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# The Effects of Focus on Performance: Evidence from California Hospitals

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# The Effects of Focus on Performance: Evidence from California Hospitals

**Abstract**

We use hospital-level discharge data from cardiac patients in California to estimate the effects of focus on operational performance. We examine focus at three distinct levels of the organization—at the firm level, at the operating unit level, and at the process flow level. We find that focus at each of these levels is associated with improved outcomes, namely, faster services at higher levels of quality, as indicated by lower lengths of stay (LOS) and reduced mortality rates. We then analyze the extent to which the superior operational outcome is driven by focused hospitals truly excelling in their operations or by focused hospitals simply "cherry-picking" easy-to-treat patients. To do this, we use an instrumental variables estimation strategy that effectively randomizes the assignment of patients to hospitals. After controlling for selective patient admissions, the previously observed benefits of firm level focus disappear; focused hospitals no longer demonstrate a statistically significant reduction in LOS or mortality rate. However, at more granular measures of focus within the hospital (e.g., operating unit level), we find that more focus leads to a shorter LOS, even after controlling for selective admission effects.

**Keywords**

productivity, quality, health-care operations, service operations

**Disciplines**

Health and Medical Administration | Operations and Supply Chain Management

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We use hospital level discharge data from cardiac patients in California to estimate the effects of focus on operational performance. We examine focus at three distinct levels of the organization – at the firm level, at the operating unit level, and at the process flow level. We find that focus at each of these levels is associated with improved outcomes, namely faster services at higher levels of quality, as indicated by lower lengths of stay (LOS) and reduced mortality rates. We then analyze the extent to which the superior operational outcome is driven by focused hospitals truly excelling in their operations or by focused hospitals simply "cherry-picking" easy-to-treat patients. To do this, we use an instrumental variables estimation strategy that effectively randomizes the assignment of patients to hospitals. After controlling for selective patient admissions, the previously observed benefits of firm-level focus disappear; focused hospitals no longer demonstrate a statistically significant reduction in LOS or mortality rate. However, at more granular measures of focus within the hospital (e.g. operating unit level), we find that more focus leads to a shorter LOS, even after controlling for selective admission effects.

## 1. Introduction

In his seminal paper, Skinner (1974) states that the "focused factory will out-produce, undersell, and quickly gain competitive edge over the complex factory." Numerous examples of successful focus factories serve to support Skinner's claim. For example, Motel 6, a low-budget inn and Southwest Airlines, a national US carrier are both successful focused operations that cater to the group of budget-conscious travelers. Likewise, Federal Express has built a lucrative business around focusing on providing courier services to customers seeking guaranteed overnight delivery. In healthcare delivery, Shouldice Hospital, a Canadian facility that specializes in inguinal hernia repair procedures has an unusually high rate of success (Heskett 1983). Herzlinger (1997) views focus as one of the key sources towards achieving the much needed efficiency improvement in the healthcare industry, and describes numerous opportunities for hospitals to focus their operations. Herzlinger's argument in favor of focused operations has been widely discussed in the business press (e.g., see The Economist July 2009) and discussions relating to focused hospitals have played an important role in the ongoing debate on healthcare reform in the US (Time July 2009).



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Despite anecdotal accounts of thriving focused factories, few studies have empirically estimated the operational benefits of focus and even fewer studies have sought to identify the underlying sources of focus-based efficiency improvements. Why are focused factories better than non-focused factories? Are they truly superior in their operations, or is their superior performance a result of them cherry-picking an attractive product line at the expense of other factories, competition, or society? These are the central research questions of our work.

To answer these questions, we study the market for cardiac care delivery in California using patient level data of 500,437 patients treated in a variety of hospitals. We distinguish between three levels of focus – firm level focus, operating unit level focus and process level focus. Our definition of firm level focus is the hospital's focus on cardiac care. This is simply the percentage of patients admitted primarily for cardiology reasons. Our definition of operating unit level focus is the cardiology department's focus on a specific set of patients. We choose to examine the cardiology department's focus on patients undergoing coronary revascularization procedures[1], one of the most common cardiac procedures. The operating unit level of focus is thus defined to be the percentage of patients admitted to the hospital's cardiology department who undergo a coronary revascularization procedure. Our most granular level of focus takes place at the process level and is based on the specific flow path and care process of a patient. In our analysis, we define the process level focus to be the percentage of cardiac revascularization patients who undergo a cardiovascular artery grafting (CABG) procedure.

Focused hospitals can derive improved outcomes from both superior service delivery and from cherry-picking their patients (i.e. selectively admitting easy-to-treat patients). To disentangle these two effects, we use an instrumental variables (IV) estimation strategy. The levels of focus in the set of hospitals that happen to be located close to a patient's home is not likely to be correlated with any medical characteristics of the patient, but is known to have some influence on the likelihood with which the patient chooses a focused hospital for his cardiac procedure. Our sample includes patients who were assigned to a focused hospital not only because of their medical conditions, but also because of their close proximity to one. In other words, the explanatory power of the relative travel distances to predict patient-hospital assignment provides a quasi natural experiment and thereby mimics a random patient-to-hospital assignment.

[1] A candidate for coronary revascularization has varying degrees of blockage in one or more of the vessels that supply oxygenated blood to the heart muscle. Coronary revascularization involves bypassing blockages or removing obstructions in the clogged arteries to restore blood flow to the heart muscle.



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Our theoretical framework with its three levels of focus and our instrumental variable estimation strategy allow us to make the following four contributions. **First**, we estimate the benefits of focus at the firm level by comparing hospitals that have a larger percentage of their patients admitted in cardiology (focused hospitals) with hospitals having a lower percentage of total cardiac patients (non-focused hospitals). We find that an increase in focus by 10% is associated with a reduction in length of stay by 3.88%; for the average patient, a 0.l unit increase in focus corresponds to a percentage reduction in mortality by a factor of 2.1%. **Second**, we show that these benefits of focus continue to be occur as we move from the firm or hospital level (percentage of patients admitted to cardiology) to the operating unit or cardiac department level (percentage of patients in cardiology that require a revascularization procedure) and ultimately to the process flow level (percentage of revascularization patients who undergo a CABG). Specifically, we find that at the operating unit level an increase in focus by 10% is associated with a greater reduction in length of stay by 4.92%. For the average patient, a 0.l unit increase in operating unit focus corresponds to a percentage reduction in mortality by a factor of 1.5%. In addition, a 0.1 unit increase in process level focus is associated with a percentage reduction in mortality rate by 5.6%. **Third**, we compare the pre-operative risk levels across focused and non-focused hospitals and show that cardiology patients admitted to focused hospitals have a significantly lower pre-operative risk score. This is consistent with the hypothesis that focused hospitals cherry-pick their patients. **Fourth**, once we adjust for the selective admissions using our IV estimator, we find that at the firm (or hospital) level, focus does not lead to a statistically improved length of stay (LOS) or mortality. However, in examining operating unit focus, we find that cardiology departments that focus on revascularization procedures achieve a shorter LOS and similar levels of mortality risk (controlling for the fact that they admit less risky patients).

Our findings lead to several managerial and policy implications. From the perspective of a profit-seeking enterprise, focus is an attractive strategy to pursue. A profit maximizer does not need to worry about the sources of the improved operational performance; it is the result that counts. From a societal perspective, the benefits of focused hospitals are much smaller than what was previously believed. Cherry-picking of easy-to-treat patients is not illegal, unless the referring physician has a financial stake in the hospital where the patient is sent (see Iglehart 2005 for a discussion). In fact, a division of labor in which some hospitals deal with easy-to-treat patients while others treat high risk patients with relatively rare medical conditions might even be in the interest of social welfare. Yet, this requires an adjustment of hospital reimbursement practices, such as an increase in payments made to general service hospitals, who may deal with riskier patients requiring more costly service. Finally, our results also suggest that in order to achieve real operational improvement beyond cherry-picking, a focused factory strategy needs to be implemented at the operational level rather than at the firm level.

# 2. Literature

The idea of focus in operations goes back to Skinner's (1974) claim that the focused factory "does a better job because repetition and concentration in one area allows its workforce to be more effective." Subsequent research has studied the implications of focus in various industries. McLaughlin et al (1995) explore attributes of professional service firms for which a focused strategy is effective. They identify customer group selection and operating process as separate focus service strategies in professional service delivery. Pesch and Schroeder (1996) explore the extent to which variables including plant size and number of product lines determine the level of factory focus. Similarly, MacDuffie, Sethuraman and Fisher (1996) study productivity in automotive manufacturing and find that focus on the number of models does not negatively impact productivity, but focus on the number of parts does. Brush and Karnani (1996) also study the effect of focus on manufacturing productivity. Following an empirical examination of US manufacturing firms from 1972 to 1984, they find limited support for the argument that plant focus increases productivity. Suarez et al (1996) show the benefits associated with focus in the printed circuit board industry. Lapré and Scudder (2004) find that airlines that cherry pick routes and less congested airports tend to have fast turnaround times for their planes. Tsikriktsis (2007) also looks at the strategic effects of focus in the US Airline industry and finds that focused airlines significantly outperform their competitors. Collectively, these papers argue that the benefits of focus more than offset any gains achieved from an increase in product variety.

Organizational learning is one of the mechanisms through which focused operations can generate process improvements. For example, Lapré et al (2003) find that the development and dissemination of knowledge is an important driver of quality improvements. However, an increase in process complexity can impede learning and hinder process improvements. Tucker et al (2007) argue that in healthcare delivery, where medical knowledge is constantly changing, knowledge transfer is especially important. Using data from several Intensive Care Units, they demonstrate that learning activities have an appreciable impact on the quality of care. Similarly, Lapré and Tsikriktsis (2006) explore the effects of organizational learning on focus. They look at the strategic effects of focus on reducing customer dissatisfaction in the US Airline industry and find that although the average focused airline did not learn faster than the average full-service airline, the best focused airline did. Although our paper does not specifically focus on learning, we point out organizational learning as a potential source of gains at focused factories.

Huckman and Zinner (2008) study the benefits of focus in the management of clinical trial sites. They distinguish the effects of focus at the firm level from the effects of focus at the divisional level. They explain how by using Skinner's concept of a "plant within a plant" some of the sites in their sample appear to be unfocused if looked at from an aggregate perspective (these sites are involved in clinical trials and they provide traditional patient care), yet focus at the operational (divisional) level by maintaining separate and dedicated divisions (branches in the language of the authors) for the associated patients. We follow Huckman and Zinner (2008) and separately measure focus at the firm (hospital) levels as well as within the operating unit (cardiology department).

Generations of MBA students have been exposed to the idea of focused operations based on the Shouldice Hospital case (Heskett 1983). The case highlights several process-specific and patient-specific factors that improve patient care. For example, in order to reduce post surgery recovery time, local anesthesia is used as a cheaper and safer alternative to general anesthesia. Similarly, following surgery, patients are encouraged to engage in moderate physical activity in order to help reduce recovery time and overall hospital stay. On the other hand, Shouldice Hospital is also known to enforce a stringent patient selection process. Prospective patients are required to fill out a lengthy questionnaire prior to admission, and are screened for eligibility. For example, applicants who are overweight must lose weight before they can be admitted. Lee et al (2009) explore the impact of individual patient characteristics on the performance of healthcare delivery, and find that patient heterogeneity can significantly impact both patient admissions and service rates amongst individual service providers. Broadly speaking, the development of a focused strategy is a complex decision that requires identifying target market segments and firm-level operational competence.

There has been recent interest in the medical community on specialty hospitals, which have been compared to focused factories (see Casalino et al 2003 and Shactman 2005). Estimating the productivity and quality of these hospitals, however is confounded by several factors. As Iglehart (2005) notes, superior physician productivity and quality may result from repeatedly performing a narrow set of procedures. On the other hand, selective admission of patients can also be a driver of superior outcomes. Disentangling these two effects to estimate the process-specific gains at focused hospitals is not trivial. Cram et al (2005) compare the outcomes of cardiac surgery patients at specialty hospitals by accounting for a number of observable controls. They find that specialty hospitals often choose low-risk patients. Greenwald et al (2006) conduct a series of hospital-level observations and reach similar conclusions, i.e. patient selectivity is shown to exist at specialty hospitals. Similarly, Barro et al (2006) consider the market-wide effects of a specialty hospital. By comparing population level outcomes amongst hospital markets that differ in whether they experienced a focused entry or not, they find support for market-wide efficiency gains resulting from a specialty hospital's entry. However, these papers do not separately identify the effect of operational gains due to focus and the effect of patient selectivity ("cherry picking"). Furthermore, the literature on specialty hospitals has not considered the impact of multiple levels of organizational focus on outcomes. We find that the levels of organizational focus, as well as patient selectivity can affect outcomes.

# 3. Medical Context: Cardiac Care

Our choice of cardiac care delivery as the empirical setting of our research is motivated by three reasons. First, any direct and objective comparison of operational performance requires choosing a specific industry context. It is simply difficult to compare absolute levels of quality of a hotel, an airline, and an automotive plant. Cardiac care delivery is particularly well suited for inter-firm comparisons of operational data because of quantifiable and objective performance metrics. Our analysis examines the effects of focus on a hospital's service quality as measured by its patient mortality and on its service time as measured by the patient's length of stay. Both of these metrics are measured in all hospitals and have extensively been used in prior studies in Operations Management (e.g. Pisano et al 2001, and Kc and Terwiesch 2009) and Healthcare (e.g. IHI 2008). In addition, from a research design perspective, there exists a large body of medical literature on risk adjustment of cardiac patients, which allow for a reliable patient level risk adjustment of outcomes. Second, cardiac care is a high volume and high revenue service sector that accounts for a third of the entire patient volume in the US and over a third of all Medicare spend-ing (American Heart Association 2010). This sheer economic importance and its impact on public health alone make this a setting worthy of extensive research. Third, recent developments within the health care industry have re-ignited an interest in the service focused factory (e.g. Herzlinger 1997). Specialty hospitals, which are focused hospitals that specialize in a limited number of types of treatments, have generated significant attention from both policy makers and care providers. A recent study conducted by the US Government Accountability Office (GAO 2003) reported a three-fold increase in the number of specialty hospitals between 1990 and 2003. This rapid proliferation of specialty hospitals underscores the need to better understand the effect of focus in healthcare delivery, and to examine the impact of a focused firm on the competitive landscape.

To examine the effect of focus on hospital performance, we collected patient level discharge data from California hospitals from 2007. The hospitals in our data set vary greatly in their degree of focus. Similarly, patients vary in their risk factors, including age, gender, diagnosis, payer, and travel distances to hospitals. Our objective is to estimate whether the degree of focus determines our patient level outcomes of interest, including mortality rate and length of stay.

As a preliminary analysis, consider the data shown in Table 1. The table compares the average LOS, the standard deviation of LOS, mortality, and the average Charlson index (a broad based measure of patient risk) across patients in focused and non-focused hospitals. For the purpose of Table 1, we classified a hospital as focused (unfocused) if it had a larger (lower) than median percentage of its patients admitted for cardiac problems.

Observe that cardiac-focused hospitals have patients with a lower average value of the Charlson index, indicating lower risk. Note further their lower average standard deviation in the length of stay, 0.12 for the cardiac-focused and 0.32 for the non-focused hospital. In line with Skinner's argument, Table 1 also shows that patients at focused hospitals generally exhibit lower average lengths of stay and lower mortality rates than do patients at non-focused hospitals. Based on the superior operational outcomes of cardiac-focused hospitals as revealed by our preliminary analysis in Table 1, it is not clear whether some or all of the gains are due to operational efficiencies versus patient selection. Similar reports (Greenwald 2006, Leapfrog 2002) suggest both sources as possible drivers of outcome improvements. As we argue in the following section, one needs to be careful in interpreting the data in Table 1.

# 4. Theory and Model Development

We now develop a set of concise hypotheses with respect to the effect of focus on performance as measured by patient outcomes. Let $Y_{ih}$ be the outcome measure of patient *i's* treatment at hospital *h*. In the following discussion, we will focus on this general outcome measure, while in the subsequent estimation of our model, we will use the lengths of stay ($LOS_i$) and incidence of mortality ($MORT_i$) as specific measurements of $Y_{ih}$.

Assuming a linear, additive model of operational performance, we can write:

$$Y_{ih} = \delta + \boldsymbol{P_i}\beta + \boldsymbol{H_h}\gamma + \varphi Focus_i + u_{ih} \qquad (1)$$

where $\boldsymbol{P_i}$ is a vector of patient-specific covariates including gender, age, diagnosis, type of procedure and type of payer. $\boldsymbol{H_h}$ is a vector of the hospital level observables such as size, location and patient volume. The variable $Focus_i$ is a measure of the degree of focus associated with the care for patient *i* was treated and $u_{ih}$ captures the effect of all other variables which are unobservable to the researcher. The model specified by (1) allows us to examine the effect of a continuous measure of focus and also adjusts the outcomes for various patient specific ($\boldsymbol{P_i}$) and hospital specific ($\boldsymbol{H_h}$) variables that are unrelated to focus. This ensures that we are truly measuring the effect of focus instead of confounding it with effects such as the patient risk or the size of the hospital.

In our discussion of focus, we will follow the argument of Huckman and Zinner (2008) and define focus at multiple levels of analysis. Specifically, we examine the effects of focus at three distinct levels of the organization, and compute $Focus_i$ at the firm level, the operating unit level, and at the process flow level.

We begin our analysis by also examining the effect of focus on outcomes at the firm (or hospital) level. Consider our research setting of cardiac care. Prior research investigating the benefits of focus in this setting has measured focus as “the percentage of patients in a particular hospital in a particular year whose primary diagnosis […] falls in the area of cardiovascular disease (GAO 2003)”. In other words, a hospital is focused on cardiovascular services if a large fraction of its patients will be treated in the cardiology department, relative to the other departments within the hospital. Previous research on the benefits of focus in hospital operations (e.g., Clark and Huckman 2010, Greenwald 2006) has examined focus at this level of the organization. Like other researchers before in healthcare operations (Clark and Huckman 2010, Greenwald

2006), we define firm level focus to be the proportion of cardiac patients in the entire hospital (cardiac patients / total patients) and hypothesize that:

*H1: Firm level focus is associated with better patient and hospital adjusted operational outcomes ($\varphi<0$), including shorter lengths of stay and lower likelihood of mortality.*

A hospital whose cardiovascular patients comprise a large fraction of the total hospital-wide admissions volume however might still have a cardiology department that is not focused. Cardiac patients require treatment for an array of cardiac ailments, including arrhythmia (irregular heart beat), tachycardia (excessively rapid heartbeat), coronary artery disease, or pericardial effusion (fluid around the heart). While all these conditions fall under the broad classification of cardiovascular diseases, they require very different resources and medical interventions. A patient with arrhythmia might be treated by implanting a pace maker, a patient with coronary artery disease might be treated with a cardiac bypass surgery, and a patient with pericardial effusion might be treated with anti-inflammatory drugs or steroids. Thus, at the firm level, a hospital might have a focus on cardiology patients. But it might have a rather diverse set of cardiac treatment protocols that reduce focus at the level of its cardiology department (or operating unit).

To measure the operating unit, or the focus *within* the cardiology department we define the department's focus on revascularization procedures as the percentage of all cardiac patients that receive a coronary revascularization procedure. That is, operating unit focus = revascularization patients / cardiac patients. A coronary revascularization is a surgical procedure that involves bypassing blockages or obstructions in the coronary arteries in order to restore blood flow to the heart muscle. Patients requiring such a procedure all have one or more clogged arteries. Moreover, this group of patients is relatively homogenous in their level of risk (e.g. McClellan et al., 1994). From an operating unit perspective, revascularization patients experience a common care path starting with pre-operative planning, hospital admission, surgery, ICU recovery, discharge to an observation unit, and ultimately a discharge from the hospital. For these reason, one can think of the operations for the "product line" of revascularization patients in line with Skinner's concept of a plant-within-a-plant. We postulate that the benefits of focus increase as the unit of analysis becomes more granular, i.e. as we move from studying firm (hospital) level focus to operating unit (or cardiac department) level focus.

*H2: The benefits of focus are higher at the operating unit level (focus on the set of revascularization patients within cardiology) than at the firm level (focus on cardiac care).*

In addition to a cardiology department's focus on revascularization, we develop an even more granular measure of focus. While homogenous in their need for *some* surgical intervention, revascularization patients differ in terms of *which* exact intervention they require. The two most common surgical interventions for revascularization patients are a coronary artery bypass graft (CABG) procedure and a percutaneous coronary intervention (PCI) procedure, commonly known as a coronary angioplasty. A CABG procedure is an open-heart surgery, which requires making an incision on the sternum to access the heart, and subsequently restoring blood flow to the heart muscle by by-passing the clogged artery with a donor vessel. On the other hand, a PCI is a relatively minimally invasive procedure; this procedure involves inserting a catheter and mechanically widening the narrowed or obstructed blood vessel, and obviates the need to open up the patient's chest. Medical research (e.g. McClellan et al., 1994) has compared the pre-operative risk amongst revascularization patients who undergo CABG versus PCI, and find that the two groups of patients are similar in terms of pre-operative risk levels.

Although both groups of revascularization patients follow the same care path described previously, they differ as far as two operational aspects are concerned. First, they use different resources, in particular different doctors performing the surgical intervention. A CABG surgery is performed by a cardiothoracic surgeon while a PCI is performed by an interventional cardiologist. Second, given the minimally invasive nature of PCI, the two groups differ with respect to their activity times along the care path.

Mixing CABG and PCI patients thus creates variability across patients in activity times, in particular with respect to the time patients spend in the ICU and in post-ICU recovery. Such variability, in turn, is associated with significant losses in throughput and longer flow times (see, e.g., Cachon and Terwiesch 2008 or any other introductory Operations Management book for discussions on how variability in activity times reduces process throughput and increases wait times). By focusing on CABG procedures, a cardiac unit may thus be able to reduce such variation in activity times, and ultimately improve patient length of stay. As the unit of analysis becomes more refined, we not only increase the degree of specialization of the care resources, but also reduce the flow variability in the care process. This should improve the patient flow and hence improve the length of stay and outcomes.

In our analysis, we choose to focus on CABG procedures, which are surgically more invasive, more complex, and generally more time consuming than PCI. Thus, to examine the effect of process-level focus on outcome, we analyze revascularization patients who have a CABG. To examine this focus on a particular patient profile, we define a cardiology department's focus on CABG patients as the percentage of revascularization patients that undergo a CABG procedure. In short, process focus = CABG patients / revascularization patients.

*H3: The benefits of focus are higher at the process level (focus on a specific cardiac procedure) than at the operating unit level (focus on revascularization patients)*

Next, we argue that the benefits from focus are cumulative; focus at each of the three organizational levels (viz. firm, operating unit, and process) will independently drive improved outcomes for a given patient. Said differently, CABG patients who are admitted to a hospital with process flow level of focus will derive additional operational benefits if the operating unit and firm are also focused. We argue that this is due to the fact that *some* of the drivers of firm, operating unit, and process focus are independent. For example, firm level focus may result from a better managed cardiac ICU, which is used to treat all cardiac patients; operating unit focus may result from better peri-operative diagnosis capability for treating revascularization patients; process level focus could be due to having a skilled CABG surgeon and better post-operative care in preventing sternum wound infections. That is:

*H4: The benefits of organizational focus are cumulative.*

As a result of a selective admission policy in focused hospitals, the coefficient estimate of $\varphi$ captures the aggregate gains achieved from focus, but it does not distinguish between the gains due to better service delivery from the gains due to targeting a specific patient profile. According to the SSV framework proposed by Heskett (1986), targeting a customer market and service delivery excellence are two separate organizational capabilities of service firms. Firms can excel in one or both of these areas. That is, some firms are good at picking the right customers, and some are good at service delivery. Distinguishing between these two capabilities is important. For example, a policy maker or a hospital manager engaged in benchmarking hospitals needs to understand how much of the performance advantage from focused hospitals is due to superior operations and how much reflects a selective admission policy. In other words, they need to *control* for the effect that focused hospitals seek to treat an easier patient mix.

Some of the differences in patient characteristics are observable to us as researchers. For example, our patient level data includes information about the age of the patients and the most important co-morbidities. These variables are part of the previously introduced vector, $\boldsymbol{P_i}$, in our regression model (1). In particular, we use patient level medical information, including age, gender, the Charlson index (a commonly used measure of risk, see Charlson et al 1987 for details), and various diagnoses in order to produce a pre-admission level of mortality. Thus, unlike the analysis underlying Table 1, the regression model (1) appropriately controls for differences in $\boldsymbol{P_i}$ across patients. To test for a cherry picking behavior of focused hospitals, we simply need to compare the patient characteristics across focused and un-focused hospitals. We thus hypothesize:

*H5: Patients treated in focused hospitals have, on average, a lower pre-operative risk of mortality compared to patients treated in a non-focused hospital.*

While the variables in $\boldsymbol{P_i}$ can control for heterogeneity in patient characteristics across hospitals, they are not sufficient to control for all differences in admission policies. Other variables, such as prior relationships between hospital and patient, data revealed in lab reports, or details only visible on imaging studies, might also influence in which hospital a particular patient $i$ is likely to be treated. This is problematic from an econometric perspective. An essential assumption underlying an estimation based on (1) is that the error term $u_{ih}$ is not correlated with any of the explanatory variables, including $Focus_i$. In other words, the model implicitly assumes that patients are assigned randomly to hospitals and not based on some unobservable patient characteristics included in $u_{ih}$. Thus, in addition to controlling for the observable variables in $\boldsymbol{P_i}$, we also need to account for unobservable differences in patient admission. We do this by using an instrumental variable (IV) estimation technique based on the levels of focus in the set of hospitals in proximity to the patient's home. This approach provides a quasi natural experiment and thereby mimics a random patient-to-hospital assignment.

With this IV estimation strategy, we can determine if and to what extent focus leads to superior operations. Beyond the benefit of selective patient admission, focused hospital might simply benefit from specialization and the associated learning and thereby obtain a higher level of operational performance. Thus in keeping with this line of reasoning and the argument made by Heskett (1986), we thus hypothesize that the benefits of focus can exist even after accounting for the benefits of selective patient admissions:

*H6: A focused hospital is associated with better patient and hospital adjusted operational outcomes (φ<0), including shorter lengths of stay and lower odds of mortality, even after controlling for its selective admissions policy*

# 5. Data Collection and Variable Definition

Our empirical analysis is primarily based on a data set published by the California Office of Statewide Health and Planning (OSHPD), which includes observations for every inpatient discharge in the state of California from 2007. In addition, we use the Dartmouth Atlas of Healthcare to obtain information with respect to hospital markets.

In order to account for market specific effects, we follow the Dartmouth Atlas of Healthcare's classification to designate hospital markets based on the health referral regions (HRR). Hospital referral regions (HRRs) represent regional health care markets for tertiary medical care. In the Dartmouth Atlas, each HRR has been defined to contain at least one hospital that performed major cardiovascular procedures. Minor modifications were made to the HRR's to achieve geographic contiguity.

We use the OSHPD data set to account for our patient level variables. In addition to the outcome variables (length of stay and mortality), we control for patient demographic factors that could influence outcome, including patient age, gender and race. We also control for medical measures that have been known to significantly affect outcome, such as the diagnosis, overall medical condition of the patient at admission, as well as a range of clinical conditions including, hypertension, chronic renal failure, diabetes, chronic obstructive pulmonary disease, cerebrovascular disease, peripheral vascular disease, congestive heart failure, current myocardial infarction (heart attack), and any previous incidence of a myocardial infarction. In addition, we control for patient insurance status. Table 2a provides some patient-level summary statistics. Patients with one or more cardiovascular diagnosis were classified as cardiac patients. We see that the average length of stay for cardiac patients in California is 4.31 days, and the average mortality rate is 2.4%.

Next, we sought to identify the various sources of heterogeneity at the hospital level. From the OSHPD data set, we computed the aggregate inpatient volume at each hospital as well as the volume of admissions that occurred primarily for cardiac related causes. The number of cardiac admissions divided by total number of admissions (or the fraction of cardiac-related admissions) was used as our measure of hospital (or firm) level focus. The mean hospital level focus was estimated to be 12.4%, and the standard deviation was 7.3%. Similarly, we find that the mean level of cardiac department focus (number of revascularization patients / number of cardiac patients) is 13.7% and its standard deviation is 14.1%. The mean of the process flow level of focus (number of CABG patients / number of revascularization patients) is 40.7% and its standard deviation is 29.8%. Figures 1a through1c provide a distribution of the levels of hospital, cardiac department and process flow focus in our sample. We find that although 391 hospitals treat cardiac patients, only 187 hospitals perform coronary revascularizations and only 157 perform CABG procedures (Table 2b). We also observe that the three measures of organizational focus are not strongly positively correlated, eliminating concerns about collinearity (Table 2c).

In order to determine the pre-operative risk levels, we use a logistic risk adjustment model (see Kc, Terwiesch and Horak 2010) based on observed cardiac risk factors including age, gender, hypertension, chronic renal failure, diabetes, chronic obstructive pulmonary disease, cerebrovascular disease, peripheral vascular disease, congestive heart failure, and myocardial infarction.

We also used the hospital ZIP codes to infer the geographic categorization of the hospital. Specifically, the ZIP code allows us to identify the HRR. Including the HRR fixed effect in our empirical specifications allows us to account for market-specific effects, including rural/urban categorizations, as well as market-specific economic factors.

# 6. Aggregate Effects of Focus

The results of our empirical analysis are reported in Tables 3a-4b. We estimate using heteroskedasticity consistent robust standard errors clustered at the hospital level, in order to allow for differences in the variance/standard errors due to arbitrary intra-group correlation. Table 3a summarizes the results of the OLS regression analysis with the length of stay as the dependent variable, a side-by-side comparison of the impact of each of the three levels of focus on the length of stay. Table 3b summarizes the effect of the probit regression on the post-operative mortality rate as the dependent variable. These specifications include all the observed covariates including patient and hospital level observables. To simplify the exposition of our results, we do not show these control variables in the results tables.

We note that the three specifications in Tables 3a and 3b are applicable to distinct patient populations, as indicated in our hypothesis development. The relevant patient population in column (1), which examines the effect of firm (or hospital) level focus, is the set of all cardiac patients; the relevant patient population for examining the effect of operating unit (or cardiac department) is the set of all revascularization patients; the effect of process (or CABG procedure) is examined on all patients who undergo a CABG.

First we consider the effect of firm (hospital) level focus. The regression analysis of equation (1) estimates the coefficient for hospital level focus to be -0.388 ($p < 0.01$), implying that hospital stays for patients are 3.88 % shorter for a focus increase of 10%. This supports Hypotheses 1. As discussed previously, this estimate captures the aggregate effects of focus. The regression shows that hospitals with hospital level focus have shorter lengths of stays, even after adjusting for a number of observable patient and hospital level variables. We obtain similar qualitative results for the effect of focus on the likelihood of mortality. We find that focus is associated with a reduced likelihood of mortality (coefficient estimate -0.315, $p = 0.1$ see Table 3b), in support of Hypothesis 1.

Consistent with the presence of economies of scale, we find that an increase in volume is associated with a reduction in both lengths of stay and odds of mortality. Economies of scale might reflect efficiency gains driven by volume-induced learning. Alternatively, they might reflect a better availability of various treatment and diagnostic services that can influence the length of stay (e.g. radiology, respiratory services, lab testing).

Next, we compare the effects of focus at the two lower levels of the organization (columns 2 and 3). We find that operating unit (cardiac department) focus is associated with a reduction in the length of stay. In particular, a 10% increase in cardiac department focus is associated with a reduction in the length of stay by 4.92%. This is larger in magnitude (although not statistically different) compared to the 3.88% reduction in length of stay due to a similar increase in focus at the hospital level. We find process level focus does not have a statistically significant impact on reducing the length of stay.

The results in Table 3b show that focus at all three levels of the organization is associated with a reduction in the likelihood of mortality. The coefficient estimates for firm, operating unit and process level focus are -0.315, -0.345, and -0.564 respectively. These findings provide support for hypotheses 2 and 3 (i.e. process level focus has a greater impact than operating unit focus, which has a greater impact than firm level focus). The coefficient of -0.315 for the effect of hospital level focus corresponds to a reduction in the probability of mortality by 0.051% for the average cardiac patient with a predicted mortality rate of 2.43 % for a 0.l unit increase in focus; this corresponds to a percentage reduction in mortality by a factor of 2.1%. Similarly the coefficient estimate of -0.345 for the effect of cardiac department focus implies that a 0.1 unit increase in cardiac department focus reduces the probability of mortality by 0.041% for the average revascularization patient with a predicted mortality rate of 2.74%; this corresponds to a percentage reduction in mortality by a factor of 1.50%. Finally the coefficient estimate of -0.564 for the effect of process level focus implies that a 0.1 unit increase in cardiac department focus reduces the probability of mortality by 0.165% for the average CABG patient with a predicted mortality rate of 2.93%; this corresponds to a percentage reduction in mortality by a factor of 5.6%.

We also find that hospital volume is associated with a reduction in the mortality rate for cardiac patients. This finding supports and extends the results from Peterson et al (2004), Halm et al. (2002), Luft et al. (1987) and Sollano et al. (1999) who have previously found that volume improves outcome. In addition to the effect of hospital volume on the outcomes for all cardiac patients, we make two more findings for the effect of volume on outcome. First, we look at the effect of volume on length of stay. Previous work has focused on primarily mortality and morbidity outcome measures. Second, we look at both hospital level volume and cardiac department volume on outcomes. Prior work has not considered the effect of these two organizational levels of volume. We find that where statistically significant, both cardiac and hospital volume have the effect of reducing LOS and mortality rates.

Finally, we examine the effect of the three levels of organizational focus on the smallest subset of patients to which all three measures of focus are applicable, viz. the set of CABG patients. Tables 4a and 4b provide the results for the effects of firm focus (column 2), operating unit focus (column 3), and process focus (column 4) on this small subset of 18,797 patients. Column (5) provides the effect of all three measures of focus on the outcome for this patient population. The results show that firm, operating unit, and process focus do not have a statistically significant effect on the LOS. Although firm and operating unit focus have an effect on reducing the LOS for all cardiac patients and all revascularization patients respectively (as discussed previously), focus at these higher levels of the organization do not appear to impact the CABG patients. However, we find that all three measures of organizational focus have an effect of improving the mortality rates for the patients undergoing CABG. In addition, we find that some of these benefits are cumulative. Table 4b column 5 provides the effect of all three measures of focus on the mortality rate for CABG patients. We see that operating unit focus and process focus have a significant effect on reducing the mortality rate. While each measure is statistically significant in at least one regression, firm level focus is not statistically significant in the model that includes all three measures. Although LOS is unaffected, mortality is reduced through focus.

# 7. Effects of Selective Admissions

The previous results simply show the aggregate benefits of focus. They do not disentangle the effects of patient selection and service delivery. To test whether or not focused hospitals admit easier to treat patients (Hypothesis 5) and to determine if and to what extent their operations are producing better patient outcomes even when we control for selective patient admissions (Hypothesis 6), additional analysis is needed. In this section, we will first test Hypothesis 5 (7.1). We will then introduce our IV estimation strategy (7.2) and then report our IV estimation results, including the test of Hypothesis 6 (7.3).

## 7.1 Evidence for Selective Admissions

Table 5 provides the average pre-operative risk adjusted mortality rate as a function of hospital level, cardiac department and process level focus. Specifically, we examine whether hospital focus, cardiac department focus, and process focus are associated with lower pre-operative mortality risks for all cardiac, all revascularization, and all CABG patients respectively. For the former two measures of focus, we find a negative correlation between focus and the pre-operative risk levels of patients. The statistically significant and negative coefficients for hospital level focus and cardiac department focus suggest that focused hospitals admit patients with lower pre-operative levels of risk. This provides support for hypothesis 5 (cherry picking).

However, at the process level, focus is not significant. In other words, hospitals that primarily perform CABG procedures do not seem to cherry pick from the available pool of CABG patients. One potential explanation for this is that a hospital that wants to obtain a focus in CABG might need to admit a broader set of CABG patients in order to reach a minimum level of scale. Another possible explanation it is more difficult to further discriminate on risk amongst this group of patients that is already quite specialized. In other words, at the hospital level, it is easy to distinguish between a low-risk routine patient who can be treated with medications and a high patient who needs a CABG. However, at the process level, the group of CABG patients has similar kinds of risk and resource needs.

## 7.2 Instrumental Variable Estimation Strategy

The results from Table 5 suggest that focused hospitals admit lower risk patients. This risk adjustment is based on observed measures of patient risk. By including these sources of patient heterogeneity in (1), we are able to account for observed patient level risk factors that drive outcomes. However, many attributes that determine the patient risk and his admission to a focused hospital, are not directly observable to us as researchers. Therefore, a simple ordinary least squares (OLS) regression estimate of (1) may yield a biased effect of focus on outcomes due to the confounding effects of patient selectivity.

In order to circumvent this estimation challenge and still produce a consistent estimate for $\varphi$, we employ an instrumental variables technique. Our technique allows us to estimate the effect of hospital focus on outcomes, without the need for an explicit observation of the admission process and the various drivers of patient selection. To estimate this unbiased effect of focus, we need to look at the outcome of a patient who was admitted to a focused hospital, but for whom his medical characteristics (his suitability for a focused hospital) did not factor into the admission decision. In other words, estimating $\varphi$ is feasible if we could randomly assign patients to hospitals (independent of the medical drivers of patient selection), as in a controlled experiment.

Practically, such a large scale controlled study is not feasible. However, the subsequently described instrumental variables estimation approach allows us to evaluate the outcomes of patients *as if* they were randomly assigned to focused hospitals. Basically, an instrumental variable allows us to exploit variation in the assignment of patients to hospitals that is unrelated to the unobserved confounding factors (unobserved medical characteristics) and then utilize this variation to extricate the effects of focus on outcome. We refer the readers to Wooldridge (2002) for a comprehensive overview of instrumental variable estimation.

The instrumental variables that provide this exogenous variation are the levels of focus ($Focus_{ik}$) in the set of *K* hospitals that vary in their relative distance from patient *i*'s home (see McClellan, McNeil and Newhouse 1994 for use of the differential distance as an instrumental variable to evaluate the quality of competing treatment strategies for cardiac patients). To see the validity of this set of instrumental variables, consider the factors unobserved by the researcher, such as the presence of specific known co-morbidities, or the presence of a rare medical condition. It is reasonable to assume that these unobserved variables that determine patient risk are identically distributed in the patient population. Consequently, the relative travel distance (the additional distance that the patient would have had to travel to get to a focused hospital) is unlikely to be correlated with patient characteristics, captured by $u_{ih}$. In other words, a patient's unobserved medical characteristics should not be correlated with the relative travel distances to a given set of hospitals or their degrees of focus. Thus, conditioning on the observed variables, the levels of focus in the set of K nearby hospitals, $Focus_{ik}$ (for $k$ = 1…K), must be uncorrelated with the outcome variables.

Although the relative travel distance should be uncorrelated with the patient severity level, it is likely to be correlated with the patient's eventual choice of hospital. The further a patient has to travel to get to a focused hospital, the lower the likelihood of the patient being admitted to one. One reason for this is that hospitals in close proximity are more likely to already have a prior relationship with that patient. In the event of an emergency, a patient is more likely to be admitted to a hospital that can be reached in a short period of time. It is thus sensible to assume that *ceteris paribus*, a patient would be more likely to choose a focused hospital if they live in close proximity to one.

Consider patient *i*, whose choice set consists of the hospitals in $\mathbf{H_i}$. Let *p(i,k)* denote the probability that patient *i* visits hospital *k*, where *k* is the index for the hospitals in $\mathbf{H_i}$. In particular k=1 denotes the closest hospital in the choice set, k=2 denotes the second closest hospital and so on. For each patient i who visits a hospital, we can say

$$\sum_{k \in H_i} p(i,k) = 1$$

Because greater travel distance is associated with a reduced likelihood of visit, we expect *p(i,k)* to be larger for smaller values of *k*. That is, the likelihood of a patient's visit is higher for the hospitals in closer proximity to the patient. Based on the above formulation the expected level of focus for patient $i$ is simply

$$Focus_i = \sum_{k \in H_i} Focus_{ik} \times p(i,k)$$

where $Focus_{ik}$ is the degree of focus at the k$^{th}$ closest hospital to patient $i$. The expected level of focus for patient $i$ is thus simply the weighted average of the levels of focus of the hospitals in his choice set, weighted by the probability of visit. The levels of focus in the patient's choice set, and their relative distances are expected to be uncorrelated with his underlying levels of severity. Yet, these factors influence the patient's assignment to a focused hospital. In other words, the relative travel distances provide an approximation for the relative probabilities of visit. For example, if the closest hospitals happen to be highly focused, there is a greater likelihood of the patient being treated at a hospital with a high level of focus.

This insight allows us to use $Focus_{ik}$ as instrumental variables in producing an unbiased estimate for the effects of focus on outcomes. We first derive an estimator for $\varphi$ using the two-stage least squares (2SLS) method to estimate (1) when the outcome variable of interest (Y) is log(*LOS*).

The following first stage equation is based on the effect of relative distance (in the sense of the extra distance the patient has to travel to reach a focused hospital) on the degree of focus for patient $i$.

$$Focus_i = \delta_1 + \boldsymbol{P}_i\beta_1 + \boldsymbol{H}_h\gamma_1 + \sum_{k=1}^{K} \rho_k\, Focus_{ik} + \varepsilon_i$$

The coefficient $\rho_k$ represents the amount by which an increase in focus at the k-th closest hospital leads to an increase in the expected level of focus for patient $i$. We expect the coefficient $\rho_k$ to decrease in value in a stochastic sense as k increases; this reflects the fact that closer hospitals have a greater influence on patient choice.

In the second stage of our two-stage least squares estimation we have,

$$log\,(LOS_{ih}) = \delta_2 + \boldsymbol{P}_i\beta_2 + \boldsymbol{H}_h\gamma_2 + \varphi_{IV}\,\widehat{Focus}_i + v_{ih}$$

where $\widehat{Focus}_i$ is the fitted value of $Focus_i$ based on the first stage equation. Since this second stage equation controls for patient and hospital level variables associated with patient $i$ in the same way as the first stage equation, any residual variation in $\widehat{Focus}_i$ is thus attributed to variation arising solely from the relative travel distances. Consequently, the instrumental variable estimator $\varphi_{IV}$ allows us to estimate the effect of the travel distance induced variation in $Focus_i$ on the length of stay.

Next, we examine the effects of focus on the quality of care. Although the actual quality of care for patient *i* in hospital *h* (say $Y_{ih}$) is a latent variable, we do observe the incidence of a mortality ($MORT_{ih}$), which is determined by the quality of care. That is, $MORT_{ih} = \mathbf{1}[Y_{ih} > 0]$. We use a probit transformation of the binary dependent variable (MORT). Unfortunately, we cannot use the 2SLS method to estimate the effect of focus because 2SLS does not produce consistent estimates when the second-stage regression is non-linear (see Amemiya 1990 for an explanation). Therefore we use the instrumental variable based probit MLE method outlined in Woolridge (2002), pp 472-478 to obtain consistent estimates for the effect of focus on the likelihood of mortality.

Finally, we make two comments about our instrumental variables. First, our instrumental variable estimation strategy is based on a ranked ordering of hospitals. This approach allows us to use a continuous measure of focus as the dependent variable. Secondly, our analysis is performed at three organizational levels of focus. For example, the nearest hospital for a given patient might be unfocused at the firm level, but highly focused at the operating unit and process levels. Since our analyses involve three separate measures of focus, we produce three distinct sets of corresponding instrumental variables, one for each level of organizational focus.

## 7.3 Instrumental Variable Results

In order to obtain the set of K closest hospitals, we first obtained the ZIP codes of the patient residence and that of the hospitals in their choice set. The distances between patient homes and the set of focused hospitals in California were then estimated by calculating the "crow's flight" distances between the centroids of each patient's residential ZIP code and the ZIP codes of the hospitals. For each patient in our sample, we then sorted this corresponding set of hospitals by their relative travel distance, and obtained the set of K closest hospitals. Finally, we computed the three levels of focus for each of these hospitals.

The results of our IV estimations discussed above are displayed in Table 6a. After controlling for the selective admission effect, the previously reported benefits of hospital level focus vanish. Specifically, hospital level focus is no longer statistically significant in explaining variation in length of stay. Focused hospitals apparently obtain no length-of-stay reduction with respect to a patient chosen randomly from the overall patient populations. All acceleration benefits therefore seem to result from the admissions decision. The Hausman specification test shows that that the estimator for firm (hospital) focus is endogenous (p = 0.0087), confirming the presence of selection bias.

However, we find that the effects of operating unit (cardiac department) level focus continue to hold even for the patient that is quasi randomly assigned (-0.433). In fact, the corresponding IV estimates are not statistically different from the previously reported OLS estimates. This finding suggests that selection effects are less important at lower levels of focus. At this level of the organization, the benefits of focus are thus real operational benefit. The Hausman specification test does not reject the exogeneity of operating unit (cardiac department) focus (p = 0.44) and process focus (p = 0.80). This confirms that patient selectivity based on unobserved factors is not significant in biasing our estimates for the effects of operating unit level focus and process level focus.

As shown in Table 6b, we find that the effects of focus on reducing the likelihood of mortality for the randomly assigned patient disappear with our IV estimators. The coefficient estimate for the IV estimator for hospital level focus, cardiac department level focus and process flow focus are statistically insignificant. We find that the Wald test rejects exogeneity at 0.108, 0.133, and 0.975 levels for the hospital level, operating unit level, and process levels respectively. Thus, although we may not convincingly reject firm level endogeneity, we can reject endogeneity for the estimate of process and operating unit level focus; the probit results (Table 3b column 3) thus provide an unbiased estimate for the effects of process focus. In other words, process focus has the effect of reducing mortality. Similarly, the effects of operating unit (cardiac department) focus are also unbiased (at the 0.1 level). When we perform the Wald test for firm, operating unit, and process level focus for CABG patients (Table 4b), we also fail to reject exogeneity at 0.749, 0.423, and 0.975 levels respectively. Therefore, Table 4b provides unbiased estimates for the effect of three levels of focus on outcomes for CABG patients.

In summary, our analysis shows that all levels of focus are associated with shorter lengths of stay and reduced likelihoods of mortality as compared to non-focused hospitals. However, when we separate the operational benefits from the selection benefits by effectively randomizing the assignment of patients to hospitals, we find that the benefits of focus to a randomly assigned patient depend strongly on the kind of organizational focus. In particular, focus at the level of the cardiac department continues to improve length of stay. However, the benefits from hospital level focus disappear.

# 8. Conclusions

Our econometric analysis of the effects of focus in the cardiac care delivery market in California establishes the following four results. First, we show that focused hospitals demonstrate improved outcomes in the delivery of cardiac care. Specifically, we show that focused hospitals have shorter lengths of stay and lower odds of mortality compared to non-focused hospitals.

Second, we estimate the effects of focus at three different levels of the organization. This is particularly important because much of existing literature on focused hospitals has examined focus at the level of the firm. We find that all three levels of focus are associated with improved outcomes. However the more granular levels of organization focus have a greater impact on reducing length of stay and mortality rates than hospital level focus.

Third, we separate the operational gains of focus from the admissions (patient selection) related gains. We show that focused hospitals admit lower risk patients. Fourth, we show that at the hospital level controlling for selective admissions, the operational benefits of focus are lower than what we had seen. At the hospital level, focus does not improve length of stay or mortality.

Beyond its contribution to our understanding of focus, our results have practical implications for healthcare policy. Consider the question of how care should be provided by a set of hospitals in a region. From the perspective of policy maker tasked with providing care to all patients in need, our study finds both focused and general hospitals in a positive light. General hospitals may be better equipped for treating the "harder-to-treat" patients whereas focused hospitals are more effective with easy-to-treat patients. This suggests a division of labor in which large teaching hospitals offer a broad array of services and deal with the severely ill patients. Focused hospitals do what they are best at – dealing with the easy to treat patients. Such a division of labor would be fair, assuming one could create an effective and equitable payment plans that acknowledges the cherry-picking behavior of the focused hospitals. If the large teaching hospitals are expected to handle those patients that no focused hospital wants to care for, they will end up treating more severely ill patients. This suggests that their payments should be adjusted for taking on higher risk and greater costs. Exploring the effect of incentive schemes and reimbursement procedures on overall welfare is thus an important area of future research.

One potential limitation of our study is that only one hospital had cardiac percentages exceeding 60%. According to the GAO's definition (GAO 2003), a hospital is a specialty hospital if two-thirds or more of the patient population within fall under a major diagnostic category. Thus, the majority of hospitals that we studied are not considered specialty hospitals based on the GAO definition. It is thus plausible that the effects of focus may vary at higher degrees of focus. Examining the effects of focus at specialty hospitals is another area of future research.

Future research also needs to further explore the effects of other variables that drive patient selectivity. In particular, observations on physician referral patterns can shed more light on the extent to which selective admissions contribute to operational performance. Physician treatment patterns may also significantly drive outcomes (e.g. see McGlynn et al 2003). It would therefore be useful to understand the micro-level decision making by individuals and physicians. A comprehensive data collection effort and research into the choices made by the key stakeholders would greatly further our understanding of the drivers of healthcare outcomes.

From hotels to hospitals and from financial services to airlines – operational focus has often been a source of competitive advantage. Future research needs to replicate our theoretical framework with its distinction between operational gains from focus and the selection gains associated with "cherry picking". Furthermore, as we have found, the operational gains from focus also depend significantly on the level of the organization at which focus is evaluated. While the relative magnitude of these effects will differ across industries, we believe that the theory and methods presented in the present study provide an important step towards deepening our understanding of focus.

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# Tables and Figures

**Table 1: Comparisons of Cardiac-Focused and Non-Focused Hospitals**

| Characteristic | Focused Hospital | Non-Focused Hospital |
|---|---|---|
| Mean Charlson Score | 1.208 | 1.221 |
| Average Length of Stay (days) | 3.96 | 5.47 |
| Standard Deviation of LOS (days) | 0.12 | 0.32 |
| Mortality Rate | 2.47% | 2.65% |
| N (hospitals) | 195 | 193 |

*Focused hospital and non-focused hospitals are categorized with Hospital Level Focus values above and below the median respectively.*

**Table 2a: Patient Summary Statistics**

| Characteristic | Mean | Standard Deviation | Median |
|---|---|---|---|
| Length of Stay (Days) | 4.311967 | 13.27444 | 3 |
| Mortality Rate | .0241309 | .1534557 | 0 |
| Age Unknown | .059486 | .2365323 | 0 |
| Under 1 year | .0047818 | .0689852 | 0 |
| 1–17 years | .0073316 | .0853103 | 0 |
| 18–34 years | .0197667 | .1391978 | 0 |
| 35–64 years | .3636921 | .481062 | 0 |

| | | | |
|---|---|---|---|
| 65 years or greater | .5449417 | .4979766 | 1 |
| Gender unknown | .1816952 | .3855935 | 0 |
| Female | .4247148 | .4943001 | 0 |
| Male | .39359 | .4885462 | 0 |
| Income ($) | 54,208.21 | 21,196.18 | 50,092 |
| Unscheduled at least 24 hours prior to admission | .8431811 | .3636303 | 1 |
| Travel Distance (miles) | 15.25758 | 112.2278 | 5.003141 |
| Charlson Index | 1.239023 | 1.395788 | 1 |
| Myocardial Infarction for Current Admission | .1308896 | .3372799 | 0 |
| Prior Myocardial Infarction | .1147557 | .3187272 | 0 |
| Congestive Heart Failure | .3264827 | .4689266 | 0 |
| Peripheral Vascular Disease | .0717373 | .2580527 | 0 |
| Cerebrovascular Disease | .028659 | .1668463 | 0 |
| Chronic Obstructive Pulmo-nary Disease | .199072 | .3993027 | 0 |
| Diabetes | .2701279 | .444 | 0 |
| Chronic Renal Falure | .1989361 | .3992003 | 0 |
| Hypertension | .6913178 | .4619501 | 1 |

n = 500437 patients.

**Table 2b: Hospital Summary Statistics**

| Characteristic | Mean | Standard Deviation | Median |
|---|---|---|---|
| Volume | 10012 | 8784 | 7332 |
| Firm (Hospital) Focus | 0.124 | 0.073 | 0.116 |
| Operating Unit (Cardiac De-partment) Focus | 0.137 | 0.141 | 0.122 |
| Process Flow (Procedural) Focus | 0.407 | 0.298 | 0.284 |

n = 391 Hospitals

**Figure 1a: Distribution of Hospital Level Focus**

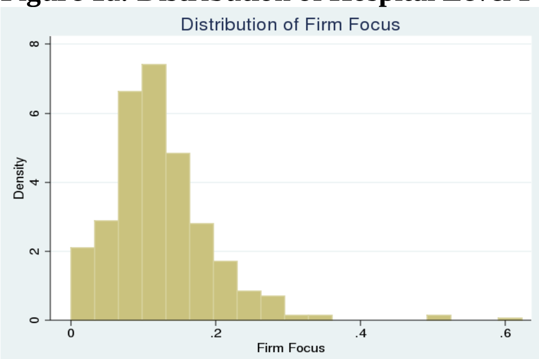


**Figure 1b: Distribution of Cardiac Department Focus**

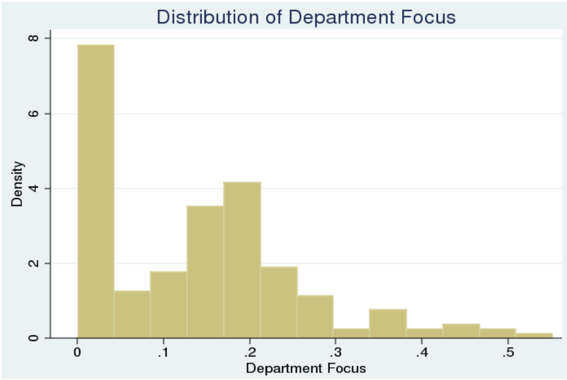


**Figure 1c: Distribution of Process Flow Focus**

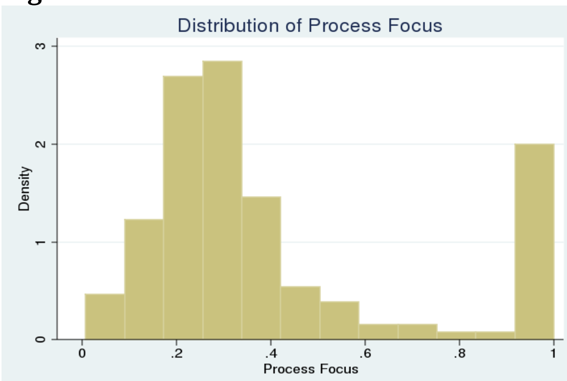


**Table 2c: Correlation between Levels of Focus**

| **Coefficient** | Hospital Focus | Cardiac Department Focus | Process Focus |
|---|---|---|---|
| Hospital Focus | 1.00 | | |
| Cardiac Department Focus | 0.399 | 1.00 | |
| Process Focus | -0.138 | -0.572 | 1.00 |

**Table 3a: Effect of Level of Focus on Log (Risk Adjusted Length of Stay)**

| **Coefficient** | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| Intercept | 0.656 *** (0.056) | 0.311 (0.24) | 1.66 *** (0.45) |
| Hospital Focus | -0.388 *** (0.151) | - | - |
| Cardiac Department Focus | - | -0.492 *** (0.104) | - |
| Process Focus | - | - | -0.023 (0.138) |
| Log Hospital Volume | -0.0387 ** (0.0178) | 0.0499 (0.31) | 0.033 (0.041) |
| Log Cardiac Volume | | -0.0144 (0.038) | 0.026 (0.037) |
| R-Square | 0.379 | 0.688 | 0.387 |
| N | 479412 | 67480 | 18797 |
| Clusters | 391 | 187 | 157 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index.*

**Table 3b: Effect of Level of Focus on Risk Adjusted Mortality Rate**

| Coefficient | (1) | (2) | (3) |
|---|---|---|---|
| Intercept | -2.01 *** (0.279) | -2.17*** (0.519) | -1.524 * (0.81) |
| Hospital Focus | -0.315 * (0.19) | - | - |
| Cardiac Department Focus | | -0.345 *** (0.137) | - |
| Process Focus | - | - | -0.564 *** (0.185) |
| Log Hospital Volume | -0.074 *** (0.021) | 0.045 (0.047) | 0.085 (0.069) |
| Log Cardiac Volume | | -0.082 (0.052) | -0.151 ** (0.069) |
| Likelihood Ratio (Pr > Chi-Square) | < 0.001 | < 0.001 | < 0.001 |
| N | 467313 | 67307 | 18630 |
| Clusters | 391 | 187 | 157 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index. A subset of DRGS's predict failure perfectly for 12099, 173 and 167 cardiac, revascularization, and easy revascularization patients respectively, and were not used in the probit regression.*

**Table 4a: Effect of Level of Focus on Log (Risk Adjusted Length of Stay) for CABG Patients Only**

| Coefficient | Controls (1) | Firm Focus (2) | Operating Unit Focus (3) | Process Focus (4) | All Focus (5) |
|---|---|---|---|---|---|
| Intercept | 1.70 *** (0.41) | 1.74 *** (0.43) | 1.66 *** (0.41) | 1.67 *** (0.45) | 1.739 *** (0.456) |
| Hospital Focus | - | -0.0168 (0.21) | - | - | -0.157 (0.23) |
| Cardiac Department Focus | - | - | 0.169 (0.41) | - | 0.23 (0.13) |
| Process Focus | - | - | - | 0.0230 (0.138) | 0.055 (0.13) |
| R-Square | 0.3869 | 0.3898 | 0.3877 | 0.3870 | 0.3882 |
| N | 18797 | 18797 | 18797 | 18797 | 18797 |
| Clusters | 157 | 157 | 157 | 157 | 157 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Hospital volume is included in all of the specifications. Cardiac department volume is included in all of the specifications except (2) and (5) because of collinearity with the construct for department focus as department focus is explained by cardiac volume and total* *hospital volume. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index. Estimates available from authors.*

**Table 4b: Effect of Level of Focus on Risk Adjusted Mortality Rate for <u>CABG Patients Only</u>**

| Coefficient | Controls (1) | Firm Focus (2) | Operating Unit Focus (3) | Process Focus (4) | All Focus (5) |
|---|---|---|---|---|---|
| Intercept | -1.788 ***<br>(0.81) | -1.34 *<br>(0.85) | -1.69 **<br>(0.81) | -1.79 **<br>(0.81) | -1.067<br>(0.855) |
| Hospital Focus | - | -0.72 **<br>(0.33) | - | - | -0.442<br>(0.335) |
| Cardiac Department Focus | - | - | -0.260<br>(0.22) | - | - 0.384 **<br>(0.192) |
| Process Focus | - | - | - | -0.564 ***<br>(0.185) | -0.622 ***<br>(0.181) |
| Likelihood Ratio (Pr > Chi-Square) | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |
| N | 18630 | 18630 | 18630 | 18630 | 18630 |
| Clusters | 157 | 157 | 157 | 157 | 157 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Hospital volume is included in all of the specifications. Cardiac department volume is included in all of the specifications except (2) and (5) because of collinearity with the construct for department focus as department focus is explained by cardiac volume and total hospital volume. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index. Estimates available from authors.*

**Table 5: Relationship between Levels of Focus and Pre-Operative Risk Levels**

| Coefficient | (1) | (2) | (3) |
|---|---|---|---|
| Intercept | -4.086 ***<br>(0.025) | -3.939 ***<br>(0.0497) | -4.115 ***<br>(0.062) |
| Hospital Focus | -0.452 ***<br>(0.173) | - | - |
| Cardiac Department Focus | - | -0.902 ***<br>(0.272) | - |
| Process Focus | - | - | - 0.0772<br>(0.123) |
| R-Square | 0.0172 | 0.0563 | 0.0025 |
| Number of Patients | 479412 | 67480 | 18797 |
| Number of Hospitals | 391 | 187 | 157 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. The pre-operative predicted mortality rate is logged to reduce the skewness in the distribution.*

**Table 6a: Effect of Level of Focus on Log (Risk Adjusted Length of Stay) with Instrumental Variables**

| Coefficient | (1) | (2) | (3) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Intercept | 0.665 ***<br>(0.272) | 0.296<br>(0.244) | 0.974<br>(0.672) |
| Hospital Focus | 0.478 (0.484) | - | - |
| Cardiac Department Focus | - | -0.433 *<br>(0.254) | - |
| Process Focus | - | - | -0.287<br>(0.44) |
| Log Hospital Volume | - 0.015<br>(0.024) | 0.055<br>(0.042) | 0.026<br>(0.045) |
| Log Cardiac Volume | - | -0.019 (0.05) | 0.032 (0.043) |
| R-Square | 0.375 | 0.688 | 0.385 |
| N | 467000 | 65454 | 18292 |
| Clusters | 391 | 187 | 157 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index. The smaller number of patients reflects the fact that some of the zip codes were not available at the patient level for the IV estimation. This is because the zip codes for randomly chosen patients were masked out to protect their confidentiality.*

**Table 6b: Effect of Level of Focus on Risk Adjusted Mortality Rate with Instrumental Variables**

| **Coefficient** | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| Intercept | -2.46 ***<br>(0.41) | -2.31 ***<br>(0.546) | -1.46 *<br>(0.79) |
| Hospital Focus | 0.696<br>(0.685) | - | - |
| Cardiac Department Focus | - | 0.329<br>(0.47) | - |
| Process Focus | - | - | 0.319<br>(1.34) |
| Log Hospital Volume | -0.048 (0.030) | 0.117 *<br>(0.065) | -0.081 *<br>(0.068) |
| Log Cardiac Volume | - | -0.169 **<br>(0.073) | -0.15 **<br>(0.07) |
| Likelihood Ratio<br>(Pr > Chi-Square) | < 0.001 | < 0.001 | < 0.001 |
| N | 455039 | 65288 | 18129 |
| Clusters | 391 | 187 | 157 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index. The smaller number of patients reflects the fact that some of the zip codes were not available at the patient level for the IV estimation. This is because the zip codes for randomly chosen patients were masked out to protect their confidentiality.*

# Appendix:

## Robustness Tests

We performed several tests to examine the robustness of our findings. We first performed a distance-based instrumental variables regression based on a median split of the patient population. Specifically, we first split the hospitals into focused and un-focused categories based on the median value for focus; only those hospitals with values for focus greater than the median were designated as focused hospitals. For each patient, we then calculate the differential distance, defined as the distance to the nearest focused hospital less the distance to the nearest hospital that can treat the patient. We next use this differential distance as the instrumental variable to identify the effect of focus on outcome. We perform these analyses for all three measures of focus; we find statistical significance for the effect of focus at the cardiac department level and process flow levels on reducing the length of stay. In addition, we now find that hospital level focus is associated with a longer hospital stay for the randomly assigned patient. This provides further evidence that the gains from hospital level focus are driven primarily by selective admissions.

Second, although we account for various hospital level controls in our analysis, it is plausible that unobserved hospital level factors may bias our estimates for the effects of focus. To verify that such hospital level factors do not impact our results, we performed a longitudinal analysis of the effects of focus in which we include hospital fixed effects. More specifically, we regressions we run are the form:

$$Y_{iht} = \alpha_h + \eta Focus_{iht} + \boldsymbol{X}_i\beta + \gamma_t + \varepsilon_{iht}$$

where $\alpha_h$ is the hospital fixed effect, and $\gamma_t$ is the year dummy. $\boldsymbol{X_i}$ is a vector of patient controls and $\eta$ captures the effect of focus on outcome ($Y_{iht}$) for patient *i* in hospital *h* in year *t*.

To perform this regression, we collected additional data for the variables described in Section 5 for the years 1998 through 2006. We examined the effect of focus on both length of stay and the likelihood of mortality for all three organizational levels of focus. The results are summarized in Tables 11 and 12. We find that the coefficient for $\eta$ is negative and similar for all cases, suggesting that hospital level confounding factors did not significantly impact our results.

In the first stage IV regressions, we needed to determine the number of hospitals to include in the patient's choice set. We included hospitals as long as the regression coefficients were statistically significant at the 10% level. In our analysis, we limited the number of hospitals (K) in a patient's choice set to the 15 nearest. As tests of robustness, we also include additional hospitals (corresponding to larger values of k). However, we find that the inclusion of additional hospitals does not significantly affect the patient's choice, as evidenced by the statistically insignificant coefficient estimates for $\rho_k$. The additional variables also had no impact on our estimators (focus). This was to be expected because hospitals that are far away (say 15th in the patient's choice set) have little impact on patient choice. As expected, we find that the coefficient values for $\rho_k$ are larger for smaller values of $k$ in a stochastic sense, indicating that patients are more likely to end up at a focused hospital if they live in close proximity to one (Appendix Tables 7 and 8). This provides evidence that our instrumental variable is relevant.

The independence between the error term and the instrumental variable, also referred to as the exclusion restriction condition, is required for the validity of the instrumental variables. We verify the lack of strong statistical correlation between $Focus_{ik}$ and the patient's predicted risk of mortality, which is an observed measure of severity as evidence in support of the exclusion restriction condition (Table 13).

We performed the Hausman specification test to examine the endogeneity of the three focus measures. We find that firm (hospital) Focus is endogenous ($p = 0.0087$). The F-statistic value from the first-stage regression for the IV estimator is statistically significant for the hospital level focus indicating that our identification is strong. However, the Hausman specification test does not reject the exogeneity of operating unit (Cardiac Department) Focus ($p = 0.44$) and Process Flow Focus ($p = 0.80$). This confirms that patient selectivity based on unobserved factors is not significant in biasing our estimates for the effects of Cardiac Department Focus and Process Flow focus. This finding also provides an explanation for the similarity of the IV and OLS estimates based for these two focus measures. We also examine the exogeneity of the focus measures for estimating the effects on mortality using the Wald test. We find that the exogeneity is rejected at 0.108, 0.133, and 0.975 levels for the hospital level, operating unit level, and process levels respectively. Thus, although we can reject endogeneity at the process level and operating unit levels (and hence rely on the probit results), we can only marginally reject endogeneity at the firm level.

Finally, to test the robustness of the results for process flow focus, we split up the revascularization patients based on the mean values of the pre-operative risk; the results are similar to those obtained with a median split.

**Table 7: First Stage Estimates for the Effect of focus on Log (Risk Adjusted Length of Stay)**

| Coefficient | (1) | (2) | (3) |
|---|---|---|---|
| Intercept | 0.35389 | 0.084619 | 0.322618 |
| Focus0 | 0.180923 | 0.178841 | 0.069194 |
| Focus1 | 0.099249 | 0.133907 | 0.039594 |
| Focus2 | 0.08443 | 0.145081 | 0.029369 |
| Focus3 | 0.044693 | 0.161685 | 0.02893 |
| Focus4 | 0.012251 | 0.102908 | 0.020304 |
| Focus5 | 0.014997 | 0.099244 | 0.016689 |
| Focus6 | - | 0.079232 | 0.013614 |
| R-square | 0.157 | 0.334 | 0.121 |
| Prob > F | 0 | 0 | 0 |

*All coefficients have statistical significance of 0.1 or better.*

**Table 8: First Stage Estimates for the Effect of Focus on Risk Adjusted Mortality Rate**

| Coefficient | (1) | (2) | (3) |
|---|---|---|---|
| Intercept | 0.350845 | 0.079261 | 0.278161 |
| Focus0 | 0.176053 | 0.179538 | 0.066761 |
| Focus1 | 0.09848 | 0.133458 | 0.039313 |
| Focus2 | 0.080838 | 0.146689 | 0.029175 |
| Focus3 | 0.042867 | 0.162374 | 0.029046 |
| Focus4 | 0.012186 | 0.104394 | 0.020422 |
| Focus5 | 0.016108 | 0.100608 | 0.014973 |
| Focus6 | - | 0.080563 | 0.013768 |
| Prob > F | 0 | 0 | 0 |

*All coefficients have statistical significance of 0.1 or better.*

**Table 9: Effect of Focus on Risk Adjusted Log (Length of Stay) with median split of IV**

| Coefficient | (1) | (2) | (3) |
|---|---|---|---|
| Firm Focus | 1.12 (0.68) * | - | - |
| Operating Unit Focus | - | -1.36 (0.56) ** | |
| Process Focus | - | | -1.74 (1.078) * |
| R-Square | 0.374 | 0.684 | 0.725 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index.*

**Table 10: Effect of Focus on Risk Adjusted Mortality Rate with median split of IV**

| Coefficient | (1) | (2) | (3) |
|---|---|---|---|
| Firm Focus | 0.475 (1.047) | - | - |
| Operating Unit Focus | - | -1.50 (1.048) | |
| Process Focus | - | | 3.19 (7.31) |
| Likelihood Ratio (Pr > Chi-Square) | < 0.001 | < 0.001 | < 0.001 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index.*

**Table 11: Effect of the Three Levels of Focus on Log (Length of Stay) with Hospital Fixed Effects**

| **Coefficient** | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| Hospital Focus | -0.482 ***<br>(0.108) | - | - |
| Cardiac Department Focus | - | -0.613***<br>(0.152) | - |
| Process Focus | - | - | -0.099<br>(0.075) |
| Log Hospital Volume | -0.0406 ***<br>(0.016) | -0.0346<br>(0.0468) | -0.0316<br>(0.0307) |
| Log Cardiac Volume | - | -0.000312<br>(0.0388) | 0.0257<br>(0.036) |
| R-Square | 0.3976 | 0.6735 | 0.4064 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Hospital Volume was included for all specifications and Cardiac department volume is included in all of the specifications except (1) because of collinearity with the construct for department focus as department focus is explained by cardiac volume and total hospital volume. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index. Estimates available from authors.*

**Table 12: Effect of the Three Levels of Focus on Probit (Mortality) with Hospital Fixed Effects**

| **Coefficient** | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| Hospital Focus | -0.841 ***<br>(0.227) | - | - |
| Cardiac Department Focus | - | -0.332 **<br>(0.159) | - |
| Process Focus | - | - | -0.281 ***<br>(0.115) |
| Log Hospital Volume | | 0.105<br>(0.64) | 0.066<br>(0.073) |
| Log Cardiac Volume | | -0.15 ***<br>(0.06) | -0.159 **<br>(0.067) |
| Likelihood Ratio<br>(Pr > Chi-Square) | < 0.001 | < 0.001 | < 0.001 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Hospital Volume was included for all specifications and Cardiac department volume is included in all of the specifications except (1) because of collinearity with the construct for department focus as department focus is explained by cardiac volume and total hospital volume. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index. Estimates available from authors.*

**Table 13: Correlation between Predicted Mortality Rate and Instrumental Variables**

| Coefficient | Hospital Focus | | Cardiac Department Focus | | Process Flow Focus | |
|---|---|---|---|---|---|---|
| | Estimate | Standard Err | Estimate | Standard Err | Estimate | Standard Err |
| Focus1 | 0.000395 | 0.000459 | 0.000951 | 0.000715 | -0.00099 | 0.000654 |
| Focus2 | -0.00049 | 0.000452 | -0.00028 | 0.000633 | -0.00131 | 0.000684 |
| Focus3 | -0.00011 | 0.000457 | 0.001589 | 0.000699 | 0.000133 | 0.000547 |
| Focus4 | -0.00046 | 0.000504 | 0.002157 | 0.000851 | -0.00166 | 0.000618 |
| Focus5 | -0.00018 | 0.000436 | 0.000633 | 0.0007 | -0.00039 | 0.000588 |
| Focus6 | 0.000341 | 0.000481 | 0.003142 | 0.000825 | -0.00025 | 0.000618 |
| Focus7 | -0.00044 | 0.000451 | 0.001183 | 0.000826 | -0.00038 | 0.000651 |
| Focus8 | -0.00084 | 0.000491 | 0.000379 | 0.000817 | 0.000664 | 0.000592 |
| Focus9 | 0.000308 | 0.000523 | -0.00023 | 0.000819 | 0.000503 | 0.000693 |
| Focus10 | -0.00057 | 0.00053 | 0.000628 | 0.000756 | 0.000791 | 0.000657 |
| Focus11 | -9.9E-05 | 0.000492 | -0.00014 | 0.000643 | -0.00105 | 0.000568 |
| Focus12 | 0.000573 | 0.000505 | -0.00043 | 0.000788 | -0.00015 | 0.000539 |
| Focus13 | 5.96E-05 | 0.000487 | 0.001025 | 0.000616 | -0.00077 | 0.000647 |
| Focus14 | -1.8E-05 | 0.00046 | 0.000455 | 0.000636 | 0.000469 | 0.000505 |
| Focus15 | 0.000232 | 0.000463 | 0.000875 | 0.000763 | -0.0001 | 0.000691 |

**Table 14: Effect on LOS for the subset of 18,797 patients undergoing a CABG**

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | | Model 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Estimate | Std Err | Estimate | Std Err | Estimate | Std Err | Estimate | Std Err | Estimate | Std Err |
| 1-17 years | baseline | | | | | | | | | |
| 18-34 Years | -0.0880 | 0.3075 | -0.0758 | 0.3140 | -0.1092 | 0.3042 | -0.0832 | 0.3065 | -0.0967 | 0.3106 |
| 35 - 65 Years | 0.1010 | 0.3002 | 0.1156 | 0.3067 | 0.0804 | 0.2976 | 0.1054 | 0.3009 | 0.0951 | 0.3057 |
| 65 Years or greater | 0.2013 | 0.3004 | 0.2159 | 0.3069 | 0.1806 | 0.2978 | 0.2059 | 0.3010 | 0.1956 | 0.3058 |
| Male | -0.0653 | 0.0160 | -0.0676 | 0.0161 | -0.0627 | 0.0155 | -0.0645 | 0.0148 | -0.0618 | 0.0133 |
| Admission Unscheduled | 0.6158 | 0.0358 | 0.6207 | 0.0366 | 0.6219 | 0.0370 | 0.6172 | 0.0400 | 0.6320 | 0.0420 |
| Current Myocardial Infarction | 0.0306 | 0.0140 | 0.0319 | 0.0139 | 0.0297 | 0.0140 | 0.0304 | 0.0135 | 0.0298 | 0.0133 |
| Old Myocardial Infarction | -0.1276 | 0.0335 | -0.1263 | 0.0337 | -0.1276 | 0.0336 | -0.1276 | 0.0334 | -0.1266 | 0.0335 |
| Congestive Heart Failure | 0.1999 | 0.0137 | 0.1995 | 0.0138 | 0.2012 | 0.0142 | 0.2000 | 0.0138 | 0.2016 | 0.0143 |
| Peripheral Vascular Disease Diagnosed | -0.1030 | 0.0342 | -0.1020 | 0.0342 | -0.1024 | 0.0342 | -0.1031 | 0.0341 | -0.1012 | 0.0341 |
| Peripheral Vascular Disease Surgery | 0.0876 | 0.0710 | 0.0892 | 0.0705 | 0.0861 | 0.0716 | 0.0876 | 0.0709 | 0.0867 | 0.0714 |
| Cerebrovascular Disease | 0.1463 | 0.0167 | 0.1456 | 0.0166 | 0.1458 | 0.0170 | 0.1463 | 0.0168 | 0.1449 | 0.0169 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| COPD | -0.0242 | 0.0295 | -0.0231 | 0.0296 | -0.0256 | 0.0295 | -0.0239 | 0.0297 | -0.0248 | 0.0298 |
| Diabetes | -0.0924 | 0.0283 | -0.0917 | 0.0282 | -0.0914 | 0.0283 | -0.0921 | 0.0283 | -0.0896 | 0.0282 |
| Diabetes with Sequelae | -0.1271 | 0.0572 | -0.1252 | 0.0572 | -0.1268 | 0.0573 | -0.1270 | 0.0572 | -0.1246 | 0.0572 |
| Chronic Renal Failure | 0.0047 | 0.0624 | 0.0073 | 0.0627 | 0.0043 | 0.0625 | 0.0047 | 0.0623 | 0.0061 | 0.0624 |
| Hypertension | -0.0683 | 0.0115 | -0.0673 | 0.0116 | -0.0675 | 0.0111 | -0.0686 | 0.0111 | -0.0672 | 0.0108 |
| Charlson Risk Score | 0.1151 | 0.0297 | 0.1142 | 0.0297 | 0.1149 | 0.0297 | 0.1150 | 0.0298 | 0.1137 | 0.0297 |
| Log Hospital Volume | 0.0324 | 0.0403 | 0.0475 | 0.0331 | 0.0538 | 0.0440 | 0.0328 | 0.0409 | 0.0455 | 0.0322 |
| Log Cardiac Volume | 0.0268 | 0.0370 | - | - | 0.0051 | 0.0442 | 0.0265 | 0.0370 | - | - |
| **Hospital Focus** | | | **-0.0169** | **0.2104** | | | | | -0.1575 | 0.2289 |
| **Cardiac Department Focus** | | | | | **0.1688** | **0.4105** | | | **0.2301** | **0.1337** |
| **Process Focus** | | | | | | | **0.0230** | **0.1384** | **0.055243** | **0.13396** |
| Intercept | 1.6896 | 0.4155 | 1.7366 | 0.4360 | 1.6600 | 0.4105 | 1.6653 | 0.4532 | **1.739039** | **0.456901** |
| **R-square** | **0.3869** | | **0.3898** | | **0.3877** | | **0.3870** | | **0.3882** | |

## Table 15: Effect on Mortality for the subset of 18,797 patients undergoing a CABG

| | **Model 1** | | **Model 2** | | **Model 3** | | **Model 4** | | **Model 5** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Estimate** | **Std Err** | **Estimate** | **Std Err** | **Estimate** | **Std Err** | **Estimate** | **Std Err** | **Estimate** | **Std Err** |
| 18-34 | -0.339 | 0.438 | -0.339 | 0.438 | -0.348 | 0.441 | -0.316 | 0.440 | -0.328 | 0.444 |
| 35-65 | -0.315 | 0.054 | -0.314 | 0.054 | -0.316 | 0.054 | -0.314 | 0.054 | -0.314 | 0.054 |
| 65 and above | baseline | | | | | | | | | |
| Male | -0.181 | 0.046 | -0.181 | 0.046 | -0.180 | 0.046 | -0.181 | 0.047 | -0.181 | 0.046 |
| Unscheduled (baseline missing) | -0.276 | 0.602 | -0.273 | 0.606 | -0.268 | 0.601 | -0.305 | 0.583 | -0.294 | 0.582 |
| Current Myocardial Infarction | 0.131 | 0.055 | 0.130 | 0.055 | 0.132 | 0.055 | 0.139 | 0.055 | 0.142 | 0.054 |
| Old Myocardial Infarction | -0.599 | 0.120 | -0.599 | 0.120 | -0.599 | 0.119 | -0.601 | 0.119 | -0.601 | 0.118 |
| Congestive Heart Failure | 0.158 | 0.044 | 0.158 | 0.043 | 0.157 | 0.043 | 0.157 | 0.043 | 0.154 | 0.043 |
| Peripheral Vascular Disease Diagnosed | -0.164 | 0.113 | -0.163 | 0.113 | -0.166 | 0.113 | -0.161 | 0.112 | -0.162 | 0.112 |
| Peripheral Vascular Disease Surgery | 0.345 | 0.216 | 0.343 | 0.216 | 0.348 | 0.214 | 0.344 | 0.216 | 0.347 | 0.213 |
| Cerebrovascular Disease | 0.083 | 0.066 | 0.082 | 0.066 | 0.084 | 0.066 | 0.085 | 0.066 | 0.088 | 0.066 |
| COPD | -0.411 | 0.110 | -0.412 | 0.110 | -0.410 | 0.109 | -0.416 | 0.110 | -0.416 | 0.109 |
| Diabetes | -0.554 | 0.107 | -0.554 | 0.107 | -0.558 | 0.107 | -0.557 | 0.106 | -0.562 | 0.106 |
| Diabetes with Sequelae | -1.158 | 0.215 | -1.158 | 0.215 | -1.160 | 0.216 | -1.163 | 0.214 | -1.166 | 0.215 |
| Chronic Renal Failure | -0.446 | 0.196 | -0.449 | 0.196 | -0.447 | 0.195 | -0.442 | 0.197 | -0.446 | 0.195 |
| Hypertension | -0.295 | 0.050 | -0.297 | 0.050 | -0.297 | 0.049 | -0.292 | 0.049 | -0.295 | 0.049 |
| Charlson Risk Score | 0.390 | 0.092 | 0.390 | 0.092 | 0.391 | 0.092 | 0.392 | 0.092 | 0.394 | 0.092 |
| Log Hospital Volume | 0.102 | 0.073 | -0.065 | 0.059 | 0.070 | 0.077 | 0.085 | 0.070 | -0.066 | 0.056 |
| Log Cardiac Volume | -0.164 | 0.070 | - | - | -0.130 | 0.076 | -0.151 | 0.069 | - | - |
| **Hospital Focus** | | | **-0.722** | **0.330** | | | | | **-0.442** | **0.335** |
| **Cardiac Department Focus** | | | - | - | **-0.260** | **0.212** | | | **-0.384** | **0.192** |
| **Process Focus** | | | - | - | | | **-0.564** | **0.185** | **-0.622** | **0.181** |
| Intercept | -1.788 | 0.817 | -1.337 | 0.856 | -1.688 | 0.811 | -1.524 | 0.815 | -1.067 | 0.855 |
| (Pr > Chi-Square) | 0.000 | | 0.000 | | 0.000 | | 0.000 | | 0.000 | |

**Table 16a: Effect of Level of Focus on Log (Risk Adjusted Length of Stay) with Instrumental Variables for CABG Patients Only**

| **Coefficient** | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| Intercept | 2.178 ***<br>(0.85) | 1.099<br>(0.744) | 0.974<br>(0.672) |
| Hospital Focus | -1.18 (1.477) | - | - |
| Cardiac Department Focus | - | -0.581<br>(0.680) | - |
| Process Focus | - | - | -0.287<br>(0.44) |
| Log Hospital Volume | - 0.062<br>(0.056) | - 0.042<br>(0.094) | 0.026<br>(0.045) |
| Log Cardiac Volume | - | 0.10 (0.09) | 0.032 (0.043) |
| R-Square | 0.367 | 0.372 | 0.385 |
| N | 18292 | 18292 | 18292 |
| Clusters | 157 | 157 | 157 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, incidence of PCI, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index. The smaller number of patients reflects the fact that some of the zip codes were not available at the patient level for the IV estimation. This is because the zip codes for randomly chosen patients were masked out to protect their confidentiality.*

**Table 16b: Effect of Level of Focus on Risk Adjusted Mortality Rate with Instrumental Variables for CABG Patients Only**

| **Coefficient** | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| Intercept | -0.879<br>(1.589) | -1.94 **<br>(0.953) | -1.46 *<br>(0.79) |
| Hospital Focus | -1.069<br>(1.23) | - | - |
| Cardiac Department Focus | - | 0.530<br>(1.07) | - |
| Process Focus | - | - | 0.319<br>(1.34) |
| Log Hospital Volume | -0.102 (0.127) | 0.163<br>(0.14) | -0.081 *<br>(0.068) |
| Log Cardiac Volume | - | -0.23 *<br>(0.14) | -0.15 **<br>(0.07) |
| Likelihood Ratio<br>(Pr > Chi-Square) | < 0.001 | < 0.001 | < 0.001 |
| N | 18292 | 18292 | 18129 |
| Clusters | 157 | 157 | 157 |

*Asymptotic Standard Errors in Parentheses * 10 % Statistical Significance, ** 5% Statistical Significance, *** 1 % Statistical Significance. Standard Errors are clustered at the hospital level. Patient level controls included age, gender, ZIP code household income, type of admission, DRG categorical variable, incidence of Myocardial Infarction, incidence of PCI, Congestive Heart Failure, Vascular Disease, COPD, Diabetes, Chronic Renal Failure, Hypertension, and the Charlson Index. The smaller number* *of patients reflects the fact that some of the zip codes were not available at the patient level for the IV estimation. This is because the zip codes for randomly chosen patients were masked out to protect their confidentiality.*