PRELIMINARY

HOSPITAL CONSOLIDATION AND THE DELIVERY OF CARDIAC CARE

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ABSTRACT

This paper examines the private and social implications of hospital integration. Using patient-level administrative and clinical records from New York State for the period from 1992 to 1998, I examine the effect of hospital acquisitions on the distribution of market share across providers in target markets. I test for the presence of both business stealing and business creation in the primary market areas of target hospitals following consolidation events and consider the welfare implications of such activity.

I analyze the effect of acquisitions on three major cardiac procedures: cardiac catheterization, coronary artery bypass graft (CABG) surgery, and percutaneous transluminal coronary angioplasty (PTCA). I find evidence of business stealing with respect to all three procedures and business creation for catheterizations. The resulting movement in volume across providers leads to a decrease in the average risk-adjusted, in-hospital mortality (i.e., an increase in average quality) and an increase in average cost for CABG patients in the primary markets of target hospitals. Similar effects are not found for PTCA. Overall, the New York evidence suggests that hospital integration represents a relatively cost-effective means of improving the quality of cardiac care.

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I. INTRODUCTION

During the past two decades, the American health care industry has undergone significant consolidation.[1] As noted by Gaynor and Haas-Wilson (1999), this consolidation has occurred both within and across the hospital, physician, and insurance sectors. Consolidation within the hospital sector represents the most visible of these trends, particularly since the early 1990s. Between 1980 and 1993, the annual number of hospital consolidations in the United States remained relatively stable at between 10 and 30 transactions per year (Figure 1). The number of transactions, however, jumped to 100 in 1994 and reached a peak of 198 in 1998 before declining to 142 in 1999.

This wave of hospital integration raises two important questions. First, why is integration privately beneficial for the hospitals involved? Second, what are its implications for social welfare? With respect to the first question, theory suggests three responses. First, consolidating hospitals may attempt to raise price either with or without a change in the quality of care provided. Second, the parties to a transaction may increase the quantity of services they provide, assuming that the marginal cost of those services does not exceed their price.[2] This response would appear as some combination of "business stealing" (i.e., garnering a larger share of existing market volume) and "business creation" (i.e., increasing market volume) by consolidating hospitals. Such volume increases might serve to improve quality via learning or lower cost through

[1] "Consolidation" serves as an umbrella term covering several types of transactions including full asset merger, sponsorship, and the formation of a holding company. A more detailed definition of this term is provided in Section II.

[2] To the extent that increases in quantity serve to decrease price, this condition requires that the price *after* a volume increase remains greater than marginal cost. For certain types of hospital care (e.g., Medicare) prices are administered, so marginal changes in quantity do not directly affect price.

learning or economies of scale. Finally, hospitals may use consolidation to benefit from synergies that are independent of procedure volume. These include quality improvement or cost reductions due to the transfer of best practices between hospitals or the easing of capital constraints that may face small facilities prior to consolidation.

The existing literature provides relatively strong support for the view that increased market concentration allows hospitals to increase their prices (Melnick *et al.*, 1992; Keeler *et al*., 1999) and price-cost margins (Dranove and Shanley, 1995). The literature, however, contains only weak evidence of cost savings resulting from consolidation (e.g., Lynk, 1995[3]). In general, these papers do not explicitly examine changes in quantity or quality that may occur as a result of consolidation. This paper tests for consolidation-related changes in volume and examines a potential mechanism by which these changes affect average cost and quality.

The second question in this paper concerns the welfare implications of consolidation. A small number of recent studies have addressed this question in varying levels of detail and for different types of health care providers. Hamilton and Ho (2000) and Kessler and McClellan (2000) examine the effects of hospital consolidation; Baker and Brown (1999) consider mammography units; and Banaszak-Holl *et al*. (2000) study nursing homes.[4] Consolidation may impact welfare through several channels. Price

[3] Using data from a four-hospital merger, Lynk (1995) suggests that consolidations can reduce the "peak-load" associated with fixed capacity and highly variable demand. Nonetheless, he does not provide evidence that such efficiencies actually are realized after consolidation.

[4] Whereas Hamilton and Ho (2000) rely on administrative data in the risk-adjustment of outcomes, this paper benefits from combining patient-level administrative *and* clinical data. The impact of this clinical data on risk-adjustment is considered later in this paper. Kessler and McClellan (2000) focus on the welfare implications of *horizontal* consolidation. This paper examines similar issues with respect to the *vertical* elements of hospital integration (e.g., integration's effects on referral patterns for patients who live near a target hospital but require care that is not provided by that target). The panel of hospitals in the data set used in this analysis allows for a fixed-effects approach that addresses some of the unobserved

changes may affect social welfare to the extent that they alter levels of utilization and insurance coverage. The literature on inefficient entry suggests that business stealing may reduce welfare in industries characterized by high fixed costs (Perry, 1984; Mankiw and Whinston, 1986; Berry and Waldfogel, 1999). In these situations, the costs associated with reduced scale economies for incumbents outweigh the benefits of increased competition created by entry. Business creation will also increase (decrease) welfare if it expands access to treatment for which marginal benefit is greater (less) than marginal social cost. Finally, synergies unrelated to procedure volume will affect welfare to the extent that they change the average quality or cost of care.

This paper aims to answer the two questions raised above by examining the impact of integration that occurred in the State of New York between 1990 and 1997. During that period, New York hospitals were involved in 34 consolidations.[5] I focus on "acquisitions"—which I define as consolidations between an "acquirer" that offers full-service cardiac care and a "target" that offers more modest cardiac services.[6] Due to the asymmetry in service offerings between acquirers and targets, this study provides greater insight into vertical, rather than horizontal, aspects of hospital consolidation.

To facilitate my welfare analysis, I focus further on the effect of consolidation on the provision of major cardiac procedures: cardiac catheterization, coronary artery bypass

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heterogeneity issues that required instrumental-variable methods in prior cross-sectional studies (e.g., Baker and Brown, 1999).

[5] This number represents a lower bound for the total number of consolidations that occurred in New York between 1990 and 1997. All transactions occurring after 1994 were verified using the annual survey of hospital merger activity conducted by *Modern Healthcare*. For the years from 1990 to 1994, consolidations were identified on the basis of public news reports identified by searches of the LEXIS database.

[6] These definitions are formalized in Section II.

graft (CABG) surgery, and percutaneous transluminal coronary angioplasty (PTCA). Cardiac procedures serve as the subject of this study for several reasons. First, these procedures represent a profitable and sizeable source of revenue for hospitals. Second, they require substantial fixed investments in equipment and dedicated staff, creating the potential for consolidation to improve efficiency by exploiting economies of scale in production. Third, because a significant portion of patients receiving CABG and PTCA die in the hospital, the variation in average mortality among hospitals is large enough to make it a meaningful measure for comparing outcomes across providers. Fourth, the State of New York—the empirical setting for this study—collects detailed quality information on each CABG and PTCA case. The broad range of pre-operative risk factors reported for each patient in these data allows for the refined risk-adjustment of outcomes. Finally, prior academic work has identified wide variation in utilization rates for cardiac procedures across relatively small geographic areas (Center for the Evaluative Clinical Sciences, 1998; Tu *et al*., 1997).[7] This study considers the extent, if any, to which this variation might be explained by hospital consolidation.

Based on the sample of acquisitions in New York State between 1990 and 1997, I find strong evidence of business stealing with respect to cardiac procedures. Specifically, consolidations are correlated with the shift of a significant share of cardiac procedures in target markets to acquirer and target hospitals. For CABG and PTCA, this increase appears to peak at two years after acquisition and dissipates by the third post-acquisition year. I also find evidence of business creation with respect to some, though not all, types

[7] This result holds between the United States and Canada (Tu *et al*., 1997) and across and within American states (Center for the Evaluative Clinical Sciences, 1998). While much of this variation remains unexplained, some of it has been attributed to factors such as the availability of technology at particular

of cardiac procedures. Acquisition-related business stealing increases both the average quality—as measured by in-hospital mortality—and average cost of CABG cases in target markets. No significant changes in average quality or cost, however, are present for PTCA procedures. A rough welfare calculation suggests that consolidation serves as a relatively cost-effective method of improving the quality of care for CABG patients. This welfare calculation does not fully capture the impact of business creation or any effects of price changes that may have occurred after consolidation. Nevertheless, the fact that New York regulated the rates for a large portion of inpatient hospital care during much of the period studied suggests that hospitals were not able to substantially influence prices through consolidation. New York's regulatory structure is discussed in greater detail in Section IV.

The remainder of this paper is organized in seven sections. Section II provides a brief description of cardiac procedures, and Section III describes consolidation activity in New York State during the 1990s. Section IV describes the potential motivations for and effects of consolidation in greater detail. Section V discusses data sources, Section VI presents results for the impact of consolidation on participating hospitals, Section VII discusses implications for social welfare, and Section VIII concludes.

II. CARDIAC PROCEDURES

A Brief Summary of Cardiac Procedures

Figure 2 provides a simplified diagram illustrating the path of a typical cardiac patient through the hospital. The patient begins this process at a hospital or physician's

hospitals (Blustein, 1993; Every et al., 1993; McClellan, 1993; McClellan and Newhouse, 1997) and office with a condition that may be either emergent, such as an acute myocardial infarction, or chronic, such as ischemic heart disease. The physician decides whether to prescribe a diagnostic cardiac catheterization—which is performed at a hospital on either an inpatient or outpatient basis—to look for arterial blockage. As an alternative to catheterization, the physician may prescribe medical treatment of the patient's condition. For those patients undergoing catheterization, the physician uses the results of the diagnostic procedure to choose between three broad options—no further surgical treatment, CABG, or PTCA.

The CABG and PTCA options—together referred to as revascularizations—involve additional procedures for the patient. If either of these procedures is prescribed, a patient will receive it during his or her initial admission or will be discharged and re-admitted for revascularization at a later date. CABG is an invasive surgical procedure that involves taking a section of artery, typically from the patient's leg, and grafting it to create a bypass of the blockage in the coronary artery. It requires the opening of the patient's chest and relies on a heart-lung bypass machine to perform the functions of the heart during the grafting process. In comparison, PTCA involves the threading of a balloon device to the point of blockage. The balloon is inflated to expand the artery and restore blood flow. PTCA, therefore, is less traumatic than CABG, as PTCA patients avoid the substantial chest incision and arterial reconstruction that are integral parts of the CABG procedure. PTCA patients, however, run the risk of restenosis, or the return of blockage to the artery.[8]

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physician practice patterns.

The Economics of Cardiac Procedures

As noted in Section I, cardiac procedures are marked by relatively high fixed costs for capital equipment and dedicated staff. Catheterizations and PTCAs are performed in dedicated catheterization laboratories. CABG procedures are performed in operating rooms that—while sometimes available for general surgical procedures—often are dedicated to cardiac procedures. The magnitude of the fixed investment required for cardiac procedures is best illustrated by an example. A major teaching hospital in the United States recently invested $12 million to build a six-room catheterization laboratory. Roughly half of this amount was used to purchase equipment and the remainder covered the significant costs associated with specialized construction (e.g., leaded glass, ceiling reinforcements, and wiring). This figure does not include the costs associated with the 30 nurses and technologists who are dedicated to the lab. Because these employees are not deployed to other parts of the hospital during periods of low catheterization or PTCA activity, a substantial portion of the catheterization laboratory's labor costs is not entirely variable. Such investments of between $1 million and $2 million per catheterization room are common across hospitals. When combined with limitations imposed by state regulation of hospital investment, these high fixed costs have enabled only a portion of hospitals to develop full-service cardiac programs. Integration, therefore, may represent an opportunity for existing programs to either: 1) run more volume through their existing cardiac capacity or 2) install capacity in a new geographic area where there is substantial demand for cardiac services.

[8] In recent years, the problem of restenosis for PTCA patients has decreased due to the development of stents, which are small metal inserts that prop open the artery after angioplasty.

Cardiac procedures represent a major source of profit for hospitals, both on average and at the margin. The average Medicare reimbursement for an admission involving CABG in New York was approximately $33,700 in 1997; the analogous figure for PTCA was roughly $15,200 (Table 7, Panel A).[9] The average cost per Medicare admission in 1997 was $31,700 for CABG and $13,100 for PTCA. These figures imply an average profit of $2,000 (6%) for CABG and $2,100 (14%) for PTCA. The average hospital performing CABG and PTCA in 1997 thus generated revenues of $15.7 million (4.5% of hospital total) and profits of $1.3 million (4.4% of hospital total) from Medicare patients receiving CABG or PTCA.[10] Medicare patients, however, account for only 45% of all admissions involving CABG or PTCA. Adding the remaining 55% of CABG and PTCA admissions into the above calculations will increase the percentages of total revenue, profits, and inpatient days attributable to CABG and PTCA admissions.[11]

Due to the large fixed costs associated with CABG and PTCA, the *marginal* profitability of these procedures substantially exceeds their average profitability.

[9] The revenue-per-admission figures are based on the fact that New York hospitals received and average of $6,164 per case-mix adjusted Medicare case in 1997 (New York State Blue Cross and Blue Shield, www.nysblues.org, 2000). The average case-mix index across all Medicare CABG patients in New York was 5.47 in 1997, resulting in the estimated revenue figure of $33,700 (≈$6,164 x 5.47) per case. For PTCA, the average case-mix index was 2.47. To correct for the small number of cases with unrealistically low reported charges, these average case mix figures exclude CABG cases with reported charges of less than $5,000 (roughly 1.2% of CABG cases) and PTCA cases with reported charges of less than $2,500 (roughly 3.4% of PTCA cases).

[10] This figure is based on average revenue of $24,500 per admission receiving CABG and/or PTCA (≈$6,164 x DRG weight of 3.99), an average cost of $22,400 per admission, and an average of 640 Medicare admissions involving CABG and/or PTCA per hospital in 1997.

[11] More detailed information from a teaching hospital in the United States provides anecdotal support for the average trends found in the New York data. This hospital recently estimated its average profit on catheterization, CABG, and PTCA procedures combined to be roughly $3,500 per procedure on revenues of about $21,000. The implied margin of 17% is dramatically larger than the margins for the hospital as a whole. In addition, cardiac surgery alone accounted for 10.5% of this hospital's total costs—and, based on relative margins, a larger portion of revenue—in 1999. This figure does not include PTCA, which is included in the additional 13.3% of the hospital's costs that are attributed to cardiology.

Specifically, the marginal cost for an admission involving CABG in 1997 was approximately $26,700, implying a marginal profit of $6,200. For PTCA, the marginal cost was $9,800 and marginal profit was $4,900.[12] Thus while hospitals make a healthy profit on the *average* cardiac procedure, they have an even stronger incentive to attract the *marginal* cardiac procedure that may be obtained via acquisition-related business stealing or business creation.

III. CONSOLIDATIONS IN NEW YORK STATE, 1990-1997

Definitions

For the purposes of this study, a "consolidation" is defined as any transaction that involves delegating the key decision-making rights of two or more hospitals to a single board. The universe of consolidations thus includes full asset mergers, holding companies that include substantially all of the operations of multiple hospitals, and any other "active parent" relationships[13]. Hospitals participating in these transactions typically combine their administrative and business functions such as marketing,

[12] The marginal cost estimates are based on the estimated effect of ln[annual CABG (PTCA) admissions] for hospital *h* on average cost per CABG (PTCA) admission at hospital *h* (see Equation (4)). The marginal cost estimates are calculated by dividing the growth in total costs due to a 1% increase in volume by the absolute magnitude of the 1% volume increment.

[13] The following excerpt from the New York State Department of Health's Workgroup on Network Development (1998) describes an "active parent" relationship: "Under [an] 'active parent' arrangement, the individual facilities within the network retain their separate corporate identities but are subsidiary to the larger parent corporation to which they have delegated some operating authority. The network itself is usually also a 'member' of each subsidiary corporation. The active parent arrangement is generally an option only for not-for-profit corporations…A more recent example is the North Shore Health System (NSHS) and six affiliated hospital which seeks an establishment approval to expand this model to its fullest legal extent short of merger. It is proposed that the affiliated hospitals delegate financial decision-making authority with respect to obligated group financing, and such other NSHS authority as hospital corporations are authorized to exercise. In other words, NSHS will be specifically established to

managed care contracting, capital budgeting, and financial management. Clinical services, however, are less likely to be combined across hospitals than are administrative and business functions (Barro and Cutler, 2000). This may be due to the substantial distances between many hospitals that consolidate. The definition of consolidation provided above excludes relationships such as joint marketing agreements for particular services (e.g., cardiac care, oncology) and academic affiliations. These latter relationships typically do not result in the joint functions (e.g., budgeting, managed care contracting, and capital investment) that are common in consolidations.

Consolidations can be classified further as either "acquisitions" or "mergers" depending on the relative characteristics of the hospitals involved. An acquisition joins two or more parties that are asymmetric with respect to size or services offered. As a result, acquisitions involve a clear "acquirer" (i.e., the hospital that is larger or offers the service in question) and "target" (i.e., the hospital that is smaller or lacks the service). Alternatively, mergers bring together parties that are roughly similar with respect to size and services.

In this paper, I define acquirers and targets by their cardiac service offerings. Specifically, an acquirer is a hospital that offers all three of the cardiac procedures mentioned above and was involved in an acquisition between 1990 and 1997. This range of dates reflects the fact that minimal acquisition activity occurred in New York prior to 1990. A target is a hospital that was involved in an acquisition between 1990 and 1997 and did not offer CABG or PTCA prior to consolidation. Target hospitals, however, may

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exercise, on behalf of each affiliate, all of the elements of operating authority an affiliate is entitled and obligated to exercise on its own behalf."

have offered diagnostic catheterization prior to acquisition.[14] This distinction between acquirers and targets suggests that the acquisitions in the New York sample involve a degree of vertical integration. That is, these transactions bring together hospitals that possess fundamentally different capabilities with respect to cardiac procedures.

Based on the definitions above, nearly 75% of the consolidations in New York between 1990 and 1997—25 of 34—were acquisitions (Figure 3). In two of the nine mergers, both hospitals offered CABG and PTCA, and, in the remaining seven, none of the parties offered CABG or PTCA prior to merger. These two types of mergers are referred to as "big-big" and "small-small", respectively, in Figure 3.

Sample of Transactions

The sample of transactions for this study includes 32 consolidations—25 acquisitions and 7 "small-small" mergers—in New York State between 1990 and 1997. The year of a given transaction is defined as the one in which it legally closed. In cases where the date of closure is not available, the year in which both hospital boards approved the consolidation is used as the year of the transaction[15]. "Small-small" mergers are included as controls for identifying the effects of acquisitions. The two "big-big" mergers in the sample, both of which occurred in 1997, are not included in the sample due to the inference problem associated with such a small number of events.

[14] The costs associated with a catheterization laboratory offering only catheterization are substantially lower than those for a laboratory that offers PTCA as well as catheterization.

[15] The dates of transactions were determined using the following sources: searches of the LEXIS/NEXIS database using the names of potential acquirers; the annual survey of hospital consolidation activity in the United States conducted by *Modern Healthcare* for each year after and including 1994; the Greater New York Hospital Association's annual surveys of health care systems in New York for each year after and including 1993; and author's correspondence with hospital executives.

Table 1 provides descriptive statistics for 1992—the first year of discharge data used in this study—for the hospitals in the sample of 25 acquisitions. On average, acquirers were more than twice as large as targets in terms of inpatient beds and hospital days and over three times as large in terms of net revenue and operating expenses. In addition, the average acquirer provided nearly three times as many catheterizations per year as the average target (1,777 versus 599). Finally, acquirers performed over 650 CABG and 450 PTCA procedures per hospital while the targets did not offer these procedures.

Figure 4 shows the location of the facilities involved in acquisitions. Nearly 80% of these transactions occurred between facilities located in the densely populated southern portion of the state—the five boroughs of New York City and Nassau, Suffolk, and Westchester counties. The remaining transactions were focused around the metropolitan areas of Rochester, Buffalo, and Binghamton. Across all transactions in the sample, the average distance between the zip codes of acquirers and targets was 13.8 miles, with a standard deviation of 11.6 miles.[16]

Primary Market Areas

The "primary market area" of a hospital represents the geographic region in which that hospital has, or reasonably could be expected to have, a significant share of the market for inpatient care. A primary market is composed of two types of areas, First, it includes the "historic" market of the hospital. A hospital's historic market consists of those zip codes in which it had at least five inpatient admissions and a 20% share (10%

[16] Distances represent the geographic distance between the centers of the zip codes of the acquirer and target.

for areas within the five boroughs of New York City)[17] of admissions in 1992. In addition, a primary market includes all zip codes that accounted for at least one discharge at the hospital in 1992 and are located within a given "primary" radius around the hospital. This radius is defined as the mean distance between the center of the hospital's zip code and each zip code that is part of the hospital's historic market. The average primary radius across the 231 hospitals in New York is 7.4 miles, with a standard deviation of 10.8 miles.[18]

IV. THE POTENTIAL EFFECTS OF HOSPITAL CONSOLIDATION

Before analyzing the implications of acquisitions for social welfare, it is necessary to understand the mechanisms by which such transactions might generate benefit for the hospitals and managers involved. This question is particularly relevant in the New York hospital market, which is dominated by the not-for-profit ownership form. A growing literature has found increasing similarity in the behavior of not-for-profit and for-profit hospitals as managed care has made health care markets more competitive during the 1990s (Cutler and Horwitz, 2000; Keeler *et al*., 1999). Even if the managers of not-for-profit hospitals are not profit maximizers, it is likely that their utility is increasing in the perquisites or prestige that are associated with running a hospital that is large and, to a lesser extent, profitable. This reasoning underlies the agency cost view of mergers that is

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[17] The definition of "primary market area" was adjusted for the five boroughs of New York City due to their high population density.

[18] Based on the above definition, two of the 25 acquisition targets in the New York sample do not have primary markets, as they do not reach the share threshold required to define such a market in any zip

common in the corporate finance literature (Jensen, 1986; Morck, Shleifer, and Vishny, 1990). Regardless of the motives of management, the incentives for merger outlined below—higher prices, increased quantity, and synergies unrelated to quantity—are likely to explain a large portion of the desire for consolidation.

Higher Prices

One possible effect of hospital consolidation is an increase in price or price-cost margins resulting from greater market concentration (Dranove and Shanley, 1995; Melnick *et al*., 1992; Keeler *et al*., 1999). Unfortunately, New York collects data at the patient level only on gross charges, not on actual prices paid. As a result, this study is not able to consider the effects of market concentration on price. Nevertheless, the regulatory environment in the state suggests that the price effects of consolidations during much of the period studied may be relatively small. Until January 1997, hospital rates for inpatients with commercial (i.e., non-HMO and non-government) insurance were administered by a statewide pricing formula. In addition, all Medicare inpatient rates were set by the federal government under the Prospective Payment System (PPS) adopted in 1983. Between the New York and federal price regulations, over 69% of the 1996 inpatient admissions involving CABG or PTCA in New York were covered under some form of price regulation (SPARCS, 1996). As of January 1997, hospitals theoretically had the ability to negotiate inpatient prices for patients with HMO and commercial insurance coverage. These populations collectively represent 45% of the patients receiving catheterization, CABG, or PTCA in New York in 1998 (SPARCS, 1998). The

code. These targets are Columbus Hospital (acquired in 1996) and Community Hospital of Brooklyn (acquired in 1993).

degree to which hospitals actually were able to increase prices via consolidation cannot be determined from the data available for this study.

Increased Quantity: Business Stealing and Business Creation

Given the high level of marginal profitability for cardiac procedures, hospitals would prefer to increase the amount of such care that they provide. The benefits of increased quantity for acquirers and targets can be broadly classified in two categories: business stealing and business creation. Barro and Cutler (2000) illustrate the connection between acquisitions and business stealing when they suggest that large "downtown" hospitals may buy small "suburban" hospitals to increase the share of patients traveling from the suburbs to the downtown facility. For the purposes of this study, business stealing occurs when an acquirer or target increases its share of cardiac procedures at the expense of other hospitals serving the primary market of the target. For the target, business stealing would appear as an increase in its share of catheterizations, while for the acquirer, it could involve increases in CABG and PTCA, as well as catheterization.

At first glance, it may not be clear why integration is preferred to market transactions as a means stealing business from competitors. The transaction costs literature (Coase, 1937; Williamson, 1975 and 1985) would suggest that integration enables the acquirer to access patient referrals from target markets in a manner that minimizes transaction costs. Underlying this explanation is the assumption that patients in target markets have a high degree of loyalty to target hospitals and the physicians who practice at those facilities. The cost of acquiring a target may be lower than the cost of the numerous transactions (e.g., marketing to individual physicians and patients in the target market) that would be required to replicate the key relationships held by that target.

Kumar, Rajan, and Zingales (1999) refer to "critical resources", which are assets—either tangible or intangible—that provide their owners with power over the holders of complementary assets. The corporate strategy literature provides a related explanation in the form of the resource-based view of the firm (Wernerfelt, 1984; Dierickx and Cool, 1989; Peteraf, 1993; Capron, 1999), which states that firms integrate to correct failures in the market for resources, such as brand names or management expertise. In the case of hospital integration, both acquirers and targets may hold critical resources. Through integration, the acquirer might gain access to the target's resource of a close attachment to local patients and physicians; the target might gain access to the quality reputation of the acquirer and—given the relatively large size of acquirers—to valuable contracts with managed care payors. For both parties, the resources secured via integration likely are subject to some degree of market failure in the absence of consolidation.

Business creation represents a second mechanism by which integrated hospitals may increase their volume of procedures. Due to the high marginal profitability of cardiac care, *all* hospitals have a financial incentive to increase the number of procedures they provide *ceteris paribus*. By developing formal ties to target facilities, however, acquirers may be in a better position than other hospitals to increase their volume of procedures from target markets. It is possible that business stealing serves as the link between acquisitions and business creation. For example, the methods that acquirers use to entice physicians in target markets to refer patients to their hospital rather than competitors may also encourage those physicians to recommend cardiac procedures for patients whose severity places them at the margin for treatment. To test for business creation, I examine whether acquisitions are correlated with increases in the *overall* utilization rate for cardiac procedures in target markets.

To the extent that acquisitions increase the annual and cumulative number of procedures performed at an acquirer, they may reduce the average and marginal cost of care via economies of scale and learning, respectively. Further, higher volumes may result in improved quality through learning. While these changes in cost and quality likely are beneficial for merging hospitals, their theoretical impact on social welfare is ambiguous. Specifically, lower costs (higher quality) for acquirers may be offset to the extent that non-acquirers experience higher costs (lower quality) due to business stealing.

Synergies Unrelated to Procedure Volume

A third explanation for integration is the creation of synergies that are not related to changes in procedure volume. For example, acquisitions may increase the degree of formal or informal communication between physicians in the target market and those practicing at acquiring hospital. To the extent that this improved communication allows the acquirer to reduce cost and increase quality for cardiac patients, it serves as a motivation for consolidation. In addition, consolidation allows each hospital to benefit from any administrative strengths (e.g., managerial expertise) found at the other facility. Finally, many target hospitals—which are noticeably smaller than acquirers along several dimensions (Table 1)—may face financing constraints that reduce their ability to invest in new clinical services. Due to New York's restrictions on for-profit ownership, philanthropy and debt represent the only alternatives to internal cash flow for funding investment by most targets. By linking small targets with larger acquirers—who likely have higher internal cash flows and fewer borrowing constraints—acquisitions may serve to decrease the financing costs for targets.

V. DATA

A critical reason for using New York as the setting for this study is the high quality of data—both administrative and clinical—available for cardiac patients. The Statewide Planning and Research Cooperative System (SPARCS) database provides discharge-level information on every inpatient hospital case in the state.[19] This database includes detailed information about the patient (e.g., age, race, sex, insurance status, zip code of residence), providers (e.g., hospital and physician identifiers), diagnoses, and procedures performed. In 1997, this database included over 2.3 million records, the smallest total for any of the seven years—1992 through 1998—analyzed in this study.

The information from SPARCS is supplemented by discharge-level data on all CABG and PTCA patients from the New York State Department of Health's Cardiac Advisory Committee (CAC). These data provide additional clinical detail on each patient undergoing revascularization between 1991 and 1996 (for CABG) and 1993 and 1995 (for PTCA). This clinical information is not available for patients who received only catheterization without CABG or PTCA. The annual number of CABG procedures in the

[19] The SPARCS data were obtained following approval from the Data Protection Review Board of the New York State Department of Health. The data used in the study do not include those records that did not receive a Diagnosis Related Group (DRG) code. In 1992, 84,581 admissions (3.2% of total) did not

CAC data ranges from a low of 14,935 in 1991 to a high of 20,078 in 1996;[20] for PTCA, these figures vary from 17,621 in 1993 to 22,738 in 1995.

Table 2 provides descriptive statistics on the discharges in the statewide sample. While the total number of discharges decreased from 1992 to 1998, the percentage of discharges involving catheterization increased from 2.3% in 1992 to 3.0% in 1998. Over the same period, the number of PTCA cases per catheterization case grew from 25.3% to 42.2% while the number of CABG cases per catheterization case reached a peak of 33.7% in 1995 and declined steadily to 28.7% by 1998. These trends likely reflect some degree of substitution of PTCA for CABG over the course of the study. Finally, the average age of patients receiving each of these procedures also increased over the seven years considered in this study.

Figure 5 provides univariate results on the market share of acquirers in target markets during the years surrounding acquisitions. These averages are weighted by the number of procedures in a given zip code but are not adjusted for demographic differences across areas or for trends related to calendar time. As an additional caveat, I note that the panel of observations is not balanced (i.e., the five years of data covered in the figure are available for 16 of the 25 acquisitions in the sample). Finally, in cases where a given zip code is part of more than one target market, the "Year Relative to

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have a DRG; in 1993, this figure was 117,135 (4.3%). For all years after 1993, all records in the SPARCS data received a DRG.

[20] The CAC data includes information only for "isolated" CABG procedures. A CABG is "isolated" when it occurs on a patient who does not receive any other major heart surgery (e.g., valve or other heart procedures) during the same admission (New York State Department of Health, 1998). The summary figures in Table 2 are based on the SPARCS database and differ from the CAC numbers in two respects. First, they include *all* CABG procedures (i.e., isolated and non-isolated). Second, they measure the *number of patients* receiving each procedure, rather than the *number of procedures*. Because some patients receive multiple CABG or PTCA procedures, the figures in Table 2 underestimate the number of total procedures recorded in the SPARCS data.

Acquisition" is based on the first transaction affecting that area. For all three procedures, the share of cases going to acquirers appears to decrease slightly in the two years prior to acquisition. During the two years after a transaction, acquirers' shares increase, especially for CABG and PTCA, which witness gains of five and nine percentage points, respectively. While these basic results do not present conclusive evidence of business stealing or business creation, they do provide motivation for the multivariate analysis in Section VI.

The cost regressions and welfare calculations appearing in Section VI draw upon data from the Medicare Prospective Payment System (PPS) cost reports for each hospital in New York. These data are used to calculate cost-to-charge ratios for each hospital performing CABG or PTCA in New York for each year between 1992 and 1998.

VI. RESULTS AND IMPLICATIONS FOR FIRMS

Business Stealing

To test for business stealing, I determine whether acquisitions are correlated with changes in the shares of providers serving the primary markets of target hospitals. Further, I examine the sources of any market share gains and losses made by specific types of hospitals. For example, to the extent that acquirers (targets) gain market share after consolidation, one might wonder whether this increased share comes at the expense of targets (acquirers) or hospitals that are external to the transaction.

The identification of acquisition-related changes in market share comes from the timing of the transaction. I estimate the following fixed-effects specification using data from all zip codes that are within the primary market of at least one target hospital[21]:

$$SHARE_{it} = \boldsymbol{a}_i + \boldsymbol{g}_t + \sum_k D_{it}^k \boldsymbol{d}_k + z_{it}\boldsymbol{b} + \boldsymbol{e}_{it} \qquad (1)$$

$SHARE_{it}$ represents the market share of a particular provider type in zip code i in year t. For each of the three procedures—catheterization, CABG, and PTCA—the above specification is estimated separately for the acquirer and target associated with a given zip code. To identify the sources of market share changes, this equation is also estimated separately for the following three groups of hospitals: 1) other (i.e., non-acquirer, non-target) hospitals in the acquirer's county; 2) other hospitals in the target's county; and 3) other hospitals in "outside" counties (i.e., counties other than those of the acquirer or target).

Zip-code and year fixed effects appear as $\boldsymbol{a}_i$ and $\boldsymbol{g}_t$, respectively. The zip-code fixed effects control for time-invariant characteristics of given areas that might affect the market share of specific providers. Similarly, the year fixed effects control for changes in market share due to time-related factors that might affect the share of acquirers or targets as a class. D_{it}^k is a dummy variable equal to one if zip code i is in the primary market of a

[21] The dependent variable in these regressions is constrained to values between zero and one. Despite this constraint, the linear regressions do not provide any predicted values that fall outside of this range for CABG or PTCA. For catheterization, only five out of over 1,800 observations have predicted values outside of this range. Nonethless, I run the share regressions using a logit transformation of the dependent variable. The direction and significance of the key coefficients are similar to those in the original models.

target hospital that: 1) was acquired between 1990 and 1997 and 2) is k years away from the date of acquisition in year t.[22] Because I am interested in identifying changes in primary markets after consolidation, I test whether each D_{it}^{k} coefficient is significantly different from that for the year of acquisition, D_{it}^{0}. The pre-transaction dummy variables serve to distinguish acquisition-related changes from the simple continuation of existing trends that may be unrelated to consolidation.

The vector z_{it} includes additional demographic controls. These include Medicaid, HMO, and female patients, respectively, as a percentage of patients receiving a particular cardiac procedure in a given zip code. These variables control for the possibility that certain providers may be more likely to target particular socioeconomic, payor, or gender categories. In addition, z_{it} includes the percentage of patients from a given zip code in each of several age categories[23]. These categories allow for the possibility of a non-linear relationship between patient age and the market shares of particular types of hospitals. Finally, z_{it} includes an indicator variable to account for zip codes that are included in the primary market of more than one target hospital.[24] This variable takes a value of one if zip code i is part of the primary market of more than one target hospital and year t is after the date of *all* acquisitions affecting that area.

Table 3 presents results for the impact of acquisitions on the catheterization market shares of acquirers and targets. Column 1 indicates that acquirers are losing

[22] The index k assumes negative values for years prior to merger.

[23] The age categories include: less than 50, 50-59, 60-64, 65-74, 75-84, and greater than or equal to 85.

[24] Among zip codes that are in the primary market of *at least* one target, roughly 70% are in the primary market of *only* one target, 27% are in the primary market of two targets, and 3% are in the primary market of three targets. No zip code is in the primary market area of four or more targets.

market share in the primary markets of targets prior to acquisition. This fact suggests that share retention in target markets may serve a key motivation for acquirers to pursue consolidation. Acquirers' share losses continue after acquisition, though they seem to dissipate by three years after consolidation. By two years after a transaction, the share to an acquirer falls by roughly 1.3 percentage points. This decrease is calculated as the difference between the coefficient on the dummy variable for "2 Years Post-Acquisition" (-0.015) and that for "Year of Acquisition" (-0.001). The magnitude of this decline, however, is smaller than the decrease of 3.8 percentage points that occurs over the two years prior to acquisition. Whether this reduction in the rate of share loss by acquirers is due to consolidation or a natural slowing of a pre-acquisition trend is not clear. Throughout my analysis, I discount the coefficient on the "4+ Years Post-Acquisition" variable, as it is based on data for only nine of the 25 acquisitions in the sample. Thus, I do not interpret its negative and significant value in Column 1 as strong evidence of deeper share losses by four years after acquisition.

In contrast to acquirers, the small number of targets that offer catheterization experience share increases prior to consolidation. After acquisition, however, the magnitude of these gains increases substantially. These results must be qualified by the fact that only six of the 25 targets offered catheterization at some point during the sample period. Nonetheless, by three years after a transaction, the average market share for targets has increased by over 13 percentage points relative to the year of acquisition. The catheterization results thus suggest that consolidated hospitals (i.e., acquirers and targets together) are experiencing increases in their combined market share after acquisition and that these gains are accruing primarily to targets. Further, these gains appear to come from other hospitals in the acquirer's county and outside counties, but not from other facilities in the target's county (Columns 3-5).

Tables 4 and 5 show that acquisitions also increase the CABG and PTCA market shares of participating hospitals. By definition, the target does not offer CABG or PTCA. Thus all of the share gains following consolidation accrue to the acquirer. As with catheterization, acquirers experience substantial losses in market share prior to merger. For CABG, the cumulative loss of share during the two years prior to acquisition is 3.6 percentage points; for PTCA, this figure is 3.3 percentage points. These losses are substantial relative to the average share of 21% for acquirers in target markets prior to consolidation and correspond to gains by other hospitals in the home counties of the acquirer and target (Tables 4 and 5, Columns 2 and 3).

During the first two years after acquisition, however, these losses are reversed and acquirers begin to regain share lost prior to merger. The cumulative increase in share during that period is 2.8 percentage points for CABG and 2.7 percentage points for PTCA. By three years after consolidation, acquirers appear to be losing these share gains to hospitals outside of the home county of the target or acquirer (Tables 4 and 5, Column 4). Despite acquirers' eventual loss of their immediate post-acquisition gains, these results illustrate that acquisition is correlated with a reversal of pre-consolidation losses. Further, it is likely that the 2.5-to-3 percentage-point figure represents a *lower bound* for the share gain by acquirers following consolidation. If not for acquisition, the share to acquirers in target markets may have continued its pre-consolidation decline, suggesting that measuring changes relative to the year of acquisition probably understates the true effect of consolidation on the share of acquirers.

Given the decline in the statewide number of CABG procedures in New York in 1998 (Table 2), it is not obvious that increased market shares translate into higher *absolute* volumes of procedures for acquirers and targets. To address this issue, I estimate additional versions of (1) using the number of procedures, rather than market shares, as the dependent variable.[25] These regressions confirm the robustness of the share results across all three procedures. As such, acquirers and targets are stealing business in absolute, as well as relative, terms.

I perform two other analyses to examine the robustness of these results. First, I "roll up" the zip codes corresponding to a given target market into a single, market-level observation for each year. This roll-up addresses the possible lack of independence among observations from different zip codes that fall within the same target market area. I find evidence post-acquisition increases in acquirers' shares for all three procedures.[26]

Second, I develop a distance-matched control market for each acquisition consisting of those zip codes that meet the following criteria: 1) their distance from the acquirer is within 20% on either side of the mean distance from the acquirer to zip codes in the relevant target market and 2) they are not part of the primary market of *any* target in the sample. I then estimate a differenced regression where the dependent variable is the share of the acquirer in a given target zip code minus the share of that acquirer in the

[25] For ease of exposition, these regression results are not presented in this paper. These results are available from the author.

[26] After rolling up zip codes to the market level, each observation corresponds to only one acquisition. As a result, the zip-code fixed effects, calendar-year fixed effects, and "year relative to merger" dummies are highly collinear. I thus drop the time dummies from this regression. Because acquirers appear to be gaining share in target markets over time—independent of acquisitions—the magnitude of the coefficients is likely overstated. Nonetheless, the coefficients for the *pre*-transaction years are not significantly different from those for the year of acquisition, while those for the *post*-transaction years are positive and highly significant.

relevant control market. Control market values for the key independent variables—Medicaid, HMO, and female share, as well as the age categories—are also subtracted from the values for target zip codes. To facilitate the differencing analysis, this regression is run only for those areas that are in the primary market of a single target. This restriction decreases the sample size by roughly 35% relative to the initial regressions. Nonetheless, the initial results hold, though at slightly lower levels of significance in some cases.

Business Creation

The test for business creation follows a methodology similar to that used to identify business stealing. If business creation occurs, one would expect to find an increase in the overall utilization rate for cardiac procedures within the primary markets of targets. The basic equation assumes a form similar to that in (1):

$$PROC_{it} = \boldsymbol{a}_i + \boldsymbol{g}_t + \sum_k D_{it}^k \boldsymbol{d}_k + z_{it}\boldsymbol{b} + \boldsymbol{e}_{it} \qquad (2)$$

$PROC_{it}$ represents the procedure rate in zip code i in year t. The above regression is run for three different dependent variables—$CATHPROC_{it}$, $CABGPROC_{it}$, and $PTCAPROC_{it}$. $CATHPROC_{it}$ is the rate of cardiac catheterization. $CABGPROC_{it}$ and $PTCAPROC_{it}$ are defined analogously for CABG and PTCA, respectively. The numerator in these rates is the number of admissions involving the procedure, and the denominator is the number of adjusted admissions[27] with a primary diagnosis of acute myocardial infarction (AMI) or ischemic heart disease (IHD). AMI and IHD patients are selected as the relevant denominator rather than *all* adjusted admissions. This is due to the bias created by using all adjusted admissions. Not all inpatients face the same underlying probability of requiring catheterization. Further, it is possible that hospitals involved in acquisitions may experience changes in their overall patient mix that are systematically different than those experienced by independent hospitals. Using only AMI and IHD patients mitigates this bias, as they are more homogeneous than the overall inpatient population with respect to their likelihood of receiving cardiac procedures. Because patients with AMI and IHD diagnoses account for over 70% of all admissions in the sample receiving catheterization, this limitation is not very restrictive.

The vector z_{it} includes several control variables. Three of these are the percentages of inpatient discharges accounted for by women, Medicaid enrollees, and HMO enrollees, respectively.[28] These variables control for the possibility that insurance status and gender may affect the rate at which individuals receive cardiac procedures. In addition, z_{it} includes the age-category and multiple-transaction controls found in (1). Finally, z_{it} includes a variable measuring the distance (in miles) from zip code i to the center of the zip code that contains the nearest hospital offering catheterization in year t.

[27] The SPARCS data does not include unique patient identifiers for discharges prior to 1995. As a result, the total number of inpatient discharges is reduced by the number of cases in which a patient received CABG or PTCA, but did not receive catheterization. This correction assumes that all patients receiving CABG or PTCA—but not catheterization in the same admission—received catheterization during a prior admission.

[28] For simplicity, I use the same notation for the Medicaid and age-category variables in (1) and (2), even though these variables differ in the two specifications. In (1), for example, $MEDICAID_{it}$ measures the percentage of patients receiving a *particular cardiac procedure* (i.e., catheterization, CABG, or PTCA) that is accounted for by Medicaid recipients in a given area. In (2), $MEDICAID_{it}$ measures the percentage of *adjusted AMI/IHD admissions* that is accounted for by Medicaid recipients in a given area.

This variable controls for the possibility that patients are more likely to receive catheterization the closer they live to a hospital that offers the procedure. Distance to the nearest catheterization facility is not absorbed by the zip-code fixed effects, as five New York hospitals added—and none eliminated—catheterization services between 1992 and 1998.[29]

There is strong evidence of increased catheterization rates in target markets after acquisition (Table 6, Column 1). This increase begins in the second year after acquisition and grows in subsequent years. By three years after acquisition, catheterization rates increase by an average of 2.3 percentage points (relative to a base catheterization rate of 42.1% across all target markets during pre-acquisition years). By four years after acquisition and beyond, this growth is over 4.5 percentage points, though this result must be qualified due to the small sample of transactions with four or more years of post-acquisition data. Column 4 suggests that the increased catheterization rates in target areas do not simply reflect overall business creation activity by the acquirer. Within their own market areas, acquirers actually show evidence of slight *decreases* in catheterization rates beginning prior to consolidation. While this trend appears to be reversed by four years or more after acquisition, the magnitude of this increase is only one quarter the size of that found in target markets by four years after acquisition.

There is no evidence of significant changes—either positive or negative—in CABG utilization in target areas (Column 2). With respect to PTCA, utilization is significantly higher by three years after acquisition, though this result may simply reflect

[29] Similar distance variables are not included for CABG and PTCA due to the fact that only two hospitals—New York Hospital Medical Center of Queens and St. Elizabeth's Medical Center-Utica—introduced these services between 1992 and 1998. As a result, there is very little variation in distance that is not absorbed by the zip-code fixed effects.

a continuation of pre-acquisition trends toward increased utilization (Column 3). The controls based on acquirer's markets reveal a post-acquisition trend for CABG and PTCA that is similar to that for catheterization—a decline in utilization. For CABG, this decline appears begins prior to consolidation, while, in the case of PTCA, it represents a reversal of a pre-acquisition trend toward greater utilization. These findings suggest that acquisitions are associated with business creation for catheterization and—to a limited extent—PTCA, but not for CABG. The controls from acquirer markets suggest that the increased utilization in target areas is not simply a reflection of broader business creation activity by acquirers in their home markets.

Incremental Profit

Using the average changes in market share for acquirers, I provide a conservative estimate of the incremental profit obtained by acquirers due to consolidation-related changes in their volumes of cardiac procedures. As a measure of the incremental profit from *all* cardiac procedures, this estimate is conservative, as it considers only the effects of added CABG and PTCA volume. The increase in profit due to the higher share of catheterizations for targets is not captured. While the profit associated with these catheterizations may be relatively small—as these cases do not include either CABG or PTCA—it is, nonetheless, likely to be positive.

Table 7 provides the details for this profit calculation. Panel A reiterates the information from Section II on the average and marginal profitability of CABG and PTCA cases. Panel B provides estimates of the number of cases that traveled to the average acquirer due to acquisition for each of the first two years after acquisition. These figures are based on the share movements for one and two years after merger (Tables 4 and 5, Column 1). Because a plurality of the acquisitions occurred in 1996, I determine the average number of procedures that would have traveled to the acquirer using 1997 volumes for the "1 Year After Acquisition" figures and 1998 volumes for the "2 Year" figures. The "low" scenario assumes that the increase in share is simply the share to the acquirer after acquisition minus the share to the acquirer in the year of acquisition. As noted above, however, the declining trend in acquirer share prior to merger suggests that this scenario provides a lower bound of the share increase associated with acquisition. The "high" scenario measures the changes in share relative to what the acquirer's share would have been had the declining pre-acquisition trends continued past the date of acquisition.

Column 5 shows that, during the first two years after acquisition, the incremental profit for acquirers from CABG and PTCA alone is between $175,000 (low) and $380,000 (high). Panel C provides some perspective on the magnitude of these incremental profits. In each of the first two years, these additional profits represent between 0.25% and 1% of the average annual net income for hospitals providing CABG and PTCA in New York.

VII. WELFARE IMPLICATIONS

Changes in price, quantity, and cost resulting from consolidations may all have implications for social welfare. To the extent that price changes simply reflect transfers between consumers (or insurers) and providers, they do not affect social welfare.

Nonetheless, price changes may affect welfare to the extent that they create deadweight loss or alter the level or structure (e.g., cost sharing percentage) of insurance coverage. The welfare calculation presented below does not capture these effects of price changes on welfare. Nevertheless, the regulated pricing system in New York during much of the period studied suggests that the ability of firms to affect welfare through post-acquisition price changes is likely small.

Determining the welfare implications of acquisitions requires estimating their effects on the quality and cost of care. A common measure of the quality of CABG and PTCA procedures is the risk-adjusted mortality rate (RAMR). Due to the extremely low risk of death associated with catheterization, mortality does not serve as a meaningful indicator of quality for that procedure. As a result, any potential welfare effects associated solely with changes in catheterization shares and utilization are not considered in this analysis.

Previous studies have used administrative covariates, such as age, race, gender, and the number of comorbidities as the basis for the risk-adjustment of outcomes (Hamilton and Ho, 2000). The advantage of New York's Cardiac Advisory Committee (CAC) data is that it provides a full range of clinical covariates for each patient.[30] This information, such as the patient's ejection fraction and whether he or she has a history of

[30] To determine the impact of the CAC clinical covariates on risk adjustment, I ran the mortality regression without these covariates. This alternate specification did include the administrative covariates (i.e., age, race/ethnicity, gender, and dummy variables for year) that have appeared in prior studies. For CABG, the adjusted R^2 for this "administrative-only" version is 0.012 versus 0.067 for the version with clinical covariates. Further, the post-acquisition decline in the average hospital-specific RAMR intercept in target markets is larger in the administrative-only version than when the clinical covariates are included. For example, the cumulative change by two years after acquisition is –0.00055 (p<0.01) in the administrative-only version versus -0.00040 (p<0.01) in the specification with clinical covariates. These findings suggest that the CABG cases moving as a result of acquisition are of below-average severity for target markets. For PTCA, the adjusted R^2 in the administrative-only mortality regression is 0.006 versus 0.116 for the version with clinical covariates.

diabetes or myocardial infarction, allows for risk-adjustment that is more refined than that based solely on administrative data. New York State uses this CABG and PTCA data to create mortality rankings for individual physicians and hospitals in the entire state. These rankings have been released in annual public reports (e.g., New York State Department of Health, 1998) each year since 1993 (for CABG) and 1995 (for PTCA).

Most of the literature on the volume-outcome relationship employs a semi-logarithmic functional form in which annual volume enters the mortality and cost equations non-linearly (Luft, Hunt, and Maerki, 1987; Farley and Ozminkowski, 1992). After testing the New York cost and mortality data against functional forms with linear, quadratic, and logarithmic terms for annual volume, I find nearly the same level of fit for all specifications.[31] As such, the risk-adjustment equations for mortality—run separately for CABG and PTCA—are semi-logarithmic functions of the following form:

$$MORT_{iht} = \delta_h + \gamma_t + \ln(x_{h,t-1})\beta_d + m_{iht}\phi + \varepsilon_{iht} \tag{3}$$

$MORT_{iht}$ is an indicator that assumes a value of one if patient *i* died during her stay in the hospital following the procedure. δ_h and γ_t represent fixed effects for hospital and year, respectively. The hospital-specific intercepts are used in the welfare calculation below to measure the impact of patient movement between providers with different levels of time-invariant, hospital-specific quality and cost. $x_{h,t-1}$ is the volume of relevant procedures—either CABG or PTCA—performed at hospital *h* in year *t-1*. I use the lagged value of

[31] For the CABG mortality regression, the adjusted R^2 is 0.067 for all three specifications. For the CABG cost regression, the adjusted R^2 is 0.118 for all three specifications. For the PTCA mortality regression, the adjusted R^2 is 0.116 for all three specifications. Finally, for the PTCA cost regression, the adjusted R^2 is 0.137 for the semi-logarithmic model and 0.138 for the linear and quadratic models.

annual volume to avoid the possible endogeneity of volume in the current year.[32] Finally, m_{iht} is a vector that includes demographic and clinical controls for each patient. A list of the controls included in each equation appears in the Appendix.[33]

A specification analogous to (3) is used to estimate the risk-adjusted cost of CABG and PTCA cases. The form of this equation is:

$$COST_{iht} = m_h + g_t + \ln(x_{h,t-1})\,b_c + s_{iht}f + e_{iht} \qquad (4)$$

Similar to (3), the above equation includes fixed effects for hospital (m_h) and year (g_t) as well as a vector, s_{iht}, which contains both a linear and quadratic control for patient age. $COST_{iht}$ represents the estimated cost of patient *i*'s *entire admission*, regardless of whether that patient received procedures other than CABG or PTCA. This cost variable is estimated because New York provides data only for gross charges—not actual cost or prices paid—at the level of the individual patient. To estimate the cost per patient admission, I calculate the cost-to-charge ratio for each hospital-year using data from the Medicare PPS Cost Reports. For a given hospital, the cost-to-charge ratio is simply total operating expense divided by gross patient revenues. The average value of this ratio

[32] With respect to mortality, observed volume-outcome effects may be due to either learning or the selective referral of patients to facilities with higher quality (Luft, Hunt, and Maerki, 1987). In terms of cost, the volume-outcome relationship may reflect the presence of learning (i.e., a decreasing relationship between volume and *marginal* cost), economies of scale (i.e., a decreasing relationship between volume and *average* cost), or both. While the panel data that I use in estimating the mortality and cost equations allow me to identify learning effects for mortality, they do not enable me to distinguish between economies of scale and learning with respect to cost.

[33] Because length of stay may be an endogenous determinant of mortality, it is not included in the regressions presented in this paper. Nevertheless, including length of stay does not have a material effect on either the coefficient on lagged volume or the relative values of the hospital-specific intercepts.

across the nine acquirers in the sample—77.4%—is roughly similar to the average value of 75.9% for targets (Table 1).

This single ratio does not capture the heterogeneity in cost-to-charge ratios across various clinical departments within a given hospital (e.g., the cost-to-charge ratios for cardiac care may be quite different from those for general medical care). To the extent that each hospital's composition of low-margin and high-margin services differs, the use of a single cost-to-charge ratio for each facility may hinder comparison of cardiac costs across facilities. Limiting this analysis only to hospitals that provide CABG and PTCA likely provides greater homogeneity in case mix across sample hospitals than that found in the entire cross section of New York facilities. Nevertheless, the remaining heterogeneity across sample hospitals cannot be easily measured or controlled for using the data available for this study.

For several reasons, the mortality and cost regressions are run on patient populations that overlap significantly, but are not identical. First, the CAC data is not available for the same years as the SPARCS data.[34] In addition, a small percentage of cases in the SPARCS data have unrealistically low reported charges. To partially address the resulting bias, I exclude CABG cases with reported charges of less than $5,000 (roughly 1.2% of CABG cases) and PTCA cases with reported charges of less than $2,500 (roughly 3.4% of PTCA cases) from the cost regressions. These cases may or may not be included in the CAC data, and, hence, in the mortality regressions. Given differences in their encryption methodologies, the CAC and SPARCS data could not be

[34] The CABG mortality results are based on CAC data for all cases from 1992 to 1996—the most recent year for which CAC data is available. The PTCA mortality regressions use CAC data only for the period from 1994 to 1995. These years are the only ones for which PTCA data is available. The cost

linked, so clinical covariates could not be incorporated into the cost regressions. As a result, the risk-adjustment methodology for cost is more limited than that for mortality.

Table 8 indicates the presence of volume-outcome effects with respect to both mortality and cost. For CABG, a 10% increase in a hospital's lagged CABG volume is correlated with a 0.09 percentage point decrease in its risk-adjusted mortality rate. This 0.09 percentage-point decrease represents a change of 3.3% relative to the statewide mortality rate for CABG of 2.66%.[35] In contrast, the PTCA regressions suggest a positive, but insignificant, relationship between lagged hospital volume and mortality. The PTCA results must be qualified, however, as they are based on only two years of data.

The cost regressions illustrate volume-outcome relationships in the direction of lower cost as volume increases. These effects are small, but highly significant, for both CABG and PTCA. For CABG, a 10% increase in volume leads to a $230 decrease in the average cost per case (0.8% relative to the average of $28,000 per case across all years and zip codes in the sample. For PTCA, a similar increase in volume leads to a $220 decrease in cost (1.9% relative to the average of $11,800 per case across all years and zip codes).

The acquisition-related changes in average mortality and cost may be decomposed into effects on two groups of patients—"movers" and "stayers". Movers are those patients who, as a result of a consolidation, receive their CABG or PTCA procedures at the acquirer rather than another hospital. The quality and cost of care for these patients

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regressions—which rely on the patient-level charge information found in SPARCS but not in the CAC database—include CABG and PTCA patients for the six-year period from 1993 to 1998.

[35] Represents the statewide, in-hospital mortality rate for CABG in New York for the period from 1991 to 1996.

may change due to two factors: 1) changes in time-invariant, hospital-specific quality or cost and 2) the volume-outcome effects due to changes in hospital-specific procedure volume resulting from consolidation. The second group—stayers—is comprised of those patients who do not move as a result of an acquisition. For these individuals, only volume-outcome effects will change the quality and cost of care.

Using the coefficients from Equations (3) and (4), I calculate the acquisition-related change in welfare for CABG patients as follows:

$$\Delta W_{total} = \Delta W_{movers} + \Delta W_{stayers} \tag{5}$$

where

$$\Delta W_{movers} = \sum_m \Big\{ V[\delta_{h_{post}} - \delta_{h_{pre}} + \beta_d[\ln(x_{h_{post},t-1}) - \ln(x_{h_{pre},t-1})]] - (\mu_{h_{post}} - \mu_{h_{pre}}) - \beta_c[\ln(x_{h_{post},t-1}) - \ln(x_{h_{pre},t-1})]\Big\}_m \Big/ N_m \tag{6}$$

and

$$\Delta W_{stayers} = \sum_s \Big\{ V[\beta_d[\ln(x_{h_{post},t-1}) - \ln(x_{h_{pre},t-1})]] - \beta_c[\ln(x_{h_{post},t-1}) - \ln(x_{h_{pre},t-1})]\Big\}_s \Big/ N_s \tag{7}$$

In the equations above, h indexes hospitals and m and s index the individual movers and stayers, respectively, who are affected by acquisitions. Further, N_m and N_s are the numbers of movers and stayers, respectively. The coefficients δ and β_d are based on the estimates from (3) and μ and β_c are from (4). The "pre" and "post" subscripts denote time periods relative to consolidation. Finally, $V[\cdot]$ is the dollar value associated with a given change in CABG mortality.

The methodology for valuing changes in mortality requires some elaboration. Changes in average procedure quality can be expressed as gains or losses in the total number of quality-adjusted life years (QALYs) for patients undergoing that procedure.

To the extent that acquisitions are associated with significantly lower (higher) mortality rates, the total number of quality-adjusted life years for a given population increases (decreases). After establishing a monetary value for a QALY—a reasonable estimate from the economic literature is between $70,000 and $175,000 (Tolley *et al*., 1994)—one can then determine the overall value of acquisition-related changes in mortality.

As a final note, the welfare calculation described above captures the impact of business stealing but not that of business creation. This latter effect is not measured due to the difficulty in determining the marginal benefits and costs for "added" catheterization patients using only administrative data. Nevertheless, the fact that business creation activity is weak, if existent, for CABG and PTCA helps reduce the bias created by excluding it from the welfare calculation.

While I do not find significant shifts in the average mortality or cost intercepts for PTCA, I do find evidence of such changes for CABG. Using the controls in (1), I determine the change in the average hospital-specific intercepts for two and three years after consolidation. I then use the average of the two- and three-year estimates as inputs for the welfare calculation. The average CABG mortality intercept in target markets decreases by 0.03 percentage points (roughly 1.2% relative to the average CABG mortality of 2.54% in target markets prior to consolidation) by two-to-three years after acquisition. Over the same period, the average cost intercept for CABG increases by approximately $142 in target markets (0.5% relative to an average cost of $28,700 per case in target markets prior to consolidation). As a third input into the welfare calculation, I determine the change in the average value of the annual volume variable, *ln(x)*, in target markets in 1998, the year in which the maximum number of transactions have at least one year of post-acquisition data.

Table 9 presents results on the statistical deaths averted and costs incurred due to changing the allocation of CABG share across hospitals. These figures represent the annual changes in total mortality and cost that would have been expected as a result of *all transactions* in the New York sample. For movers, the consolidations result in a decrease in total annual mortality of 2.39 statistical deaths. This figure is relatively large compared to the 7.6 deaths that would have been expected within target markets based on applying the statewide mortality level to the number of CABG cases in all target markets. Movers also account for an increase in costs of roughly $745,000. Most of the impact on mortality and cost is due to changes in hospital-specific mortality rather than volume-outcome effects.

On average, stayers experience both decreased quality and increased cost, though the absolute magnitudes of these effects are small relative to those for movers. The quality improvement and cost reduction that occur as a result of adding cases to acquirers (1.00 lives and $260,000) is slightly lower than the quality reduction and cost increase due to moving cases away from other hospitals (1.10 lives and $285,000). For stayers as a group, mortality increases by 0.10 statistical deaths and costs rise by roughly $25,000. Summing the effects for movers and stayers, I find that the consolidations result in an overall decrease of 2.29 statistical deaths from CABG and a corresponding increase in costs of $775,000. The implied cost per statistical death averted is roughly $340,000.

Translating costs per statistical death averted into costs per life-year saved requires an assumption concerning the post-procedure life expectancy of CABG patients.

Using New York data for all CABG patients from 1993 to 1995, Hannan *et al*. (1999) find three-year survival rates of between 89% and 96% depending on the severity and location of disease. Based on a meta-analysis of CABG patients from the United States, Europe, and New Zealand, Eagle *et al*. (1999) find survival rates of 90% after five years and 74% after 10 years. Ten years thus represents a conservative estimate of the life-expectancy for the median CABG survivor. Nevertheless, the fact that the deaths averted by acquisition likely represent marginal (i.e., relatively sick) rather than median survivors suggests decreasing the life-expectancy estimate to some degree. I thus use 10 years as an estimate for the life expectancy of a marginal CABG survivor. This assumption yields a cost of roughly $34,000 per statistical life-year saved by acquisition. There is reason to expect that $34,000 may overstate the cost per life-year saved. This is due to the fact that while the overall decrease in the number of deaths is significantly different from zero at the five percent level, the estimate of the overall increase in cost is not significant at conventional levels.

The cost-effectiveness of acquisitions depends on the quality-adjusted value one places on a year of life after CABG. Viscusi's (1993) survey of the literature suggests that reasonable estimates for the value of life fall in the range of $3 million to $7 million. Assuming life expectancy of 75 years, this range translates into an average value per life-year of $40,000 to $95,000. Cutler and Richardson (1999) acknowledge the estimates of Tolley *et al*. (1994) for the value of a life-year *in perfect health*—$70,000 to $175,000—and choose $100,000 as their benchmark value. They calculate a quality-adjusted life year (QALY) weight for cardiovascular disease of 0.71 in 1990, thus implying a QALY value of $71,000 per year for a cardiovascular patient. Thus, results from the New York sample suggest that acquisition represents a cost-effective method of improving the quality of care for CABG patients.

The welfare implications provided by this study rely on in-hospital mortality as an outcome measure. Ideally one would like to examine mortality within some fixed period after hospital discharge (e.g., 30 days or six months) to account for the possibility that acquirers may discharge patients sooner than non-acquirers in an attempt to reduce their reported in-hospital mortality. To address this potential bias, I obtain death records for all CABG patients in the State of New York, excluding those who died in the five boroughs of New York City, for the years from 1995 to 1997.[36] While this data is available for years prior to 1995, it cannot be linked to the SPARCS discharge records during those years.

I consider all CABG patients who were discharged in 1995, 1996, and the first six months of 1997. To determine whether there is cause for concern over the use of in-hospital mortality, I compare the ratio of mortality for patients at acquirers and non-acquirers at three different points relative to discharge: at discharge, within 1 month after discharge, and within 6 months after discharge. At discharge, this ratio is 1.77. That is, the observed mortality for patients at acquirers is higher than that for patients at non-acquirers. This result is based on observed mortality and, as a result, does not control for differences in patient severity at each type of hospital. As such, this finding is consistent with the fact that acquirers have lower risk-adjusted, in-hospital CABG mortality. To the extent that acquirers' RAMR results are driven by the speedier discharge of patients, one

[36] The restricted sample for which post-discharge mortality data is available (i.e., all deaths excluding those that occur within the five boroughs of New York City) captures approximately 50% of the in-hospital deaths for CABG patients.

would expect the ratio of the observed mortality rates to increase by three and six months after discharge. In contrast, this ratio remains constant at 1.77 by three months after discharge and *declines* slightly to 1.71 by six months after discharge. This result suggests that, if anything, the bias associated with using in-hospital mortality may operate in a direction that strengthens the results presented above.

VIII. CONCLUSION

Using patient-level administrative and clinical data for cardiac procedures in the State of New York, I find that acquisitions are associated with substantial business stealing activity by acquirers and targets. Both acquirers and targets increase their share and volume of cardiac procedures in the primary market areas of targets. For acquirers, this result is strongest for CABG and PTCA procedures, though it appears that the magnitude of acquirers' gains may peak in the second year after consolidation and begin to decline slightly thereafter. Business stealing by targets is limited to catheterization, as they do not, by definition, provide CABG or PTCA services. I also find evidence of business creation in the form of increased utilization rates for cardiac catheterization in target markets following acquisitions. While there is weak evidence of business creation for PTCA, there is no similar finding for CABG.

With respect to cardiac care, acquisitions clearly increase the private welfare of the hospitals involved, as they bring more procedures—which are highly profitable at the margin—to acquirers and targets. Further, a rough calculation suggests that acquisitions appear to increase *social* welfare. For CABG, acquisition-related shifts in market share lead to decreased risk-adjusted mortality (i.e., higher procedure quality) and increased risk-adjusted costs for patients in the primary markets of target hospitals by two-to-three years after acquisition. Under reasonable assumptions concerning the life expectancy of patients surviving CABG, appear to be a relatively cost-effective means of improving average quality for CABG patients.

The generality of this study is limited in several respects. First, it focuses on acquisitions (i.e., consolidations between hospitals with different service offerings and technological capabilities). It thus provides more insight as to the effects of vertical, rather than horizontal, integration in the hospital industry. Nevertheless, to think of acquisitions as purely vertical transactions is misleading. Despite the asymmetry of acquirers and targets with respect to certain services, there is likely some overlap in the basic services (e.g., routine obstetrics and medical care) and markets of both parties in an acquisition. That is, acquisitions involve some elements of horizontal consolidation more common to mergers. As such, the welfare implications from this study must be considered in tandem with those identified for horizontal mergers (e.g., Kessler and McClellan, 2000). Though acquisitions accounted for the vast majority of consolidations in New York between 1990 and 1997, the end of the decade has been marked by a larger number of symmetric mergers. As post-merger data becomes available for these transactions, it will be possible to compare their effects with those of asymmetric acquisitions.

Second, this study considers only *cardiac* procedures. The findings for private and social welfare hinge on characteristics—such the marginal profitability of procedures and volume-outcome effects for quality and cost—that may not generalize to other clinical areas. Cardiac procedures, however, account for a sizable portion of overall revenue for many hospitals. Furthermore, the methodology of this study can be applied to other types of complex treatment, such as advanced cancer care and high-risk obstetrics. Such future research will help determine the robustness of the findings presented in this paper.

Third, the welfare calculations in this study are based on changes in *measured* quality. Whether these changes are the result of true quality improvement—due to learning—or better selection of low-risk cases by merging hospitals is unclear. During the period covered by this analysis, New York began public reporting of the risk-adjusted mortality results for CABG and PTCA by hospital and individual physician. To the extent that there exist imperfections in the risk-adjustment methodology used by New York State, an acquirer may be able to improve its reported mortality by accessing a broader population of low-risk patients via acquisition. The broad range of clinical data incorporated into New York's risk-adjustment methodology, however, suggests that such selection may be difficult.

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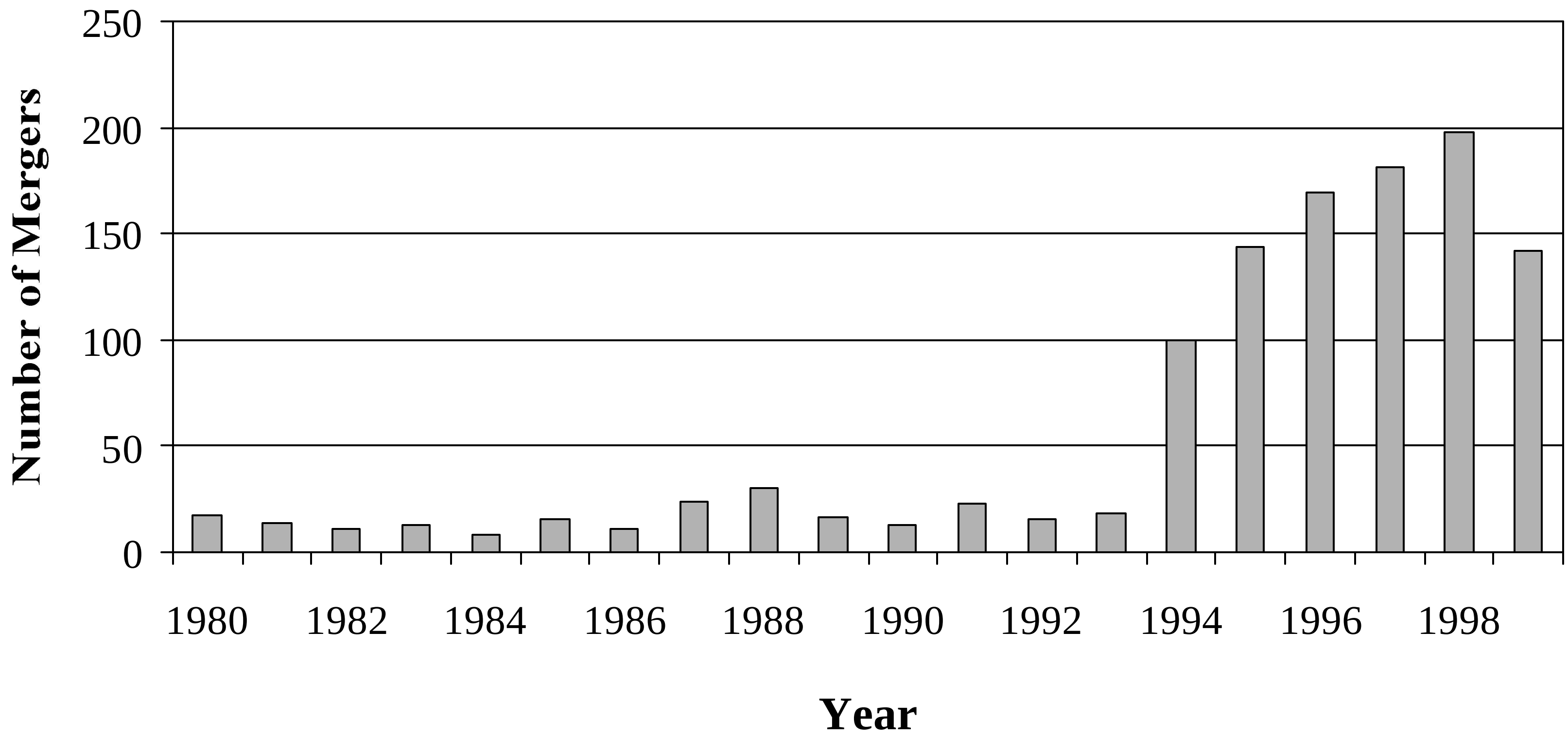
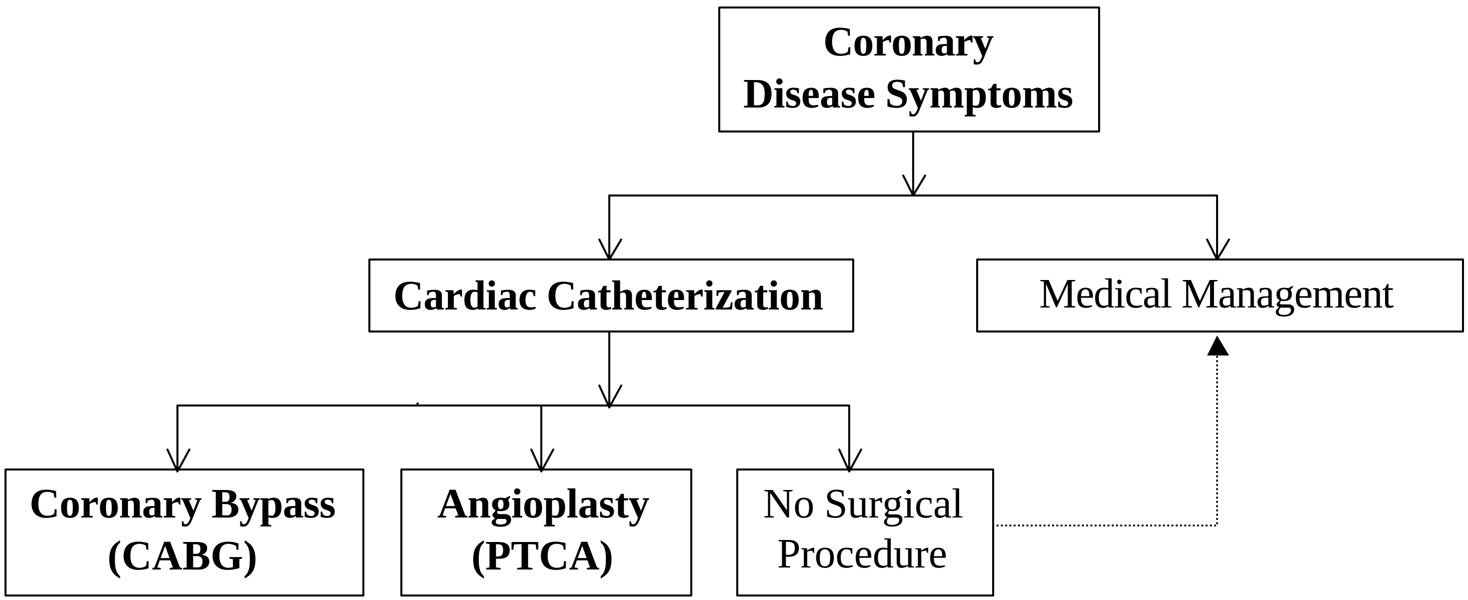
Figure 1: Hospital Consolidations in the United States, 1980-1998



Note: 1999 figure represents number of transactions that were either completed by or pending at the end of 1999.

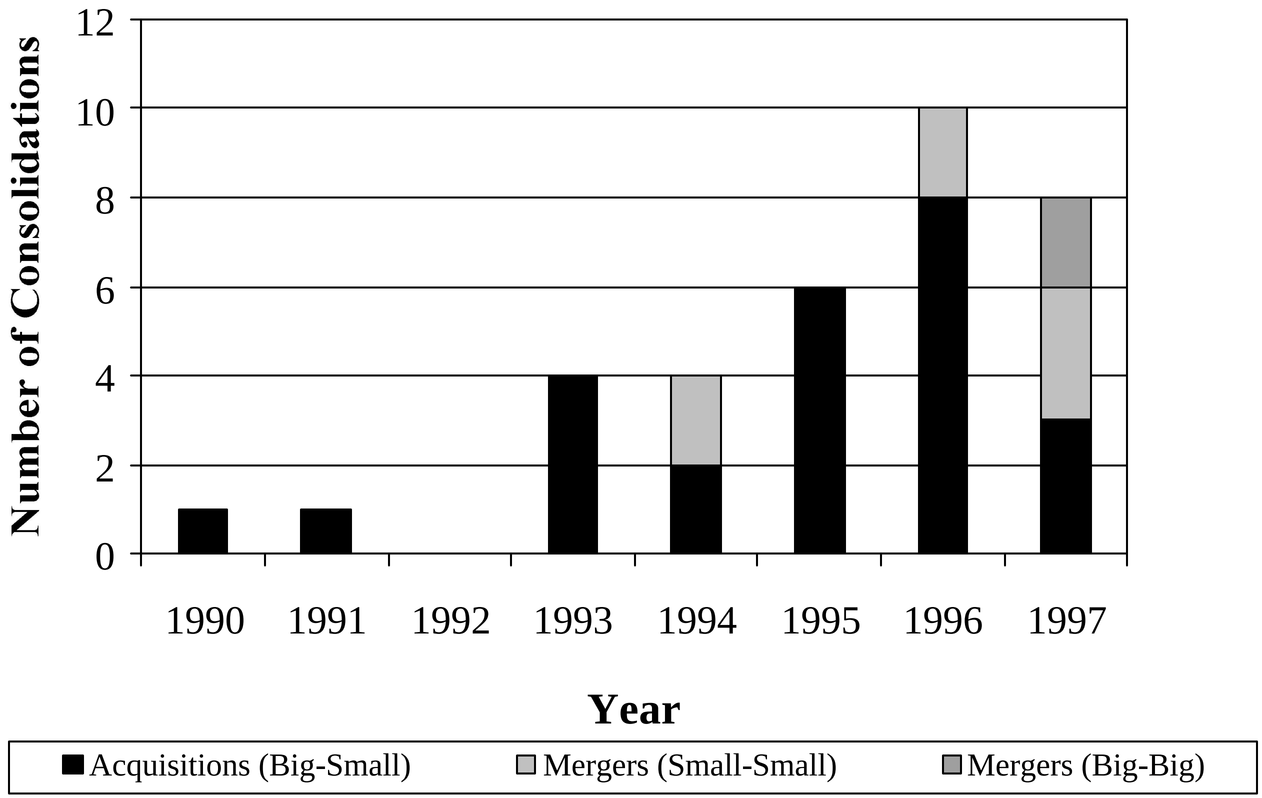
Sources: American Hospital Association, Hospital Mergers and Consolidations, 1980-1991; Modern Healthcare*; and* Hospitals and Health Networks.

Figure 2: Overview of Cardiac Procedures



Source: Adapted from Cutler, McClellan, and Newhouse (2000).

Figure 3: Hospital Consolidations in New York State, 1990-1997

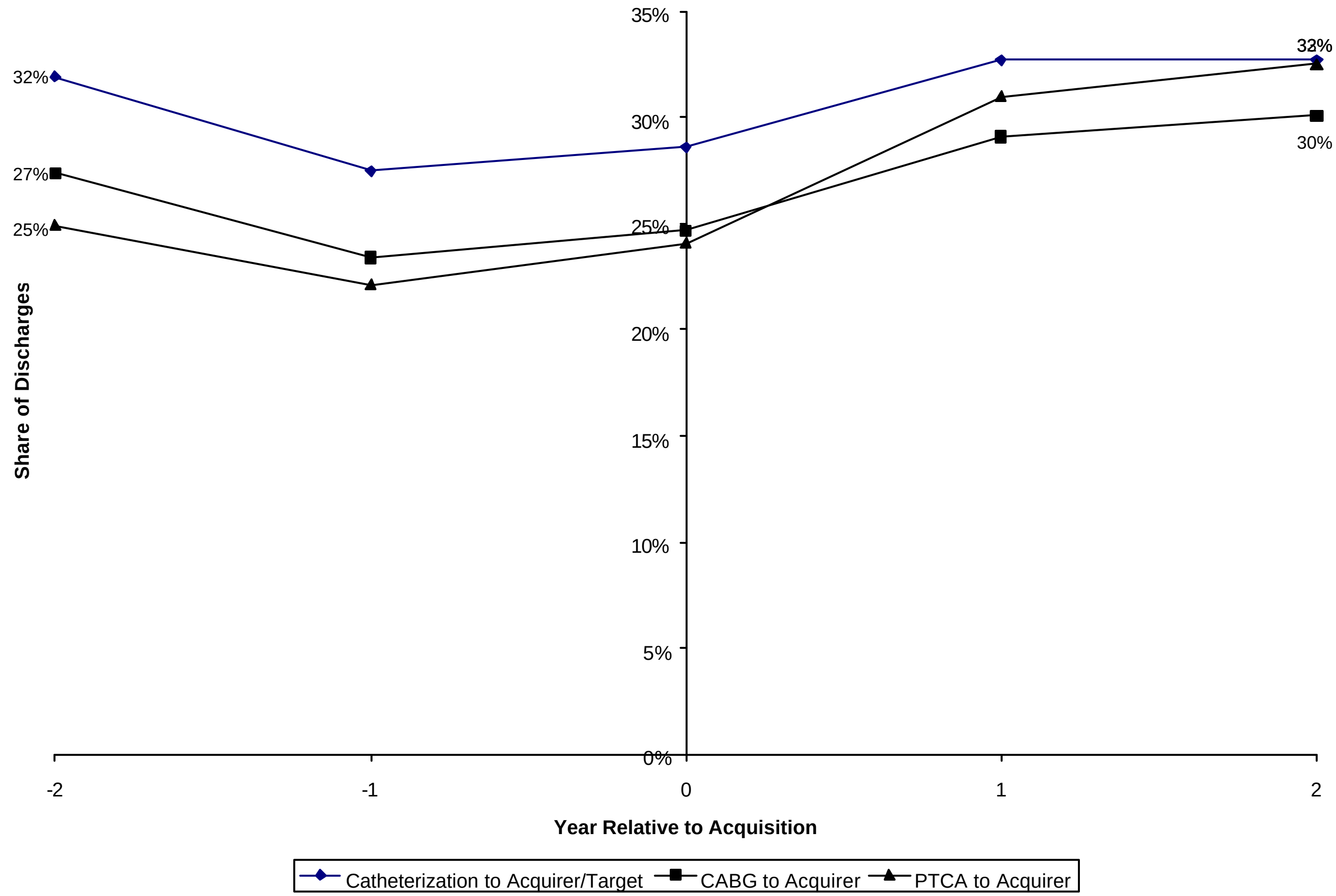


Note: A hospital is considered "big" if it offers CABG and PTCA procedures and "small" if it does not offer these procedures.

Sources: LEXIS-NEXIS search of local newspapers; Modern Healthcare*; author correspondence with hospital executives.*

Figure 4: Map of Hospitals in New York Acquisition Sample, 1990-1997

Figure 5: Weighted Average Values of Dependent Variables



Note: All means are weighted by the number of relevant procedures in each zip code. For zip codes that are part of multiple target markets, the "Year Relative to Acquisition" is based on the date of the first acquisition affecting that area.

Source: SPARCS Database, 1992-1998.

Table 1: Descriptive Statistics for Acquirers and Targets in Sample, 1992

	ACQUIRER			TARGET		
	N	*Mean*	*Standard Deviation*	*N*	*Mean*	*Standard Deviation*
Inpatient Beds	9	715	195	23	311	149
Inpatient Days	9	224,513	61,509	23	87,326	48,278
Financial Data ($000s Unless Otherwise Specified)						
Hospital Charges	9	$ 420,000	$ 207,000	23	$ 116,000	$ 76,900
Net Revenue (Hospital Charges Less Discounts)	9	293,000	133,000	23	82,100	55,100
Operating Expenses	9	316,000	152,000	23	85,900	58,800
Net Income Margin	9	0.2%	2.2%	23	0.1%	4.2%
Cost-to-Charge Ratio (Operating Expenses/Total Charges)	9	77.4%	12.9%	23	75.9%	10.2%
Patients Receiving						
Catheterization	9	1,777	483	4	599	185
CABG	9	655	276			
PTCA	9	456	187			

Note: *Data not available for one target (Columbus Hospital) in 1992. Staten Island University Hospital's two campuses reported as a single facility in 1992. Only four targets offered catheterization, and no targets offered CABG or PTCA prior to merger.*

Source: *Medicare PPS Cost Reports, 1992; New York State Department of Health, Statewide Planning and Research Cooperative System (SPARCS), 1992.*

Table 2: Characteristics of Cardiac Procedure Utilization in New York State, 1992-98

	1992	1993	1994	1995	1996	1997	1998
Total Inpatient Admissions (Adjusted)*	2,497,451	2,498,730	2,405,395	2,406,640	2,378,678	2,334,266	2,337,689
Cardiac Catheterization							
Number of Cases Receiving Catheterization	54,418	54,997	55,841	59,117	63,730	67,501	71,066
Percent of Adjusted Admissions Receiving Procedure	2.2%	2.2%	2.3%	2.5%	2.7%	2.9%	3.0%
Percent of Procedures--Female	37.7%	38.1%	37.8%	38.4%	39.1%	38.9%	39.4%
Percent of Procedures--Medicaid	8.5%	8.7%	9.4%	9.0%	9.3%	9.0%	9.1%
Average Age of Procedure Patient	61.5	61.8	62.0	62.5	63.0	63.3	63.7
CABG							
Number of Cases Receiving CABG	17,086	17,804	18,262	19,940	20,882	21,230	20,400
Cases Receiving CABG/Cases Receiving Catheterization	31.4%	32.4%	32.7%	33.7%	32.8%	31.5%	28.7%
Percent of CABGs--Female	29.0%	29.6%	29.2%	30.2%	31.0%	30.8%	31.3%
Percent of CABGs--Medicaid	5.0%	5.1%	6.4%	6.4%	6.2%	6.4%	6.9%
Average Age of CABG Patient	65.2	65.3	65.5	65.9	66.1	66.5	66.6
PTCA							
Number of Cases Receiving PTCA	13,775	14,970	16,261	19,278	23,212	26,588	30,013
Cases Receiving PTCA/Cases Receiving Catheterization	25.3%	27.2%	29.1%	32.6%	36.4%	39.4%	42.2%
Percent of PTCAs--Female	32.0%	31.3%	31.4%	31.5%	32.7%	32.8%	33.1%
Percent of PTCAs--Medicaid	6.0%	5.4%	6.4%	5.9%	6.2%	6.7%	6.7%
Average Age of PTCA Patient	61.2	61.6	61.3	62.0	62.3	62.8	63.3

**Admissions adjusted by excluding patients who received a CABG or PTCA (but not a catheterization) in a given admission.*

Source: New York State Department of Health, Statewide Planning and Research Cooperative System (SPARCS), 1992-1996.

Table 3: Catheterization Market Share in Target Markets

	Share to Acquirer (1)	Share to Target (2)	Share to Other in Acquirer's County (3)	Share to Other in Target's County (4)	Share to All Other (5)
Primary Market of Target x					
3+ Years Pre-Acquisition	0.03727 ¥¥¥	0.03025 ¥¥¥	-0.04722	-0.00294	-0.00937 ¥¥¥
	(0.0210)	(0.0230)	(0.0209)	(0.0311)	(0.0138)
2 Years Pre-Acquisition	0.03624 ¥¥¥	0.02344 ¥¥¥	-0.05811	-0.00171	0.00779
	(0.0201)	(0.0225)	(0.0189)	(0.0293)	(0.0114)
1 Year Pre-Acquisition	0.02427 ¥¥¥	0.03325 ¥¥¥	-0.06625 ¥	0.00611	0.01175
	(0.0196)	(0.0217)	(0.0186)	(0.0297)	(0.0120)
Year of Acquisition	-0.00137	0.06298 ***	-0.05626 ***	0.00078	0.01558
	(0.0179)	(0.0203)	(0.0178)	(0.0285)	(0.0116)
1 Year Post-Acquisition	0.00363	0.10926 ¥¥¥	-0.08032 ¥¥¥	-0.00800	-0.00362 ¥¥¥
	(0.0179)	(0.0206)	(0.0177)	(0.0283)	(0.0123)
2 Years Post-Acquisition	-0.01495 ¥¥	0.16033 ¥¥¥	-0.10384 ¥¥¥	-0.01112	-0.00726 ¥¥¥
	(0.0175)	(0.0209)	(0.0178)	(0.0282)	(0.0125)
3 Years Post-Acquisition	-0.01421	0.19682 ¥¥¥	-0.13597 ¥¥¥	-0.01566	-0.01398 ¥¥¥
	(0.0178)	(0.0214)	(0.0180)	(0.0285)	(0.0132)
4+ Years Post-Acquisition	-0.05020 ¥¥¥	0.27315 ¥¥¥	-0.15665 ¥¥¥	-0.06250 ¥¥¥	0.01135
	(0.0190)	(0.0256)	(0.0205)	(0.0298)	(0.0154)
Multiple Acquisitions: All Post	0.01085 ***	-0.05900 ***	0.00314	0.02766 *	0.00856
	(0.0115)	(0.0101)	(0.0103)	(0.0157)	(0.0097)
Female (As Percentage of Catheterization Cases)	0.01980	0.04643 **	-0.03736	-0.04861	-0.02315
	(0.0272)	(0.0221)	(0.0263)	(0.0327)	(0.0247)
HMO (As Percentage of Catheterization Cases)	-0.21091 ***	0.17277 ***	0.02928	-0.00436	0.12041 ***
	(0.0350)	(0.0386)	(0.0328)	(0.0397)	(0.0337)
Medicaid (As Percentage of Catheterization Cases)	0.03189	-0.00330	-0.00418	0.04004	-0.03649
	(0.0477)	(0.0425)	(0.0490)	(0.0679)	(0.0485)
Average Value of Dependent Variable Prior to First Acquisition	0.1647	0.1130	0.2489	0.3455	0.2606
N	280	280	280	280	280
NT	1,818	1,818	1,818	1,818	1,818
Adjusted R^2	0.938	0.901	0.930	0.913	0.957

,,* Coefficient is statistically signficantly different from zero at the 1%, 5%, and 10% levels, respectively.

¥¥¥,¥¥,¥ Coefficient is statistically signficantly different from the "Year of Acquisition" coefficient at the 1%, 5%, and 10% levels, respectively.

Note: Robust standard errors are in parentheses. Each regression includes the following variables which do not appear in this table: a constant term; year fixed effects; zip-code fixed effects; and indicators for several age categories (i.e., less than 50, 50-59, 60-64, 65-74, 75-84, and greater than 84). The data for each zip-code observation is weighted by the number of cases from that zip code.

Table 4: CABG Market Share in Target Markets

	Share to Acquirer (1)	Share to Other in Acquirer's County (2)	Share to Other in Target's County (3)	Share to All Other (4)
Primary Market of Target x				
3+ Years Pre-Acquisition	0.10089 ¥¥¥	-0.03165 ¥	-0.07733 ¥¥¥	-0.01437
	(0.0266)	(0.0339)	(0.0248)	(0.0290)
2 Years Pre-Acquisition	0.08001 ¥¥¥	-0.03117 ¥¥	-0.06181 ¥¥	-0.00947
	(0.0251)	(0.0328)	(0.0231)	(0.0272)
1 Year Pre-Acquisition	0.05840 ¥¥	-0.02439 ¥¥	-0.04156	-0.00858
	(0.0248)	(0.0332)	(0.0235)	(0.0283)
Year of Acquisition	0.04372 *	-0.00535	-0.04486 **	0.00024
	(0.0242)	(0.0325)	(0.0225)	(0.0263)
1 Year Post-Acquisition	0.06147 ¥¥	-0.01149	-0.05587	0.00175
	(0.0237)	(0.0328)	(0.0223)	(0.0258)
2 Years Post-Acquisition	0.07122 ¥¥¥	-0.02205	-0.06026	0.00590
	(0.0238)	(0.0330)	(0.0222)	(0.0251)
3 Years Post-Acquisition	0.06398	-0.05474 ¥¥¥	-0.05673	0.03901 ¥¥¥
	(0.0249)	(0.0338)	(0.0227)	(0.0255)
4+ Years Post-Acquisition	0.05741	-0.08578 ¥¥¥	-0.06828	0.09012 ¥¥¥
	(0.0278)	(0.0368)	(0.0257)	(0.0254)
Multiple Acquisitions: All Post	-0.01105	-0.00292	0.01815	-0.01183
	(0.0137)	(0.0159)	(0.0141)	(0.0123)
Female (As Percentage of CABG Cases)	-0.00417	0.02776	-0.01604	0.01856
	(0.0202)	(0.0265)	(0.0214)	(0.0233)
HMO (As Percentage of CABG Cases)	-0.07016 ***	-0.01069	0.05718 **	0.04969 *
	(0.0250)	(0.0303)	(0.0228)	(0.0261)
Medicaid (As Percentage of CABG Cases)	-0.07541 *	-0.06469	0.07387	0.09127 **
	(0.0458)	(0.0525)	(0.0466)	(0.0439)
Average Value of Dependent Variable Prior to First Acquisition	0.2114	0.3028	0.2332	0.3886
N	257	257	257	257
NT	1.654	1.654	1.654	1.654
Adjusted R^2	0.960	0.904	0.933	0.956

,,* Coefficient is statistically signficantly different from zero at the 1%, 5%, and 10% levels, respectively.

¥¥¥,¥¥,¥ Coefficient is statistically signficantly different from the "Year of Acquisition" coefficient at the 1%, 5%, and 10% levels, respectively.

Note: Robust standard errors are in parentheses. Each regression includes the following variables which do not appear in this table: a constant term; year fixed effects; zip-code fixed effects; and indicators for several age categories (i.e., less than 50, 50-59, 60-64, 65-74, 75-84, and greater than 84). The data for each zip-code observation is weighted by the number of cases from that zip code.

Table 5: PTCA Market Share in Target Markets

	Share to Acquirer (1)	Share to Other in Acquirer's County (2)	Share to Other in Target's County (3)	Share to All Other (4)
Primary Market of Target x				
3+ Years Pre-Acquisition	0.16984 ¥¥¥	-0.12443 ¥¥¥	-0.08781 ¥¥¥	0.00453 ¥¥
	(0.0313)	(0.0307)	(0.0327)	(0.0222)
2 Years Pre-Acquisition	0.13046 ¥¥¥	-0.10569 ¥¥¥	-0.04572 ¥¥¥	0.00217 ¥¥
	(0.0291)	(0.0277)	(0.0305)	(0.0207)
1 Year Pre-Acquisition	0.12199 ¥¥¥	-0.08926 ¥¥¥	-0.03451 ¥¥¥	-0.00306 ¥
	(0.0289)	(0.0276)	(0.0308)	(0.0218)
Year of Acquisition	0.09790 ***	-0.05915 **	-0.01247	-0.01570
	(0.0277)	(0.0267)	(0.0300)	(0.0200)
1 Year Post-Acquisition	0.12052 ¥¥	-0.08284 ¥¥	-0.01113	-0.01383
	(0.0271)	(0.0272)	(0.0301)	(0.0199)
2 Years Post-Acquisition	0.12448 ¥¥	-0.08574 ¥¥	-0.01760	-0.01540
	(0.0272)	(0.0271)	(0.0302)	(0.0196)
3 Years Post-Acquisition	0.10374	-0.09868 ¥¥¥	-0.01898	0.02656 ¥¥¥
	(0.0276)	(0.0276)	(0.0304)	(0.0198)
4+ Years Post-Acquisition	0.07840	-0.05242	-0.02973	0.03851 ¥¥¥
	(0.0302)	(0.0316)	(0.0340)	(0.0209)
Multiple Acquisitions: All Post	-0.02625 *	-0.01724	0.01817	-0.00003
	(0.0149)	(0.0160)	(0.0158)	(0.0115)
Female (As Percentage of PTCA Cases)	0.06800 ***	-0.02578	0.00448	-0.05852 ***
	(0.0233)	(0.0255)	(0.0218)	(0.0210)
HMO (As Percentage of PTCA Cases)	-0.15846 ***	0.15111 ***	0.03821	0.04467 *
	(0.0278)	(0.0295)	(0.0242)	(0.0235)
Medicaid (As Percentage of PTCA Cases)	-0.14470 ***	0.07615	-0.00706	0.10465 **
	(0.0473)	(0.0502)	(0.0430)	(0.0419)
Average Value of Dependent Variable Prior to First Acquisition	0.2107	0.3307	0.2412	0.3669
N	259	259	259	259
NT	1.655	1.655	1.655	1.655
Adjusted R^2	0.952	0.901	0.925	0.960

,,* Coefficient is statistically signficantly different from zero at the 1%, 5%, and 10% levels, respectively.

¥¥¥,¥¥,¥ Coefficient is statistically signficantly different from the "Year of Acquisition" coefficient at the 1%, 5%, and 10% levels, respectively.

Note: Robust standard errors are in parentheses. Each regression includes the following variables which do not appear in this table: a constant term; year fixed effects; zip-code fixed effects; and indicators for several age categories (i.e., less than 50, 50-59, 60-64, 65-74, 75-84, and greater than 84). The data for each zip-code observation is weighted by the number of cases from that zip code.

Table 6: Cardiac Procedure Rates in Target and Acquirer Markets

	Primary Markets of Targets			*Primary Markets of Acquirers*		
	Catheterization Admits	CABG Admits	PTCA Admits	Catheterization Admits	CABG Admits	PTCA Admits
	Adjusted AMI and IHD Admits	Adjusted AMI and IHD Admits	Adjusted AMI and IHD Admits	Adjusted AMI and IHD Admits	Adjusted AMI and IHD Admits	Adjusted AMI and IHD Admits
	(1)	(2)	(3)	(4)	(5)	(6)
Primary Market of Target/Acquirer x						
3+ Years Pre-Acquisition	-0.00278 ¥¥	-0.00336	-0.02964 ¥¥¥	0.00083 ¥¥	0.06726 ¥¥	-0.03375 ¥¥¥
	(0.0123)	(0.0076)	(0.0106)	(0.0124)	(0.0072)	(0.0109)
2 Years Pre-Acquisition	0.00957	-0.00056	-0.00719 ¥¥¥	-0.00035 ¥	0.00946 ¥¥¥	-0.02894 ¥¥
	(0.0114)	(0.0069)	(0.0098)	(0.0124)	(0.0073)	(0.0107)
1 Year Pre-Acquisition	0.00124	-0.00162	-0.00445 ¥¥¥	-0.00754	0.00068	-0.02505
	(0.0118)	(0.0074)	(0.0101)	(0.0123)	(0.0072)	(0.0106)
Year of Acquisition	0.00761	-0.00466	0.00719	-0.00859	0.00020	-0.02012
	(0.0112)	(0.0068)	(0.0096)	(0.0120)	(0.0069)	(0.0103)
1 Year Post-Acquisition	0.00590	-0.00546	0.00710	-0.01183	-0.00067	-0.02777 ¥¥
	(0.0118)	(0.0072)	(0.0100)	(0.0121)	(0.0071)	(0.0104)
2 Years Post-Acquisition	0.02311 ¥¥¥	-0.00633	0.01301	-0.01834 ¥¥	-0.00755 ¥¥	-0.02929 ¥¥
	(0.0117)	(0.0071)	(0.0099)	(0.0125)	(0.0071)	(0.0106)
3 Years Post-Acquisition	0.03035 ¥¥¥	-0.00092	0.02033 ¥¥¥	-0.00764	-0.00551 ¥	-0.02390
	(0.0120)	(0.0074)	(0.0103)	(0.0122)	(0.0071)	(0.0106)
4+ Years Post-Acquisition	0.05311 ¥¥¥	-0.00491	0.03626 ¥¥¥	0.00426 ¥¥	0.00123	-0.01348
	(0.0134)	(0.0082)	(0.0113)	(0.0130)	(0.0075)	(0.0114)
Distance to Nearest Catheterization Facility	-0.00417 ***			-0.00430 ***		
	(0.0004)			(0.0004)		
Multiple Acquisitions: All Post	0.00229	-0.00162	0.00177	0.02357 ***	0.00249	0.00912 *
	(0.0074)	(0.0056)	(0.0064)	(0.0059)	(0.0042)	(0.0056)
Female (As Percentage of AMI/IHD Adjusted Discharges)	-0.05509 ***	-0.03371 ***	-0.02397 ***	-0.05486 ***	-0.03297 ***	-0.02409 ***
	(0.0079)	(0.0066)	(0.0070)	(0.0080)	(0.0066)	(0.0071)
HMO (As Percentage of AMI/IHD Adjusted Discharges)	0.06834 ***	0.00179	0.04262 ***	0.07122 ***	0.00287	0.04429 ***
	(0.0137)	(0.0115)	(0.0125)	(0.0141)	(0.0116)	(0.0131)
Medicaid (As Percentage of AMI/IHD Adjusted Discharges)	-0.10444 ***	-0.01989	-0.07083 ***	-0.10024 ***	-0.01936	-0.06553 ***
	(0.0182)	(0.0136)	(0.0153)	(0.0186)	(0.0137)	(0.0158)
Average Value of Dependent Variable Across All Zip Codes	0.4119	0.1535	0.1756	0.4119	0.1535	0.1756
N	1,980	1,980	1,980	1,980	1,980	1,980
NT	12,737	12,737	12,737	12,737	12,737	12,737
Adjusted R^2	0.804	0.505	0.728	0.802	0.506	0.721

,,* T-test results indicate that a coefficient is statistically signficantly different from zero at the 1%, 5%, and 10% levels, respectively.

¥¥¥,¥¥,¥ F-test results indicate that a coefficient is statistically signficantly different from the "Year of Acquisition" coefficient at the 1%, 5%, and 10% levels, respectively.

Note: Robust standard errors are in parentheses. Each regression includes the following variables which do not appear in this table: a constant term; year fixed effects; zip-code fixed effects; and indicators for several age categories (i.e., less than 50, 50-59, 60-64, 65-74, 75-84, and greater than 84). The data for each zip-code observation is weighted by the number of cases from that zip code.

Table 7: Profit Implications of Acquisitions With Respect to CABG and PTCA Cases

	CABG		*PTCA*		*CABG and PTCA*
	Medicare (1)	All Cases (2)	Medicare (3)	All Cases (4)	All Cases (5)
Panel A: Average and Marginal Profit Per Case, 1997					
Revenue/Case*	$ 33,700	$ 32,900	$ 15,200	$ 14,700	
Average Cost/Case	31,700	29,000	13,100	12,000	
Average Profit/Case	2,000	3,900	2,100	2,700	
Marginal Cost/Case**		26,700		9,800	
Marginal Profit/Case		6,200		4,900	
Panel B: Additional Profit to Acquirer Per Transaction* **					
Low Scenario					
1 Year After Acquisition (1997)		$ 31,000		$ 44,100	$ 75,100
2 Years After Acquisition (1998)		45,287		57,948	103,235
Total		76,287		102,048	178,335
High Scenario					
1 Year After Acquisition (1997)		56,609		91,183	147,791
2 Years After Acquisition (1998)		105,130		129,104	234,235
Total		161,739		220,287	382,026
Panel C: Additional Profit/Net Income Per Hospital******					
Low Scenario					
1 Year After Acquisition (1997)					0.71%
2 Years After Acquisition (1998)					0.75%
High Scenario					
1 Year After Acquisition (1997)					1.39%
2 Years After Acquisition (1998)					1.71%

* Medicare revenue/case based on the assumption of $6,164 per case mix adjusted admission. "All Cases" revenue figures assume that revenue/case is 10% greater for Commercial patients and 20% less for HMO and Medicaid patients (relative to Medicare). Further, the "All Cases" revenue assumes a payor mix similar to that in New York during 1997. For CABG this mix is 50% Medicare, 25% commercial, and 25% Medicaid or HMO; for PTCA, this mix is 40% Medicare, 30% commercial, and 30% Medicaid or HMO.

** The marginal cost estimates are based on the estimated effect of ln[annual CABG (PTCA) admissions] for hospital h on average cost per CABG (PTCA) admission at hospital h (see Equation (4)). The marginal cost estimates are calculated by dividing the growth in total costs due to a 1% increase in volume by the absolute magnitude of the 1% volume increment.

*** Number of cases to acquirer determined by multiplying share increase in target markets for each year after merger by the total number of cases from target markets in 1997 (for Year 1 figures) and 1998 (for Year 2 figures). The low scenario use market share in the year of the transaction as the baseline share. The high scenario extrapolates the the pre-transaction share decline to arrive at a lower baseline share. To keep profit estimates conservative, the small number of patients receiving both CABG and PTCA (less than 1% of patients receiving either procedure) are included in the PTCA figures.

**** Assumes average net income of $10.6 million per hospital performing CABG/PTCA in 1997 and $13.7 million in 1998.

Table 8: Fixed-Effect Regressions of Procedure Mortality and Cost on Volume and Other Covariates

	CABG Mortality, 1992-96 (1)	CABG Cost, 1993-98 (2)	PTCA Mortality, 1994-95 (3)	PTCA Cost, 1993-98 (4)
ln(Lagged Annual CABG Cases at Facility)	-0.0093 **	-2,297 ***		
	(0.0047)	(577.8)		
ln(Lagged Annual PTCA Cases at Facility)			0.0135	-2,200 ***
			(0.0085)	(211.5)
Patient Age	-0.0044 ***	-932 ***	-0.0016 ***	-373 ***
	(0.0005)	(73.2)	(0.0003)	(21.9)
$(\text{Patient Age})^2/100$	0.0041 ***	1.032 ***	0.0016 ***	375 ***
	(0.0004)	(57.3)	(0.0003)	(17.8)
Hospital Fixed Effects?	Yes	Yes	Yes	Yes
Year Fixed Effects?	Yes	Yes	Yes	Yes
Clinical Risk Covariates?	Yes	No	Yes	No
N	89.272	110.177	42.228	116.556
Adjusted R^2	0.067	0.118	0.116	0.137

***,**,* Indicates statistical significance at the 1%, 5%, and 10% levels, respectively.

Note: Results in Columns 1 and 3 are based on data from the Cardiac Surgery Reporting System. Results in Columns 2 and 4 are based on discharge data from SPARCS and cost data from Medicare PPS Cost Reports. Column 2 excludes cases with total charges less than $5,000, and Column 3 excludes cases with total charges less than $2,500. Robust standard errors are in parentheses. Each regression includes a constant term which is not reported in this table.

Table 9: Calculation of Approximate Annual Change in Total Mortality and Cost for CABG Due to All Acquisitions in Sample

	CABG		
	Change in Annual Total Mortality (1)	Change in Annual Total Cost (2)	
MOVERS (IN TARGET MARKETS)			
Change in Hospital-Specific Mortality and Cost	(1.85)	$	880,258
Change Due to Volume-Outcome Effects	(0.54)	$	(133,170)
Subtotal for Movers	(2.39)	$	747,088
STAYERS (ACROSS ALL MARKETS)			
Change Due to Volume-Outcome Effects			
Acquirers	(1.00)	$	(261,265)
All others	1.10	$	287,185
Subtotal for Stayers	0.10		25,920
OVERALL TOTAL			
Increase (Decrease) in Number of Deaths or Cost	(2.29)	$	773,009
Standard Error	[.93]		[724,000]
Cost Per Avoided Death	$338,067		

Note: The standard errors for the overall mortality and cost changes were simulated (n=1,000) using the coefficients and variance-covariance matrix generated from versions of Equation (1) with the following dependent variables: share to acquirer; average hospital-specific mortality intercept; average hospital-specific cost intercept; and average ln(1998 procedure volume).

Appendix: Clinical Covariates Included in CABG and PTCA Mortality Regressions

Variable	Description	In CABG Mortality Regression?	In PTCA Mortality Regression?
IS92	Dummy for year=1992	Yes	No
IS93	Dummy for year=1993	Yes	No
IS94	Dummy for year=1994	Yes	Yes
IS95	Dummy for year=1995	Yes	Yes
IS96	Dummy for year=1996	Yes	No
AGE	Patient age	Yes	Yes
AGEQUAD	$(AGE)^2/100$	Yes	Yes
ETHNIC	Dummy for Hispanic	Yes	No
BSA	Body surface area	Yes	Yes
ANGINA	Angina: CCS functional class	Yes	Yes
NORISK	Dummy for no pre-operative risk factors	Yes	No
MI_24HR	Dummy for MI within previous 24 hours	Yes	Yes
MI_WEEK	Dummy for MI within previous 1-7 days	Yes	Yes
PREVMI	Dummy for any previous MI	Yes	Yes
MORE1MI	Dummy for more than 1 previous MI	No	Yes
TRNSMMI	Dummy for transmural MI	Yes	Yes
STROKE	Dummy for stroke	Yes	Yes
CAROCERB	Dummy for carotid/cerebrovascular disease	Yes	Yes
AORTO	Dummy for aortoiliac disease	Yes	Yes
FEM_POP	Dummy for femoral/popliteal	Yes	Yes
UNSTABLE	Dummy for hemodynamic instability	Yes	Yes
SHOCK	Dummy for shock	Yes	Yes
HYPTENS	Dummy for hypertension history	Yes	Yes
IV_NTG	Dummy for IV_NTG within 24 hours of operation	Yes	Yes
LVENTHT	Dummy for left ventricular hypertrophy	Yes	Yes
MALVENAR	Dummy for malignant ventricular arrhythmia	Yes	Yes
CHOBPUDS	Dummy for chronic obstructive pulmonary disease	Yes	Yes
CPB	Dummy for cardiopulmonary bypass at start of procedure	No	Yes
EXCAASAO	Dummy for extensively calcified ascending aorta	Yes	No
DIABETES	Dummy for diabetes requiring medication	Yes	Yes
IMSYSTDF	Dummy for immune system deficiency	Yes	Yes
IABPPREO	Dummy for IABP pre-op	Yes	Yes
ERDXCATH	Dummy for emergency transfer to OR after cath	Yes	No
ERPTCA	Dummy for emergency transfer to OR after PTCA	Yes	No
PREVCAAD	Dummy for previous PTCA, this admission	Yes	Yes
CABEFORE	Dummy for PTCA before this admission	Yes	Yes
THROMB	Dummy for thrombolytic therapy within 7 days	Yes	Yes
SMOK2WK	Dummy for smoking history in past 2 weeks	Yes	Yes
SMOK1YR	Dummy for smoking history in past year	No	Yes
FEMALE	Dummy for female	Yes	Yes
NONWHT	Dummy for non-white	Yes	Yes
EMERGNCY	Dummy for emergency surgical priority	Yes	No
EJFR20	Dummy for ejection fraction less than 20%	Yes	Yes
EJFR2029	Dummy for ejection fraction 20-29%	Yes	Yes
EJFR3039	Dummy for ejection fraction 30-39%	Yes	Yes
LMT	Dummy for left main trunk, 50% or greater	Yes	Yes
PLAD	Dummy for Prox LAD or Maj Diag, 70% or greater	Yes	Yes
MDLAD	Dummy for Mid/Dist LAD or Maj Diag, 70% or greater	Yes	Yes
RCA	Dummy for RCA or PDA, 70% or greater	Yes	Yes
LCX	Dummy for LCA or Large Marg, 70% or greater	Yes	Yes
LESION B	Dummy for Lesion Type B	No	Yes
LESIONC	Dummy for Lesion Type C	No	Yes
CHF	Dummy for congestive heart failure	Yes	Yes
RENFAIL	Dummy for renal failure	Yes	Yes
PREVOHS	Dummy for previous open heart operations	Yes	Yes
POSSTR	Dummy for positive stress test	No	Yes

Note: *Regressions also include ln(lagged annual procedure volume) and hospital fixed effects.*