marginal effect of *FOCUS* becomes greater in magnitude as hospitals move from *RELATED1* to *RELATED2* to *RELATED3* (Hypothesis 3). Put differently, this final prediction suggests that the returns to focus should be increasing in the hospital's intensity of related activity.

Given that our measure of focus is a hospital-level construct, the level of observation in (5) is the hospital-year. Nevertheless, each of the measures in (5) is derived from patient-level discharge data such that our outcome variable, $RAMR_{jt}$, is a function of patient-level factors. To ensure that our results are not significantly influenced by rolling patient-level data into hospital-year observations, we estimate the following conditional logistic model at the patient-level:

$$\begin{aligned} & ln\left(\frac{pr(MORT_{ijt}=1|x_i)}{1-pr(MORT_{ijt}=1|x_i)}\right) \\ & = \alpha_j + \lambda_t + \beta_1 RELATED2_{jt} + \beta_2 RELATED3_{jt} + \beta_3 ln(FOCUS)_{jt-1} {*} RELATED1_{jt} \\ & + \beta_4 ln(FOCUS)_{jt-1} {*} RELATED2_{jt} + \beta_5 ln(FOCUS)_{jt-1} {*} RELATED3_{jt} \\ & + \beta_6 VOLUME_{jt-1} + \beta_7 X_i + \varepsilon_{jt} \end{aligned} \qquad \textbf{(6)}$$

As before, α_j and λ_t represent hospital and year fixed effects, respectively, and our focus measure ($FOCUS_{jt-1}$) is lagged one year and interacted with the three levels of relatedness ($RELATED1_{jt}$, $RELATED2_{jt}$, and $RELATED3_{jt}$). $MORT_{ijt}$ is a binary indicator of in-hospital death, and X_i represents a vector of patient characteristics and risk factors.[21] Our other independent variables of interest, however, remain at the hospital-level.

Estimating interaction effects and their significance can be complicated in a logistic regression. Scholars have noted specifically that the direction and significance of interactions cannot always be determined based on the reported interaction term and test statistic in logistic regressions (Ai & Norton, 2003; Hoetker, 2007). Though we estimate (6) as a conditional logit, we rely on a linear probability model

[21] These factors include primary diagnosis, age, gender, concurrent ptca or valve procedures and the following co-existing conditions: 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, Druge Abuse, Psychoses, and Depression.

(LPM) to compare patient-level results with the hospital-level results. One of the benefits of the LPM is more straightforward interpretation. We compare the direction and significance of the interaction terms from the LPM estimates to those from the conditional logit in (6) to ensure similarity. We then compare the estimates from the LPM and the conditional logit in (6) to the estimates from (5) to address concerns that our hospital-level results may be influenced by aggregation of patient-level data.

Results and Discussion

Base Results

Table 4 presents estimates for several versions of (5). In Columns 1, 3, 6, and 7 *FOCUS* enters as a linear variable. In Columns 2, 4, 5, and 8 we take the natural log of *FOCUS* as previously discussed. Columns 1 and 2 suggest that, on average, focus has a negative effect on risk adjusted mortality rates. Though suggestive—the estimate on *FOCUS* in Column 1 is significant at the 10% level—these results provide only limited support for the beneficial average impact of focus on performance identified in Hypothesis 1.

[Table 4 here]

Before considering our base specification—in which *RELATED* enters through categorical variables—we provide estimates in Columns 3, 4 and 5 of a model where *RELATED* enters as a continuous variable. Both *FOCUS* and *RELATED* have been demeaned, such that the interpretation of the coefficient on either variable is the marginal impact of one at the average level of the other. In Column 4 we take the natural log of *FOCUS*, and in Column 5 we take the natural log of both *FOCUS* and *RELATED*. As expected, the coefficient on *FOCUS* remains negative. In Column 3, the estimates for the main effects of both *FOCUS* and *RELATED* are in the expected direction, though only *FOCUS* shows significance (at the 10% level). Though the coefficient on the interaction of *FOCUS* and *RELATED* has the negative direction predicted by Hypothesis 3, it is not significant at conventional levels (p=0.18). However, when we take the natural log of FOCUS, as in Columns 4 and 5, the coefficient on the interaction is significant at conventional levels. Further, these models provide a better fit to the data than that in Column 3. These result suggests some degree of non-linearity in the interaction between *RELATED* and *FOCUS*.

Columns 6 and 7 present the results of models in which we interact linear focus with categorical levels of relatedness—first split at the median and then into thirds. As in Columns 4 and 5, the results suggest that the marginal effect of focus on in-hospital, risk-adjusted mortality depends on the level of relatedness. In Column 6 the estimated coefficient on *FOCUS* is negative but insignificant 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 estimate is also significantly different from the estimate of *FOCUS* for the *RELATEDBelowMedian* category at the 1% level. Similarly, in Column 7, the estimated effect of FOCUS is negative but insignificant for hospitals in the *RELATED1* and *RELATED2* categories, while the effect for hospitals in the *RELATED3* category is negative and of larger magnitude, while also being significant at the 5% level. These results suggest that the weak average effect of focus found in Column 1 may mask the fact that the effects of focus are contingent on the operating unit's level of involvement in related activities.

Column 8 illustrates results similar to those in Column 7 when we use the natural log of *FOCUS*. Together, Columns 4 and 8 suggest that taking the natural log of focus provides the best fit to the data, so we rely on this transformation in our base specification (Column 8). These base estimates indicate that a 10% increase from the mean value of *FOCUS*—equivalent to an increase of just under two percentage points and an increase in the natural log of *FOCUS* of 0.095—results in an overall reduction of 0.51 percentage points in the mortality rate for hospitals in the *RELATED3* category. These results are significant at the 1% level. We again note that the estimate on *FOCUS* for hospitals in *RELATED3* is significantly different than that for hospitals in either *RELATED1* or *RELATED2* at the 1% level. Overall, the results in Table 4 suggest that hospitals with the highest intensity of related services experience positive returns to focus (in the form of reduced mortality rates) and that these returns are greater for this category of hospitals than for those with lower levels of related services.

A key implication of these findings is that, in the extreme, a hospital with 100% focus on cardiovascular care—which would 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 replaces some portion of its cardiovascular activity with related (i.e., complementary) services. As such, these results provide strong support for Hypothesis 3. Though the estimates for the main effect of *RELATED* (both continuous and categorical) are, in all cases, in the expected direction, they are not significant at conventional levels and thus do not provide support for Hypothesis 2. Together, these findings suggest that—in the context of CABG patients—there appear to be benefits to hospital's investments in related services, and these benefits are driven by complementary rather than direct spillovers.

Robustness

Table 5 examines the robustness of our hospital-level regression to the use of patient-level observations. We note that Columns 1 and 2 suggest that the results of the conditional logit are largely in agreement with those from the linear probability model (LPM) in terms of the pattern and significance of the estimates. These results provide a level of confidence in reporting the patient-level LPM results for comparison with the hospital-level results. The patient-level LPM results are consistent with the hospital-level results presented in Column 8 of Table 4. Both models suggest that the marginal returns to focus are increasing in the intensity with which a hospital provides related services.

[Table 5 here]

We acknowledge that any endogeneity in our key explanatory variables may lead to biased estimates. Specifically, we recognize that hospitals with higher-quality CABG programs may attract larger absolute volumes of patients, thereby increasing their level of focus on cardiovascular care. As discussed above, we address these concerns by investigating the impact of prior performance on current focus. We estimate a "reverse" regression model, with the natural log of a hospital's current focus as the dependent variable and it's lagged risk-adjusted mortality rate for CABG as the independent variable. The model includes hospital and year fixed effects. 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. We find that this coefficient is positive and not significant at conventional levels of significance (p=0.893).[22] This result is encouraging, as it mitigates concern that a hospital's level of focus is endogenously determined by its prior performance.

As is the case with most empirical studies, our results may be sensitive to choices we have made in constructing our sample and measuring our variables of interest. To address these potential limitations, we investigate the sensitivity of our results to changes in these assumptions.

First, our base results measure focus at the disease (i.e., cardiovascular care) level, rather than the procedure (i.e., CABG) level. We have done so because other recent studies of hospital specialization have defined focus at the MDC level (Cram, Rosenthal, and Vaughn-Sarrazin, 2005; Greenwald et al., 2006), and we observe that hospital's decisions about their service offerings tend to be made at the level of a disease rather than a procedure. For example, single-specialty hospitals in cardiovascular care treat nearly all aspects of cardiovascular disease (perhaps with the exception of transplants) rather than focusing on specific cardiovascular procedures, such as CABG or angioplasty. Nevertheless, we run regressions replacing our disease-level focus measure with a CABG-level focus measure, $CFOCUS_{jt-1}$. The model specification is the same as in (5), except that our focus variable is measured as the percentage of total discharges involving at least one CABG procedure. Table 6 presents the results of this regression.

[Table 6 here]

The estimates are consistent with our base results in Table 4. Though the estimates on *FOCUS* for hospitals in *RELATED1* and *RELATED2* are negative and significant at the 10% level, that for hospitals in *RELATED3* is more negative and significantly different from the estimates for hospitals in *RELATED1* and *RELATED2* at the 9% and 3% levels, respectively. These findings are consistent with the story that the marginal impact of focus is increasing in the hospital's level of specialization in related services.

[22] The coefficient on lagged risk-adjusted mortality is 0.059 with a standard error of 0.442.

Second, our definition of related services includes the four MDCs that account for secondary diagnoses in at least 20% of cardiovascular patients. We investigate each of these MDCs individually. Additionally, we consider the differential impact of relaxing the 20% threshold (by adding MDCs 8 and 20, the next two categories below our 20% threshold in Table 1). The model specification for the results appearing in Tables 7 and 8 is the same as in (5) except that *RELATED1*, *RELATED2*, and *RELATED3* have been defined using the MDCs specified in each column.

[Table 7 here]

[Table 8 here]

The results in Table 7 suggest that each of the secondary MDCs appearing in at least 20 percent of cardiovascular patients (Columns 1 through 4) individually exhibits the previously observed patterns of *complementary* spillovers. In Table 8, we consider the impact on our results of relaxing the margin for defining related services. Column 1 repeats our base results. The results in Columns 2 and 3 suggest that as we relax the threshold—adding MDCs 8 and 20, respectively—the magnitude and significance of the impact of focus for hospitals in *RELATED3* diminishes. In addition, the fit of the models is likewise diminished. These results, however, are consistent with our predictions, as one would expect complementary spillovers 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.

Third, our base sample includes all hospitals with at least three pairs of consecutive years in the NIS data. To examine the sensitivity of our findings to this choice, we also run models on samples including: (1) all hospitals with at least two pairs of consecutive years and (2) all hospitals with at least four pairs of consecutive years. These results are reported in Table 9.

[Table 9 here]

Column 1 suggests that relaxing our selection criteria to include all hospitals with at least two pairs of consecutive years has little impact on our findings, with the exception of somewhat stronger estimates for the impact of *FOCUS* for hospitals in *RELATED1* and *RELATED2*. Nevertheless, we note that the estimate for the impact of *FOCUS* for hospitals in *RELATED3* is significantly different from the estimates for *RELATED1* and RELATED2 at the 7% and 6% levels, respectively. The results in Column 2 are likewise in line with our base result. The estimate on *FOCUS* for hospitals in *RELATED3* is significantly different from zero at the 5% level and remains significantly different from the estimate on *FOCUS* for hospitals in *RELATED1* and *RELATED2* at the 1% and 2% levels, respectively. Overall, the consistency of the results in Table 9 suggests that our findings are robust to changes in our sampling criteria.

Finally, our models include total hospital volume, which is the denominator in our measure of focus. The coefficients on our measure of focus thus represent the marginal impact on mortality of a change in focus, holding total hospital volume constant. This model allows us to assess changes in focus driven by variation in the numerator, cardiovascular volume. An alternate specification would replace our measure of focus with a simple measure of cardiovascular volume. Holding total hospital volume constant, changes in volume could then be interpreted as changes in focus. We do not use this approach for two reasons. First, there is a high degree of comovement between cardiovascular volume and total hospital volume, so we are not able to observe independent variation in each measure. The same is not true for our measure of focus and total hospital volume.[23] Second, this alternate specification constrains the impact of a one unit increase in cardiovascular volume to be the same, regardless of the absolute level of total hospital volume. Nevertheless, the change in focus for a one-unit increase in cardiovascular volume would differ depending on the level of total hospital volume, and we want to capture this difference in testing our hypotheses.

Conclusion

We consider three propositions related to the impact of focus and relatedness on operational performance. First, we investigate whether there are, on average, benefits to focus with respect to operational performance. This is a question without a definitive empirical answer, particularly with

[23] In our sample the correlation between total hospital volume and cardiovascular (MDC 5) volume is 0.80, while the correlation between total hospital volume and our measure of focus is -0.16.

respect to focus at the organizational level. We find limited evidence in support of our hypothesized positive relationship, on average, between focus and operational performance. Second, we examine the extent to which the level of related activities generates direct spillovers that impacts the level of performance for a focal activity. Though our empirical estimates are consistent in direction with the presence of direct spillovers from related services to our focal service of interest (i.e., cardiovascular care), they are, for the most part, not statistically significant. Finally, we investigate whether there are complementary spillovers in specialization across related areas. Within our hospital setting, we find that hospitals devoting a greater portion of their business to treating patients in related service categories (i.e., those with the potential for knowledge spillovers) experience higher returns to specialization in a focal service.

Overall, our results suggest that related activities play an important role in the connection between focus and performance at the level of an operating unit, not simply at the level of the firm. Further, we find evidence that complementary spillovers—not just direct spillovers or simple economies of scale in shared resources—provide a key mechanism in explaining the benefits of related diversification. These results are robust to changes in the level of observation, definition of focus, designation of related businesses, and methods for sampling organizations.

In the context of the hospital industry, our findings suggest the need for a broader conceptualization of what it means for a hospital to specialize. Specifically, single-specialty hospitals or multi-specialty hospitals interested in emphasizing a specific clinical service may need to think beyond the focal area of interest and consider complementary capabilities as well. This is consistent with the view expressed by others that to deliver value for patients, health care should be organized to include "all needed specialties and the prevalent comorbidities" (Porter and Teisberg, 2007).

Our study faces several potential limitations, and its results should be interpreted accordingly. First, we reiterate the empirical questions that we have attempted to address 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), while the literature on related diversification includes large samples of firms representing a cross-section of industries (Rumelt, 1974; Christensen and Montgomery, 1981; Rumelt, 1982; Palepu, 1985). Additionally, the theory of complementarities has been applied more broadly, for example, to large Japanese firms (Milgrom and Roberts, 1994) and the manufacturing industry (Milgrom and Roberts, 1990, 1995).

Third, we consider one measure of performance—quality as captured by risk-adjusted mortality—but are not able to consider other important 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 is data on hospital charges, which, due to 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 health care.[24]

Finally, our results suggest that complementary spillovers exist with respect to focus in cardiovascular care and related services. We have incorporated one potential mechanism in the form of knowledge spillovers (Henderson and Cockburn, 1996). We assume that service categories we identify as related represent those areas with the greatest potential for knowledge exchange given the frequency with which cardiovascular patients have secondary needs in these areas. Nevertheless, our measures are based on the *potential* for knowledge spillovers, not knowledge spillovers themselves. Though our work does examine *what* this mechanism might be, it does not describe *how* this mechanism works operationally. For example, we cannot observe whether spillovers are due to direct interactions among physicians in different specialties or other key individuals who span boundaries (Tushman, 1977; Tushman and Scanlon, 1981) across clinical specialties (e.g., nurses working with patients in both focal and related areas). Additionally, while spillovers may be important in knowledge-intensive settings like health care

[24] We define value as the quality of services relative to their costs.

delivery, other mechanisms may be more important in other environments. Additional work is required to investigate such mechanisms.

Despite these caveats, our study highlights the potential role of spillovers—specifically complementary spillovers—in generating benefits from focus at the operating unit level. It also emphasizes that the benefits of related diversification may be derived from sources beyond the amortization or simple sharing of common resources. Specifically, our findings suggest that the returns to specializing an operating unit in a given line of business may be contingent on the degree to which the unit "co-specializes" 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.

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Figure 1—Temporal trends in average risk-adjusted mortality rates

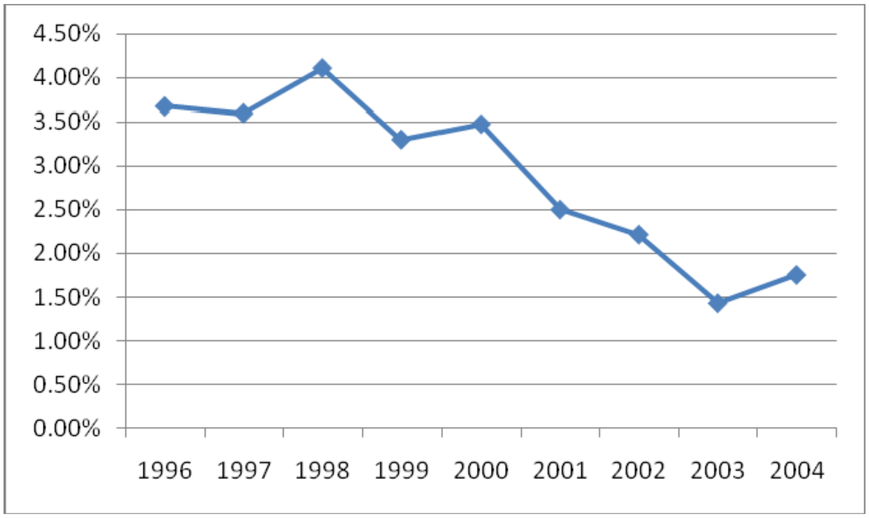

Table 1a—Sample: hospitals by number of paired consecutive years

Paired Years	Hospitals	Percent	Cum.
3	47	45.63	45.63
4	34	33.01	78.64
5	14	13.59	92.23
6	4	3.88	96.12
7	3	2.91	99.03
9	1	0.97	100
Total	103		

Table 1b—Sample: number of hospitals and CABG discharges by year

Year	Hospitals	Percent	Discharges	Percent
1996	84	21.00	33,224	22.85
1997	78	19.50	30,965	21.29
1998	66	16.50	24,496	16.85
1999	42	10.50	15,371	10.57
2000	32	8.00	9,848	6.77
2001	32	8.00	11,913	8.19
2002	23	5.75	7,717	5.31
2003	23	5.75	6,137	4.22
2004	20	5.00	5,744	3.95
Total	400		145,415	

Table 2—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%
9	Diseases and disorders of the skin, subcutaneous tissue and breast	9%
12	Diseases and disorders of the male reproductive system	4%
7	Diseases and disorders of the hepatobiliary system and pancreas	4%
3	Diseases and disorders of the ear, nose, mouth and throat	4%
2	Diseases and disorders of the eye	3%
21	Injuries, poisoning and toxic effects of drugs	2%
17	Neoplastic disorders (haematological and solid neoplasms)	1%
13	Diseases and disorders of the female reproductive system	1%
25	Human Immunodeficiency Virus Infection	0%
15	Newborn and other neonates	0%
22	Burns	0%
14	Pregnancy, childbirth and the puerperium	0%

Table 3—Summary statistics and correlations

(N=400)	Mean	SD	Min	Max	RAMR	Focus	Volume	Related	Related 1	Related 2	Related 3
RAMR	0.030	0.017	0.000	0.149	1						
Focus	0.198	0.093	0.079	0.884	-0.065	1					
Volume	19,305	10,584	2,490	68,464	0.061	-0.154	1				
Related	0.218	0.041	0.073	0.378	0.001	-0.173	-0.070	1			
Related1	0.318	0.466	0.000	1.000	-0.001	0.020	0.093	-0.689	1		
Related2	0.353	0.478	0.000	1.000	-0.060	-0.071	-0.019	-0.025	-0.503	1	
Related3	0.330	0.471	0.000	1.000	0.062	0.053	-0.072	0.708	-0.479	-0.518	1

Table 4—Regressions testing the average effect of focus and relatedness on mortality rates (Standard errors in parentheses)

COEFFICIENT	(1) RAMR	(2) RAMR	(3) RAMR	(4) RAMR	(5) RAMR	(6) RAMR	(7) RAMR	(8) RAMR
Volume (000's)	0.0008	0.0008	0.0009	0.0010	0.0010	0.0008	0.0009	0.0009
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Focus	-0.1560*	-0.0248	-0.1430*	-0.0192	-0.0207			
	(0.0802)	(0.0158)	(0.0752)	(0.0140)	(0.0141)			
Related (Continuous)			-0.1160	-0.0890	-0.0176			
			(0.0816)	(0.0817)	(0.0169)			
Focus*Related (Continuous)			-1.0300	-0.357**	-0.0777*			
			(0.7500)	(0.1540)	(0.0398)			
Related(AboveMedian)						-0.0022		
						(0.0031)		
Focus*Related(BelowMedian)						-0.0825		
						(0. 0741)		
Focus*Related(AboveMedian)						-0.2404***		
						(0. 0889)		
Related2							-0.0028	-0.0026
							(0.0020)	(0.0021)
Related3							-0.0035	-0.0010
							(0.0039)	(0.0039)
Focus*Related1							-0.0505	-0.0029
							(0.0685)	(0.0126)
Focus*Related2							-0.0709	-0.0084
							(0.0856)	(0.0155)
Focus*Related3							-0.228**	-0.0533***
							(0.0901)	(0.0185)
Transformation of Focus	**None**	**Nat Log**	**Demean**	**Nat Log Demean**	**Nat Log Demean**	**Demean**	**Demean**	**Nat Log Demean**
Transformation of Related			**Demean**	**Demean**	**Nat Log Demean**	**Halves**	**Thirds**	**Thirds**
Observations	400	400	400	400	400	400	400	400
Number of Hospitals	103	103	103	103	103	103	103	103
R-squared	0.106	0.101	0.125	0.130	0.126	0.133	0.144	0.157

Robust standard errors are clustered by hospital.
Regressions include a constant term not reported.
*** p<0.01, ** p<0.05, * p<0.1

Table 5—Regression with observations at the patient level (Standard errors in parentheses)

COEFFICIENT	(1) Log-Odds-MORT	(1) MORT
Volume (000's)	0.00001	0.0003
	(0.00001)	(0.0003)
Related2	-0.0834	-0.0025
	(0.0746)	(0.0017)
Related3	-0.0480	-0.0021
	(0.1134)	(0.0031)
Ln(Focus)*Related1	0.0208	-0.0113
	(0.3927)	(0.0111)
Ln(Focus)*Related2	0.1083	-0.0086
	(0.3946)	(0.0120)
Ln(Focus)*Related3	-0.9347**	-0.0368***
	(0.3956)	(0.0127)
Observations	145,415	145,415
Number of hospitals	103	103
R-squared	0.130†	0.044

Robust standard errors are clustered by hospital.
Regressions include a constant term not reported.
*** p<0.01, ** p<0.05, * p<0.1
†Pseudo R-squared

Table 6—Regression with focus at the CABG level (Standard errors in parentheses)

COEFFICIENT	(1) RAMR
Volume (000's)	0.0007
	(0.0005)
Related2	-0.0031
	(0.0026)
Related3	-0.0050
	(0.0040)
Ln(CFocus)*Related1	-0.00909*
	(0.0048)
Ln(CFocus)*Related2	-0.00971*
	(0.0058)
Ln(CFocus)*Related3	-0.0209**
	(0.0080)
Observations	400
Number of hospitals	103
R-squared	0.158

Robust standard errors are clustered by hospital.
Regressions include a constant term not reported.
*** p<0.01, ** p<0.05, * p<0.1

Table 7—Regressions testing the spillover effect of individual MDCs
(Standard errors in parentheses)

COEFFICIENT	(1) RAMR	(3) RAMR	(2) RAMR	(4) RAMR
Volume (000's)	0.0009	0.0009	0.0008	0.0008
	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Related2	0.0004	0.0009	-0.00699*	-0.0011
	(0.0024)	(0.0029)	(0.0037)	(0.0020)
Related3	-0.0029	0.0018	-0.0078*	-0.0015
	(0.0032)	(0.0037)	(0.0047)	(0.0039)
Ln(Focus)*Related1	-0.0051	0.0003	-0.0111	-0.0030
	(0.0140)	(0.0133)	(0.0157)	(0.0138)
Ln(Focus)*Related2	-0.0181	-0.0106	-0.0260*	-0.0258*
	(0.0149)	(0.0163)	(0.0154)	(0.0146)
Ln(Focus)*Related3	-0.0408**	-0.0546***	-0.0364**	-0.0474**
	(0.0195)	(0.0198)	(0.0181)	(0.0210)
MDC in Related	**10**	**4**	**6**	**11**
Observations	400	400	400	400
Number of Hospitals	103	103	103	103
R-squared	0.127	0.145	0.127	0.135

Robust standard errors are clustered by hospital.
Regressions include a constant term not reported.
*** p<0.01, ** p<0.05, * p<0.1

Table 8—Regressions testing the spillover effect of different combinations of secondary MDCs (Standard errors in parentheses)

COEFFICIENT	(1) RAMR	(2) RAMR	(3) RAMR
Volume (000's)	0.0009	0.0008	0.0008
	(0.0007)	(0.0007)	(0.0007)
Related2	-0.0026	-0.0013	-0.0007
	(0.0021)	(0.0029)	(0.0029)
Related3	-0.0010	-0.0021	-0.0026
	(0.0039)	(0.0055)	(0.0058)
Ln(Focus)*Related1	-0.0029	-0.0068	-0.0151
	(0.0126)	(0.0145)	(0.0139)
Ln(Focus)*Related2	-0.0084	-0.0185	-0.0178
	(0.0155)	(0.0142)	(0.0173)
Ln(Focus)*Related3	-0.0533***	-0.0400**	-0.0369*
	(0.0185)	(0.0189)	(0.0217)
MDCs in Related	**4,6,10,11**	**4,6,10,11,8**	**4,6,10,11,8,20**
MDCs Added		**8**	**8, 20**
Observations	400	400	400
Number of Hospitals	103	103	103
R-squared	0.157	0.127	0.110

Robust standard errors are clustered by hospital.
Regressions include a constant term not reported.
*** p<0.01, ** p<0.05, * p<0.1

Table 9—Regressions testing the sensitivity of results to sampling criteria (Standard errors in parentheses)

COEFFICIENT	(1) RAMR	(2) RAMR
Volume (000's)	0.0006	0.0010
	(0.0006)	(0.0008)
Related2	-0.0026	-0.0025
	(0.0020)	(0.0022)
Related3	-0.0012	-0.0003
	(0.0035)	(0.0043)
Ln(Focus)*Related1	-0.0237**	-0.0007
	(0.0119)	(0.0153)
Ln(Focus)*Related2	-0.0291**	0.0001
	(0.0144)	(0.0197)
Ln(Focus)*Related3	-0.0476***	-0.0520**
	(0.0165)	(0.0237)
Sample Restriction	**≥ 2 pairs consecutive years**	**≥ 4 pairs consecutive years**
Observations	657	259
Number of Hospitals	232	56
R-squared	0.088	0.177

Robust standard errors are clustered by hospital.
Regressions include a constant term not reported here.
*** p<0.01, ** p<0.05, * p<0.1