HOSPITAL INTEGRATION AND VERTICAL CONSOLIDATION:
AN ANALYSIS OF ACQUISITIONS IN NEW YORK STATE

Robert S. Huckman

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NBER Working Paper No. 11379
May 2005
JEL No. I1, L2

<u>ABSTRACT</u>

While prior studies tend to view hospital integration through the lens of horizontal consolidation,

I provide an analysis of its vertical aspects. I examine the effect of hospital acquisitions in New York

State on the distribution of market share for major cardiac procedures across providers in target

markets. I find evidence of benefits to acquirers via business stealing, with the resulting

redistribution of volume across providers having small effects, if any, on total welfare with respect

to cardiac care. The results of this analysis--along with similar assessments for other services--can

be incorporated into future studies of hospital consolidation.

Robert S. Huckman
T17 Morgan Hall
Harvard Business School
Boston, MA 02163
and NBER
rhuckman@hbs.edu

I.   INTRODUCTION

Studies of industry consolidation typically assume that the specific form of integration under consideration can be neatly categorized as either horizontal or vertical. Nevertheless, in certain industries, it is difficult to classify integration in this manner. The American hospital industry—which has experienced a dramatic increase in consolidation activity over the past twenty years[1]—represents one such sector. For example, consider a market in which all hospitals provide routine obstetrics, but only a few provide complex cardiac surgery. The consolidation of any two hospitals in this market would, by definition, reduce the number of firms providing obstetrics, but may leave the number of firms providing cardiac surgery unchanged. Referral patterns for cardiac surgery may change and could either increase or decrease measures of market concentration. Whether a consolidation in this market should be viewed as horizontal or vertical thus depends upon the service considered.

Most previous studies of hospital integration have relied on the horizontal model,[2] suggesting that consolidation may, in theory, affect social welfare via two countervailing channels: increased market power and greater efficiency. An attractive feature of the horizontal model is that it allows one readily to infer the effect of a merger on price and cost. Horizontal consolidation, by definition, increases market concentration, so one can

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[1] See Gaynor and Haas-Wilson (1999) for an overview of recent consolidation activity in the health care industry. 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 (American Hospital Association, 1992; Modern Healthcare, 1994-2000). The number of transactions, however, jumped to 100 in 1994 and reached a peak of 198 in 1998 before declining to 142 in 1999 (Modern Healthcare, 1994-2000).

[2] Melnick *et al.* (1992), Dranove and Ludwick (1999), and Keeler, Melnick, and Zwanziger (1999) provide support for the view that increased market concentration allows hospitals to increase their prices. Noether (1988) finds that both price and quality competition are greater in less concentrated markets,

estimate the impact of consolidation simply by examining the effect of increases in

market concentration—typically measured by the Hirschman-Herfindahl Index (HHI)[3]—

on key welfare determinants such as price and cost. This approach is common in many

studies of hospital competition (e.g., Noether, 1988; Melnick et al., 1992; Dranove and

Ludwick, 1999; Keeler, Melnick, and Zwanziger, 1999; Kessler and McClellan, 2002).

The pure horizontal model, however, is not well equipped to explain the impact of

hospital consolidation on markets for more complex services (e.g., cardiac surgery) that

are often provided by only one of the two parties to a given transaction. For these

services, hospital consolidation joins complements, rather than substitutes, in production,

with an ambiguous impact on market concentration. Further, to the extent that hospitals

providing these complex services have substantially differentiated levels of quality and

cost, the transfer of cases across a fixed number of firms could have implications for

welfare. For example, shifts in volume from low-quality to high-quality providers might

improve overall welfare regardless of whether those shifts increase or decrease market

concentration.

In this paper, I supplement existing horizontal studies by considering what I will

refer to as the *vertical* aspects of hospital integration. I focus on the impact of

consolidation on the provision of two complex cardiac procedures—coronary artery

bypass graft (CABG) surgery and percutaneous transluminal coronary angioplasty

(PTCA). Cardiac procedures are the subject of this study for several reasons. First, they

represent a profitable and sizeable source of revenue for hospitals (Appleby, 2002;

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though the impact of concentration on observed prices is not significant. Lynk (1995) suggests that
consolidations may enable hospitals to lower costs by reducing the impact of variability in demand.

Kowalczyk, 2003). Second, they require substantial fixed investments (New York State

Department of Health, 2004) 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 quality measure. I consider how acquisition events among hospitals in New

York State between 1992 and 1999[4] affected the distribution of cardiac patients across

firms and the average cost and quality of care.

A small number of studies have considered the impact of consolidation on explicit

quality in health care settings (e.g., Baker and Brown, 1999; Ho and Hamilton, 2000;

Kessler and McClellan, 2000).[5] Like prior studies that have examined the quality of

cardiac care, this paper uses risk-adjusted patient mortality as the relevant measure of

quality. Detailed clinical data about the pre-procedure health of every patient undergoing

CABG or PTCA in New York over several years allows for more complete risk-

adjustment than has been used in most previous studies.

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[3] The HHI for a given market is calculated as the sum of the squared market shares across all firms serving a given market. Kessler and McClellan (2000) outline the reasons why the use of simple HHI measures may lead to biased estimates of the effects of competition in hospital markets.

[4] This number represents a lower bound for the total number of consolidations that occurred in New York between 1992 and 1999. All transactions occurring after 1993 were verified using the annual survey of hospital merger activity conducted by *Modern Healthcare*. For 1992 and 1993, consolidations were identified on the basis of public news reports identified by searches of the LEXIS database.

[5] Ho and Hamilton (2000) suggest that, given the fixed or quasi-fixed nature of hospital prices for many services, hospitals could theoretically use lower quality as a means of lowering costs and increasing profits following consolidation. Their empirical analysis finds that consolidations among California hospitals in the early 1990s were associated with increased readmission rates for heart attack patients and higher rates of early discharge for newborns. Nonetheless, they find no significant effects on mortality for heart attack or stroke patients. Kessler and McClellan (2000) examine the impact of hospital competition on the quality and cost of heart attack patients. They find that, before 1991, competition was associated with higher costs and higher quality of care. In the early 1990s, however, competition was associated with unambiguous welfare effects (i.e., lower costs and higher quality). Baker and Brown (1999) find that increased HMO penetration leads to consolidation among mammography providers. They also find that increased HMO activity is associated with lower costs and longer waiting times for mammography appointments, but not with reductions in health outcomes.

Acquisitions that shift procedure volume from non-acquirers to acquirers are a form of "business stealing" (Mankiw and Whinston, 1986). I find evidence of such activity with respect to cardiac care. In particular, defining the "acquirer" as the hospital offering complex cardiac services, I find that consolidations are correlated with an increase in the acquirer's share of cardiac procedures originating from the primary market of the target. I consider the welfare implications of this business stealing by decomposing its effect on average quality and cost into two components: simple redistribution and volume-related changes in performance. Simple redistribution captures the impact of moving volume between hospitals with different levels of hospital-specific quality or cost. Volume-outcome effects may occur to the extent that consolidations increase volumes at some hospitals and decrease them at others. Such volume changes may affect the average quality and cost of care at both acquiring hospitals that gain volume and competing facilities that lose it. Though results differ somewhat for CABG and PTCA, hospital consolidation appears to have had little impact on average cost and quality of major cardiac procedures in New York.

II. THE POTENTIAL EFFECTS OF HOSPITAL CONSOLIDATION

Private Incentives for Business Stealing and Increased Volume

One can imagine several reasons for the pursuit of acquisitions. These include increased volume or market share, higher prices, [6] and synergies unrelated to quantity.[7] The first of these is the focus of this analysis.

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[6] One possible effect of hospital consolidation is an increase in price or price-cost margins resulting from greater market concentration (Melnick *et al*., 1992; Dranove and Shanley, 1995; Keeler,

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A 2003 news article on innovations in cardiac care noted, "For three decades, open heart surgery has been the most profitable service at many hospitals" (Kowalczyk, 2003). It continues by noting that average margins for CABG procedures have traditionally exceeded 40%. The lucrative nature of cardiac procedures has made it attractive for hospitals to attempt to steal market share from competitors. Barro and Cutler (2000) speculate that large "downtown" hospitals may buy small "suburban" hospitals to increase the share of patients traveling from the suburbs to the downtown facility.

Market transactions are an alternative to vertical integration to increase sales. In health care, however, such market transactions are labeled "kickbacks" and are subject to legal and professional sanction. For example, it is fraudulent for hospitals to sign contracts with independent physicians that are construed as involving the "purchase" of patient referrals. Such contracts are viewed as creating potential conflicts of interest for physicians who are expected to serve as agents for their patients. Nevertheless, hospitals are typically allowed to employ physicians directly.

Melnick, and Zwanziger, 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. Given the unique regulatory environment in New York during much of the sample period, however, one could argue that these effects were likely 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, Medicare inpatient rates were set by the federal government under the Prospective Payment System (PPS) adopted in 1983. As a result of the New York and federal regulations, nearly 85% of the inpatient admissions involving CABG or PTCA in New York during 1996 were covered under some form of price regulation. This regulatory structure should reduce concerns about price-related welfare effects resulting from hospital consolidation, especially in the first half of the sample.

[7] For example, acquisitions may increase the degree of formal or informal communication between physicians in the target market and those practicing at acquiring hospital. In addition, consolidation allows each hospital to benefit from the administrative skills (e.g., managerial expertise) found at the other facility. Finally, many target hospitals—which are noticeably smaller than acquirers along several dimensions (Table 2)—may face financing constraints that reduce their ability to invest in new clinical services. 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. The synergies described above, however, are not easily captured by the administrative and financial data available at the

The corporate strategy literature (Wernerfelt, 1984; Dierickx and Cool, 1989; Peteraf, 1993; Capron, 1999) notes that firms integrate to compensate for incomplete markets for resources, such as brand names, management expertise, or referrals. In the case of hospital integration, both acquirers and targets may hold critical resources for which markets are incomplete. 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 specialized technology, the quality reputation of the acquirer, and potentially valuable contracts with managed care payors.

Welfare Implications of Business Stealing

Acquisitions can change the average quality and cost of care. With respect to either quality or cost, these effects can be decomposed into two parts. First, business stealing results in the movement of patients between hospitals with different levels of underlying quality or cost. For example, patients may move from hospitals that have highly-skilled cardiac surgeons to those that have less-skilled surgeons. I refer to this impact of mergers as "simple redistribution".

Changes in volume at individual hospitals also can affect average quality and cost, creating a second channel through which acquisition-related business stealing can impact welfare. Previous studies have identified a negative relationship between annual procedure volume—at either the hospital or physician level—and mortality rates for

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hospital level. As a result, I am unable to provide an empirical test of this theoretical motivation for acquisition.

CABG and PTCA patients.[8] Similar effects may also be present with respect to the

average cost of care. Moving volume from one hospital to another may thus improve

performance at the expanding hospital while decreasing it at the shrinking facility.

III.   CARDIAC PROCEDURES

A Brief Summary of Cardiac Procedures

The path for a typical cardiac patient through the medical system begins at a

hospital or physician's 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

recommends one of 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. 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

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[8] Luft, Bunker, and Enthoven (1979), Showstack *et al*. (1987) and Hannan *et al*. (1991) consider
these relationships for CABG, while Hannan *et al*. (1997) and Ho (2000) examine them with respect to
PTCA.

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.[9]

The Economics of Cardiac Procedures

Cardiac procedures have high fixed costs in the form of specialized 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 other procedures—typically are dedicated to cardiac

surgery. Between 1996 and 2000, the State of New York received 51 applications from

hospitals that intended to build or renovate their catheterization laboratories.[10] The

average cost for these projects was $2.68 million with a standard deviation of $1.65

million (New York State Department of Health, 2004). During the same period, the state

received seven applications from hospitals that aimed to initiate cardiac surgery

programs.[11] The mean cost of these programs was $14.05 million with a standard

deviation of $20.7 million. These figures do not include the cost of nurses and

technologists who are typically dedicated to a catheterization lab or a cardiac surgery

program. When combined with limitations on hospital investment imposed by many

states, these high fixed and quasi-fixed costs enable only a portion of hospitals to offer

CABG and PTCA.

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[9] 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.
[10] To keep projects comparable, this group excludes any applications that included services other than cardiac catheterization.

Cardiac procedures are profitable for hospitals in New York, 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 1).[12] 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. Though exact revenue data are not available for non-Medicare patients, I use the actual distribution of patients across the various payor types (i.e., Medicare, commercial, and Medicaid or HMO) in 1997 and estimates of the average reimbursement rates for non-Medicare providers to arrive at an average profit per case across all payer types in 1997. These figures are $3,900 for CABG (Column 2) and $2,700 for PTCA (Column 3).[13] Multiplying these profit-per-case figures by the number of patients per hospital receiving CABG and PTCA, respectively, illustrates that the average hospital performing CABG and PTCA in New York in 1997 generated net revenues of $33.3 million (9.6% of total hospital net revenue) and operating profit of $4.7 million (16% of total hospital net income) solely from patients receiving either CABG or PTCA.

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

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[11] This figure and that for catheterization represent the number of applications submitted, not the number approved by the state.

[12] 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. 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 $33,700 ($\approx$$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).

[13] A national estimate, reported in 2002, for the average profit for a CABG procedure was $6,800 per case (Appleby, 2002). This figure differs from that in this study due to the fact that it is based on more recent data from a wider geography than just New York State.

estimate the marginal cost for an admission involving CABG in 1997 to be

approximately $26,700, implying a marginal profit of $6,200. For PTCA, the estimated

marginal cost was $9,800 and marginal profit was $4,900.[14] Most hospitals thus are in a

position of seeking to expand their volume of cardiac procedures.

IV.   ACQUISITIONS IN NEW YORK STATE, 1992-1999

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 involving substantially all of the operations of multiple hospitals, and any

other "active parent" relationships. This definition of consolidation excludes less-formal

relationships such as joint marketing agreements for particular services (e.g., cardiac

care, oncology) and academic affiliations. Consolidations can be classified further as

either "acquisitions" or "mergers" depending on the characteristics of the hospitals

involved. An acquisition joins two or more parties that are asymmetric with respect to

size or services offered. Alternatively, mergers bring together parties that are roughly

similar with respect to size and services.

This paper focuses on acquisitions and defines acquirers and targets by their

cardiac service offerings. Specifically, an acquirer is a hospital that offers CABG and

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[14] 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 (3)). 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.

PTCA and was involved in an acquisition between 1992 and 1999.[15] A target is a

hospital that was involved in an acquisition between 1992 and 1999 and did not offer

CABG or PTCA prior to consolidation. Acquisitions integrate hospitals that possess

fundamentally different capabilities with respect to cardiac procedures and, as a result, do

not necessarily result in a reduction in the number of firms providing these services in a

given market. In fact, during the time period studied, none of the CABG or PTCA

programs in New York State were closed.[16]

Based on the definitions above, over 60% of the consolidations in New York

between 1992 and 1999—28 out of 45[17]—were acquisitions (Figure 1). In six of the 17

mergers, both hospitals offered CABG and PTCA, and, in the remaining 11, 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 1.

Universe of Transactions

The universe of transactions for this study includes the 28 acquisitions involving

New York hospitals between 1992 and 1999. These 28 transactions corresponded to the

acquisition of 35 target hospitals by 16 acquirers. 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

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[15] This range of dates reflects the fact that minimal acquisition activity occurred in New York prior
to 1992.

[16] The CABG program at one facility in a multi-hospital system was moved to a different hospital
in that system in 1993. Nonetheless, the number of statewide CABG programs was not affected by this
transfer.

[17] This number represents a lower bound for the total number of consolidations that occurred in
New York between 1992 and 1999. All transactions occurring after 1993 were verified using the annual
survey of hospital merger activity conducted by *Modern Healthcare*. For 1992 and 1993, consolidations
were identified on the basis of public news reports identified by searches of the LEXIS database.

available, the year in which both hospital boards *approved* the consolidation is used as the year of the transaction.[18]

Table 2 provides descriptive statistics for 1992—the first year of discharge data used in this study—for the hospitals in the sample of acquisitions. On average, acquirers were more than twice as large as targets in terms of inpatient beds and hospital days and at least three times as large in terms of net revenue and operating expenses. With respect to cardiac procedures, the average acquirer performed nearly 650 CABG and 470 PTCA procedures in 1992.

Primary Hospital Markets

Defining hospital markets is an issue that has received significant attention in the literature (see Gresenz, Rogowski, and Escarce (2004) for a recent discussion). Some studies use fixed radii around a hospital (e.g., Shen, 2003), while others have defined markets based on variable radii around a hospital to capture a fixed percentage of its admissions (e.g., Phibbs and Robinson, 1993). Defining markets based on observed admissions may be subject to concerns of endogeneity with respect to variables of interest, such as prices, quality, or market volume (Kessler and McClellan, 2000).

I use a variant of the variable-radii approach to define the primary markets of each target hospital in my sample. The primary market of a target includes any zip codes that accounted for at least five percent of a hospital's inpatient admissions in the base year of

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[18] 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.

the study (i.e., 1992).[19] I use this simple approach to market definition because I am

identifying the impact of mergers based on longitudinal analysis of an acquirer's market

share within a given target market. The goal of my analysis is to identify an area that

represents the "historic" market for a target hospital and ask how the share of cardiac

cases traveling to the acquirer from that market changes after an acquisition.

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 records on every inpatient hospital case in the state.[20] 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 2000, this database included over 2.3 million discharges, the

smallest total for any of the nine years—1992 through 2000—analyzed in this study.

The information from SPARCS is supplemented by discharge-level data for

CABG patients from New York's Cardiac Surgery Reporting System (CSRS) and for

PTCA patients from the state's Coronary Angioplasty Reporting System (CARS). These

data provide additional clinical detail on each patient undergoing revascularization

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[19] To provide for a slightly larger market area, I repeat the base regressions using markets that include any zip code that accounted for at least *three* percent of a hospital's inpatient admissions in 1992. The results on share redistribution reported later in the paper are robust to this change in market definition.

[20] The SPARCS data were obtained following approval from the Data Protection Review Board of the New York State Department of Health. For the multivariate analysis later in the paper, I exclude those records that did not receive a Diagnosis Related Group (DRG) code. In 1992, 84,581 admissions (3.2% of

between 1991 and 1996 for CABG and 1993 and 1995 for PTCA. The annual number of

CABG procedures in the CSRS data ranges from a low of 14,944 in 1991 to a high of

20,078 in 1996;[21] for PTCA, these figures vary from 16,804 in 1993 to 21,707 in 1995.

The cost regressions and welfare calculations appearing later in this paper draw

upon data from Medicare Prospective Payment System (PPS) cost reports. These data

provide cost-to-charge ratios for each hospital performing CABG or PTCA in New York

for each year between 1992 and 1998.

VI.   RESULTS

Business Stealing

To test for business stealing, I determine whether acquisitions are associated with

changes in the shares of acquirers serving the primary markets of target hospitals. The

identification of acquisition-related changes in market share comes from the staggered

timing of individual transactions. I estimate the following specification using data from

all zip codes that are within the primary market of at least one target hospital:

$$ACQ\_SHARE_{it} = \alpha_i + \gamma_{3t} + \delta_k D_{it} + \beta Z_{it} + \varepsilon_{it} \tag{1}$$

ACQ_SHARE_{it} represents the market share of the relevant acquirer for zip code i in year t.

If zip code i is in the primary market of multiple target hospitals, ACQ_SHARE_{it} is the

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total) did not have a DRG; in 1993, this figure was 117,135 (4.6%). After 1993, all records in the SPARCS
data received a DRG.

combined share of all acquirers for that zip code.[22] The above specification is estimated

separately for CABG and PTCA.

The key independent variables are included in D_{it}, the vector of indicators for

"year relative to acquisition."   Each of the individual indicators, referred to as d_{it}^k, takes

a value of one if zip code i is in the primary market of a target hospital that: 1) was

acquired between 1992 and 1999 and 2) is k years away from the date of acquisition in

year t.[23] 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, or the year immediately preceding acquisition, d_{it}^{-1}.[24] The

pre-transaction dummy variables serve to distinguish acquisition-related changes from

the simple continuation of existing trends that may be unrelated to consolidation.

Zip-code fixed effects, α_i, are included to control for time-invariant characteristics

of given areas that might affect the market share of specific providers. 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

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[21] The CSRS 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).

[22] Seventy-nine percent of the zip codes that are in the primary market of *at least* one target are in the primary market of *only* one target, 20% are in the primary market of two targets, and 1% are in the primary market of three targets.

[23] The index k is negative for years prior to merger and assumes the following values: $\leq$-4, -3,-2,-1, 0, 1, 2, 3, and $\geq$4.

age categories[25]. These categories allow for the possibility of a non-linear relationship between patient age and the market shares of particular types of hospitals.

Fixed effects for calendar time, γ_{3t}, are included to control for changes in the average share of acquirers over time. For example, if, on average, acquirers increased their quality more than other hospitals during the period studied, one would not be surprised to see their shares growing in target areas over time even in the absence of acquisitions. Including *single-year* fixed effects concurrently with fixed effects for zip code and year-relative-to-acquisition, however, creates problems with respect to identification. In fact, the identification in such a model would come only from those zip codes that are in the primary market of more than one hospital and the "collection points"—four or more years before or after acquisition—among the year-relative-to-acquisition indicators. As an alternative to fixed effects for each year, I use indicators for three-year periods—1992 to 1994, 1995 to 1997, and 1998 to 2000—to capture the impact of calendar time on the share to acquirers.

Table 3 shows that acquisitions increase the CABG and PTCA market shares of acquiring hospitals in primary markets of their targets. Column 1 illustrates that the CABG share to acquirers increases by a total of 5.0 percentage points from Year 0 to Year 3. The magnitude of this increase—which is calculated by subtracting the value of the Year 0 coefficient from the Year 3 coefficient [0.027-(-0.023)]—is 18% of the weighted average share to acquirers prior to acquisition (27.6%) and is significant at the

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[24] Comparisons with both the year of acquisition and the year before acquisition are used because the official merger date is measured by the year in which the transaction *closes*. Changes in market share, however, may begin after the deal is *announced* but before it closes.

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

1% level.[26] The share increase for four or more years after acquisition is similar in magnitude at 4.8 percentage points and is significant at the 5% level. Though not significant at conventional levels, the share gains for the first and second years following acquisition do suggest an increasing trend. The results for PTCA (Column 2) are similar to those for CABG and suggest an increase of 6.0 percentage points (24% relative to the weighted average share in the sample) by Year 3 and 6.3 percentage points for Year 4 and beyond.[27] Figure 2 presents these results graphically, normalizing acquirer share to zero in Year 0.

As mentioned above, for many acquisitions, I was only able to confirm the year in which the transaction was *completed* rather than the year in which it was *announced*. Nevertheless, it is possible that referral patterns may begin to change after a merger is announced but before it closes. I thus test the significance of share changes relative to Year -1 rather than Year 0. Measuring changes in this manner for CABG suggest slightly larger and statistically significant changes for Year 3 and Year 4 and beyond. In addition, it shows that the change by Year 2 is also significant at the 5% level. For PTCA, the changes for Year 3 and beyond are slightly smaller in magnitude, though still significant at conventional levels.

A few features of these results merit particular attention. First, despite the inclusion of zip-code-level fixed effects, the Durbin-Watson statistics for the regressions in Table 3 suggest that some correction for correlation in the error terms may be required.

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[26] This weighted-average share is calculated using all zip-year observations prior to the year of the acquisition affecting a given zip code. In cases where a zip code is in the primary market of two or more hospitals, this figure is calculated based on the date of the first acquisition affecting that area.

[27] The dependent variable in the basic specification is limited to values between zero and one. To address the impact of this restriction, I re-estimate the regressions using the logistic transformation of the acquirer's market share in a given zip code. That is, the dependent variable in these regressions becomes

To address this issue, the standard errors in all models are clustered by target market to address any possible lack of independence in the error terms (i.e., remaining after the zip-code fixed effects) for zip codes within the same target market.[28]

A second potential critique of these results is that the occurrence of acquisitions may be endogenous. For example, acquirers may use these transactions to solidify their presence in markets where they are already gaining share. In such a case, a post-acquisition increase in share in a target market may simply represent the continuation of pre-acquisition trend. Nevertheless, the coefficients on the pre-acquisition indicators reveal that there is no significant pre-acquisition trend in market share and, therefore, reduce concerns about the effects of such endogeneity.

A third potential critique of these results is that they may be influenced by the unbalanced panel of observations. This might be the case if certain acquisitions are included in the sample for their post-acquisition years, but are not included in their pre-acquisition years and vice-versa. For example, because the data range from 1992 to 2000, a transaction that occurred in 1993 will not have observations for two, three, and four or more years *prior to* acquisition. Similarly, a transaction occurring in 1998 will not have observations for three or four or more years *after* acquisition. While the data include at least one year of post-acquisition observations for 28 transactions and two

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$LTSHARE_{it}$=ln(ACQ_SHARE_{it}/(1-ACQ_SHARE_{it})). The estimates are qualitatively similar to those in the basic specification.

[28] I also estimate these models with the assumption of an AR(1) error structure within zip codes and heteroskedasticity across zip codes. The results of this AR(1) estimation are qualitatively similar to those in Table 4, though there is some evidence of a decline in market share to acquirers prior to acquisition. The AR(1) model, however, does not account for potential correlation across zip codes within a given target market, as is the case with the clustered standard errors reported in Table 3. The clustered models, while not efficient, are robust to any type of within-group correlation. Given the support for the use of clustering over parametric assumptions in similar situations (Bertrand, Duflo, and Mullainathan, 2004), I use the results with standard errors clustered by target area for this analysis.

years for 23, there are three (four-plus) years of observations for only 19 (16) acquisitions.

To address the impact of the unbalanced panel, I re-estimate (1) on a sample that includes only those zip codes with data in each period from Year –2 to Year 2. The results of these regressions appear in Columns 1 (CABG) and 3 (PTCA) of Table 4. To ensure balance, these regressions include only those zip codes that were in the primary market of a *single* acquisition between 1992 and 1999. The resulting panels include observations from roughly 18% of the zip codes in the unbalanced CABG (PTCA) regression in Table 3.

The regressions provide strong support for the hypothesis of acquisition-related increases in the average share of procedures going to acquirers. Relative to Year 0, CABG share increases by roughly 7.4 percentage points (46% relative to the 16.1% weighted average share for the balanced sample prior to acquisition) by Year 2 (Column 1). Similarly, PTCA share rises by 13.9 percentage points (Column 3). As in the unbalanced panel, there is no significant pre-acquisition trend in share to acquirers. The results in Columns 2 and 4 extend the balanced panel to three years following acquisition and illustrate that the increase in market share continues beyond Year 2. The three-year increase for CABG (PTCA) is greater than 8.7 (19.2) percentage points. The dashed lines in Figure 2 show these results graphically.

The balanced panels that extend to three years after acquisition show some evidence of share increases prior to the year of acquisition, particularly for PTCA. Nevertheless, the growth in share from Year 0 to Year 2 is over twice the magnitude of

the growth from Year -2 to Year 0. As noted above all of the balanced-panel results must be qualified by the restricted samples on which they are estimated.

VII.   IMPLICATIONS FOR QUALITY AND COST

I next consider the effect of acquisitions 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). 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 (Ho and Hamilton, 2000). New York's CSRS and CARS data provide additional clinical covariates for each patient. This information, such as the patient's ejection fraction and whether he or she has a history of diabetes or myocardial infarction, allows for better risk-adjustment. New York State uses this CABG and PTCA data to create risk-adjusted 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).

To determine the effect of acquisitions on total mortality, I estimate the following specification:

$$MORT_{iht} = \delta_h + \gamma_t + \beta_d \, ln(\, x_{h,t-1}\,) + \varphi M_{iht} + \varepsilon_{iht} \qquad\qquad (2)$$

MORT$_{iht}$ is an indicator that assumes a value of one if patient *i* died during his or her stay

in hospital *h* following a procedure in year *t*. $x_{h,t-1}$ is the volume of relevant procedures—

either CABG or PTCA—performed at hospital *h* in year *t*. I use the lagged value of

annual volume to reduce the impact of possible endogeneity associated with using

volume in the current year. The semi-logarithmic form chosen for (2) is common in the

volume-outcome literature (Luft, Hunt, and Maerki, 1987; Farley and Ozminkowski,

1992).[29] δ_h is a vector of hospital fixed effects, γ_t is a vector of fixed effects for year, and

M$_{iht}$ is a vector of demographic and clinical controls for each patient. I estimate (2)

separately for CABG and PTCA. A list of the controls included in each equation appears

in the Appendix.[30]

A specification analogous to (2) is used to estimate the risk-adjusted cost of

CABG and PTCA cases. The form of this equation is:

$$COST_{iht} = \mu_h + \gamma_t + \beta_c \, ln(\, x_{h,t-1}\,) + \varphi R_{iht} + \varepsilon_{iht} \qquad (3)$$

Similar to (2), the above equation includes fixed effects for hospital (μ_h) and year (γ_t) as

well as a vector, R_{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 variable is

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[29] To test the fit of the semi-logarithmic form for the mortality regression, I re-estiamted this equation using: 1) only a linear volume term and 2) linear and quadratic volume terms. The adjusted R^2 were identical to three digits in all three specifications. Similar results were obtained for various forms of the PTCA mortality model. Given the use of the semi-logarithmic form in prior studies—as well as the belief that volume-outcome effects taper at higher volumes—I rely on the semi-logarithmic sepcficiation for this analysis.

[30] 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.

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 total operating expense divided by gross patient revenues. The average value of this ratio across the nine acquirers in the sample—77.1%—is roughly similar to the average value of 72.9% for targets (Table 2).

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 CSRS and CARS data are not available for the same years as the SPARCS data.[31] In addition, a small

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[31] The CABG mortality results are based on CSRS data for all cases from 1992 to 1996 (with 1991 used to generate lagged volumes) and the PTCA regressions include data for 1994 and 1995 (with 1993 data used to generate lagged volumes). These were the only years of data available as of the date this study was initiated. The cost regressions—which rely on the patient-level charge information found in SPARCS but not in the CSRS and CARS database—include CABG and PTCA patients for the six-year period from 1993 to 1998 (with 1992 used to generate lagged volumes). Given differences in encryption methodologies, the CSRS, CARS, and SPARCS data could not be linked for this study, so clinical

percentage of cases in the SPARCS data have unrealistically low reported charges; 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 CSRS and CARS data, and, hence, in the mortality regressions.

Table 5 reports the 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%.[32] 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. Further, mortality is less common for PTCA than for CABG, making outcomes noisier for the former procedure. The welfare calculations later in this section assume no volume-related quality effects for PTCA. This assumption is conservative in light of other studies that have found a volume-outcome relationship for PTCA that is in the same direction as that for CABG (Hannan *et al*., 1997; Ho, 2000).

The cost regressions find that costs fall 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

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

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

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 movement of market share between hospitals can affect total welfare via two

channels: simple redistribution and volume-outcome effects. Table 6 summarizes the

effects on cost and quality for CABG and PTCA across all of the acquisitions in this

study. Unless otherwise noted, these effects are based on changes that occur by Year 3.

To determine the values in the "Simple Redistribution" section of the table, I re-estimate

(1) using the volume-weighted, hospital-specific intercepts for mortality (δ_h) and cost

(μ_h) from (2) and (3), respectively, as the dependent variable. For the most part, share

redistribution has no significant effect on either CABG mortality or cost. The one

exception is the reduction in mortality of 3.5 deaths in the two-year balanced panel,

though this result is based on data from only 36 zip codes.

To measure volume-outcome effects, I draw upon the market share results from

Table 3. For the average target market in the year 2000, this share increase translated

into approximately seven additional CABG cases per year per target acquired. Given the

semi-logarithmic form of the volume-outcome relationships, the net effect of this

movement depends on the total number of patients at each type of hospital prior to an

acquisition. In 2000, hospitals that were acquirers during the study period had an average

of 983 CABG cases. To simplify the calculations, I divide the universe of hospitals that

"lost" volume into two groups: hospitals that made acquisitions in other markets but not

in the market in question (i.e., non-local acquirers) and hospitals that did not make any

acquisitions (i.e., non-acquirers). The former hospitals performed an average of 825

CABG procedures in 2000, while the latter performed 614. Regardless of whether the

full sample or balanced panels are used, the volume-outcome effects suggest small declines in mortality and cost at acquirers that are almost entirely offset by increases at non-local acquirers and non-acquirers. The aggregate impact of these volume-outcome effects is, therefore, very small.

These small overall volume-outcome effects are not unexpected given the magnitude of cases moving between hospitals relative to the overall size of their cardiac programs. For example, the average acquirer adds roughly seven CABG procedures per year per acquisition from seven competing facilities, while each non-acquirer loses one procedure per year per acquisition. Given the total volume of CABG procedures being performed by the hospitals in this sample (i.e., 600 to 1000), it is quite likely that this relatively small movement of volume occurs near the "flat" of the volume-outcome curve. While these volume-outcome effects are not substantial with respect to mature procedures, such as CABG, such effects could be more meaningful for procedures that are early in their lifecycle or for procedures where acquirers and non-acquirers have dramatically different initial volumes of activity. Repeating this methodology on technologies that are earlier in their life cycle represents an area for future investigation.

The bottom half of Table 6 presents analogous welfare calculations for PTCA. These figures are more sensitive to the assumptions of the analysis than is the case for CABG. For example, the unbalanced panel suggests an increase in mortality of roughly four deaths per year in New York due to the redistribution of patients to hospitals with relatively weaker PTCA programs. The balanced panel results, however, show wide-ranging outcomes. The two-year balanced panel shows trivial welfare improvement (due

to slightly reduced costs), while the three-year balanced panel reveals significant increases in mortality offset by decreases in cost, both due primarily to redistribution.[33]

The less-consistent welfare implications for PTCA relative to CABG may be due to several factors.   First, much of the effect is driven by simple redistribution and, as suggested by the change from the unbalanced to balanced panels, such patterns may depend substantially on the markets selected for analysis. In addition, these results may be affected by the limited mortality data available for PTCA. With only two years of observations, the hospital-specific coefficients used in the redistribution calculation are quite noisy. Finally, given the low average mortality rate for PTCA relative to CABG, one might question whether an outcome measure other than mortality might yield a more precise comparison of quality across hospitals.

A few caveats concerning these welfare calculations are worth noting. First, while the calculations described above capture the impact of business stealing, they do not include the effect of potential changes in the total market quantity of procedures. In a Cournot model, reductions in market quantity are associated with deadweight loss. Alternatively, one could imagine that volume-outcome effects, by changing the profitability of cardiac procedures for particular hospitals, could create incentives to increase or decrease volume. In the current setting, however, simply knowing whether the total volume of procedures increases or decreases does not allow for a definitive assessment of welfare effects. Specifically, the costs and benefits associated with the marginal procedure depend on the clinical condition of the patient receiving (or not

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[33] One could use an analysis of quality-adjusted life years (QALYs) to determine whether the value of the life years lost in some models due to redistribution of PTCA patients outweighs the associated cost savings. Such calculations, however, require assumptions about the expected survival of those patients whose mortality was "accelerated" due to the redistribution and are beyond the scope of this paper.

receiving) that treatment as well as the risk-adjusted outcome. These effects cannot be measured using the CSRS and CARS data as they do not include information on patients who were candidates for CABG or PTCA but did not receive either procedure. The welfare effect calculated in this paper thus should be viewed as an incremental effect beyond any impact that is due to the changes in the overall volume of cardiac procedures.

Second, this study examines only *cardiac* procedures and does not consider the effects of acquisitions on quality or cost in other clinical areas. Nevertheless, the methodology of this study could be applied to other types of complex treatment where volume-outcome effects may be present and a complementary relationship may exist between acquirers and targets.

Third, the welfare implications provided by this study rely on in-hospital mortality as an outcome measure. Ideally one would also like to examine other measures of quality, such as mortality or readmission within some fixed period after hospital discharge (e.g., 30 days or six months) or other measures of patient health status following a procedure. Such information, however, is not available in these data.

Finally, events other than acquisitions were occurring in New York during this period and may have affected the distribution of CABG and PTCA volume across hospitals. Of particular note is the release of hospital report cards for these procedures. Some studies have suggested that these report cards were associated with the shift of CABG volume from low-performing to high-performing hospitals (Mukamel and Mushlin, 1998; Cutler, Huckman, and Landrum, 2004). Others suggest that the institution of CABG report cards encouraged providers to operate on less severe patients (Dranove *et al.*, 2003). To the extent that poor performing hospitals were more likely to

engage in such risk selection, volume may have been redistributed between low and high performers. While it is possible that the results of this study could be confounded with the impact of report cards, I note the significant redistribution of CABG patients in the full sample (Table 3, Column 1) is not associated with redistribution effects on mortality (Table 6, Column 1).

VIII. CONCLUSION

This paper views hospital acquisitions as transactions that bring together complements—not simply substitutes—in production. When consolidation is viewed from this vertical perspective, its welfare effects must be assessed not solely by using standard relationships between measures of market concentration and market outcomes, but rather based on empirical analysis of the redistribution of volume between firms. Based on the sample of transactions from New York, I find that acquirers steal business within target markets. Though the welfare implications are somewhat more precise for CABG than for PTCA patients, hospital consolidation appears to have had relatively little impact on average cost and quality of major cardiac procedures in New York.

This study suggests that an overall assessment of the implications of hospital consolidation should consider the fact that these transactions do not simply reduce the number of firms providing substitute products. Rather, with respect to certain services, they alter the allocation of customers across firms with differentiated levels of quality and cost. Acknowledging the complementary nature of the hospitals involved in many

acquisitions makes for a more complete assessment of consolidation's impact on the

productivity of medical care.

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Figure 1: Hospital Consolidations in New York State, 1992-1999
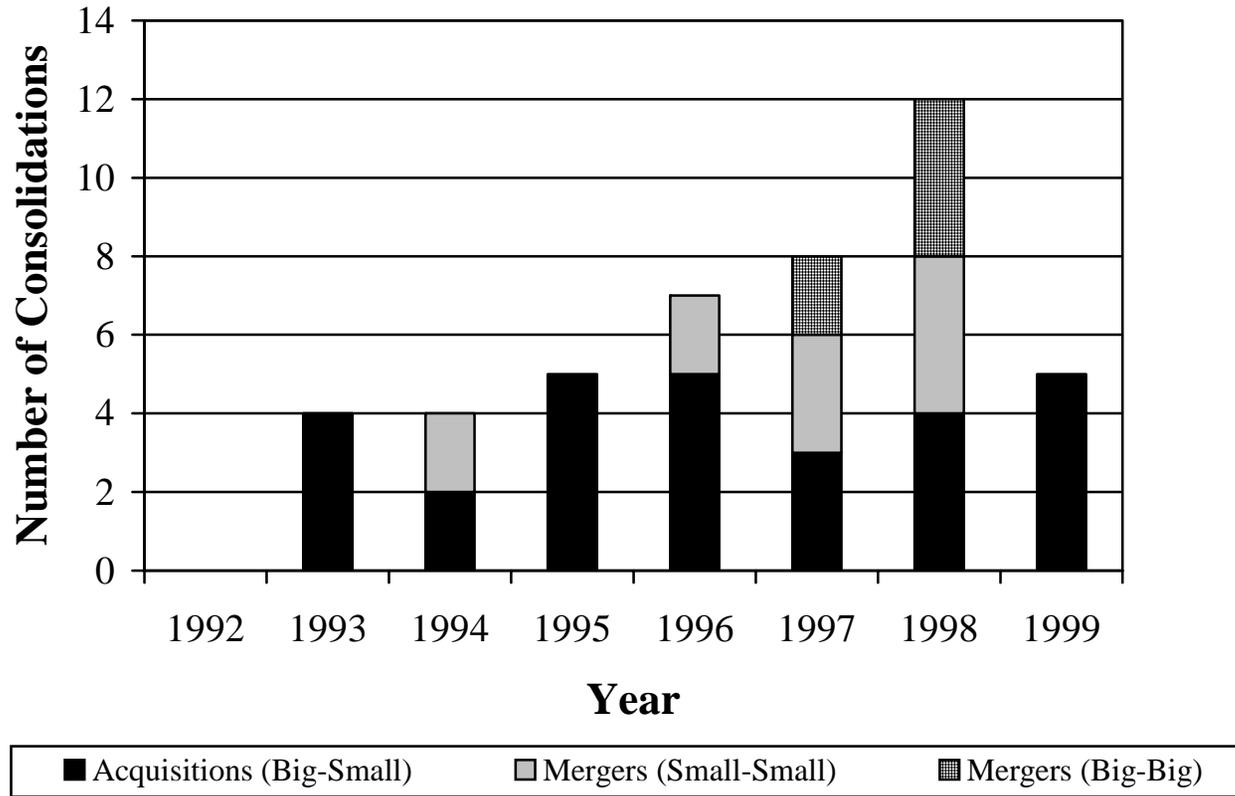
Note: A hospital is considered "big" if it offers CABG and PTCA procedures and "small" if it does not offer these procedures. Transactions involving the acquisition of multiple target facilities are counted as single consolidations.

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

Figure 2: Share to Acquirer Surrounding Acquisition Events
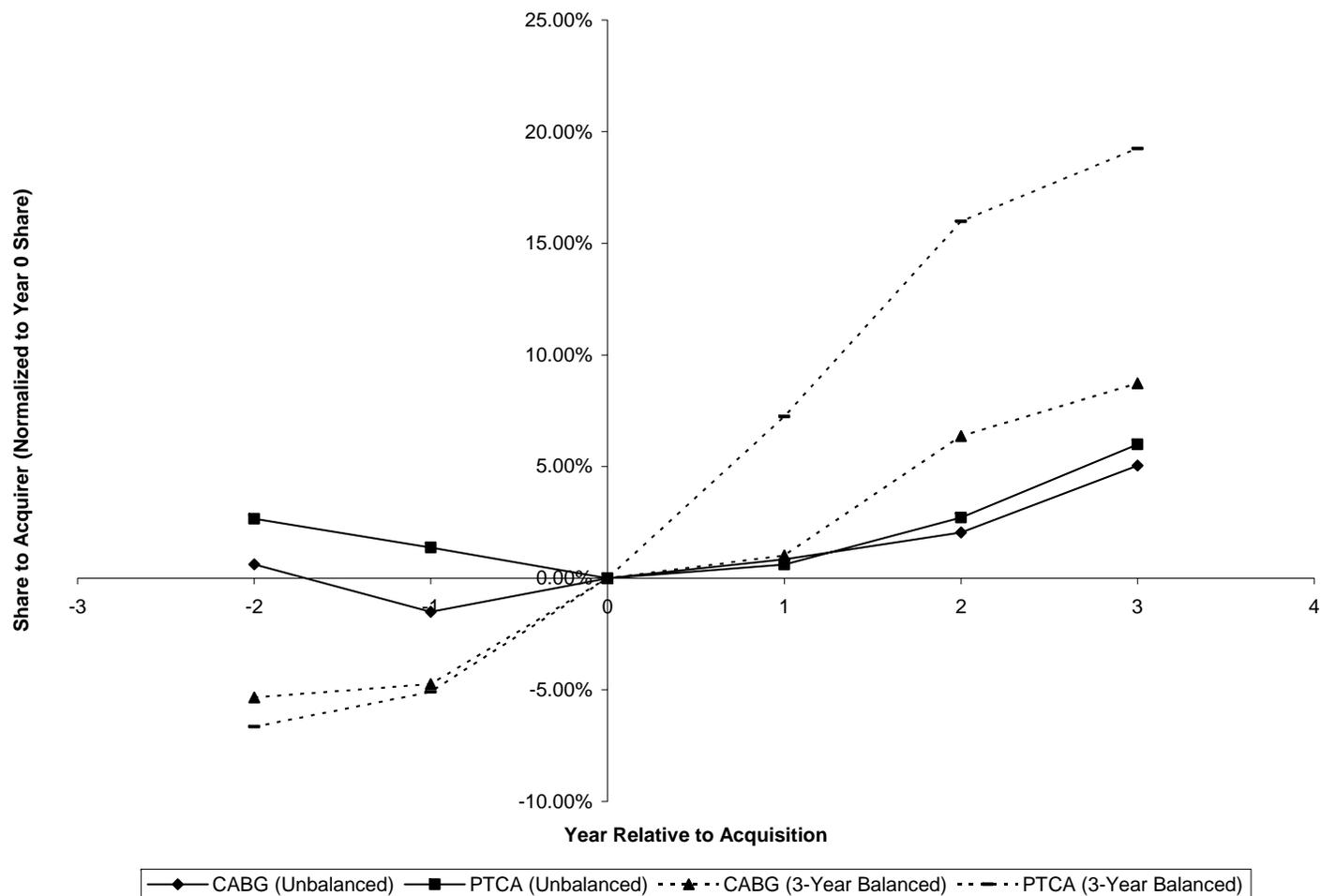
Note: Values for the unbalanced panels are obtained by subtracting the Year 0 coefficient from the relevant "year relative to merger" coefficient from Table 3, Columns 1 and 2 .

Source: SPARCS Database, 1992-1998.

Table 1: Estimated Revenues and Profits from CABG and PTCA Procedures for New York Hospitals, 1997

	CABG		PTCA		CABG and PTCA Combined
	Medicare (1)	All Cases (2)	Medicare (3)	All Cases (4)	All Cases (5)
Panel A: Per-Case Revenue and Profit from CABG and PTCA Procedures					
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: Total Revenue and Profit from CABG and PTCA Procedures					
Average Cases/Hospital		654		806	
Average Revenue Per Hospital		$ 21,505,291		$ 11,843,745	$ 33,349,036
Average Profit Per Hospital		$ 2,549,259		$ 2,175,382	$ 4,724,641

* *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 figures 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 (3)). 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.*

Table 2: Descriptive Statistics for Acquirers and Targets in Sample, 1992

		ACQUIRERS			TARGETS		
	N	Mean	Standard Deviation	N	Mean	Standard Deviation	
Inpatient Beds	16	856	318	31	421	158	***
Inpatient Days	16	269,759	96,635	31	125,084	55,111	***
Financial Data ($000s Unless Otherwise Specified)							
Hospital Charges	16	$ 521,000	$ 253,000	31	$ 173,000	$ 90,300	***
Net Revenue (Hospital Charges Less Discounts)	16	363,000	175,000	31	121,000	64,800	***
Operating Expenses	16	403,000	204,000	31	126,000	68,700	***
Net Income Margin	16	-0.9%	3.6%	31	0.9%	3.6%	*
Cost-to-Charge Ratio (Operating Expenses/Total Charges)	16	77.1%	9.9%	31	72.9%	8.9%	
Patients Receiving							
CABG	15	649	361				
PTCA	16	469	302				

*Note: ***,**, and * denote that acquirer and target means are significantly different at the 1%, 5%, and 10% levels, repsectively. Acquirer and target data are reported by facility (rather than by firm) in cases where a each facility reports data separately to Medicare. One acquirer provided PTCA but not CABG.*

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

Table 3: Acquirer Market Share in Target Markets

	Market Share to Acquirer	
	CABG	PTCA
	(1)	(2)
Primary Market of Target x		
4+ Years Pre-Acquisition	-0.035	-0.002
	(0.028)	(0.043)
3 Years Pre-Acquisition	-0.032	-0.025
	(0.020)	(0.029)
2 Years Pre-Acquisition	-0.017 ¥¥	-0.030
	(0.015)	(0.025)
1 Year Pre-Acquisition	-0.038	-0.043
	(0.016)	(0.021)
Year of Acquisition	-0.023	-0.057
	(0.013)	(0.017)
1 Year Post-Acquisition	-0.015	-0.050
	(0.016)	(0.017)
2 Years Post-Acquisition	-0.003 ¥¥	-0.029
	(0.014)	(0.018)
3 Years Post-Acquisition	0.027 ###,¥¥¥	0.003 ###,¥
	(0.013)	(0.012)
4+ Years Post-Acquisition	0.025 ##,¥¥¥	0.006 ###,¥¥
	(0.015)	(0.017)
Female (As Percentage of CABG Cases)	0.042	0.031
	(0.027)	(0.047)
HMO (As Percentage of CABG Cases)	-0.046	-0.018
	(0.059)	(0.070)
Medicaid (As Percentage of CABG Cases)	0.011	0.045
	(0.084)	(0.099)
Average Value of Dependent Variable Prior to First Acquisition	0.276	0.247
N	111	111
NT	997	997
Adjusted R^2	0.909	0.894
Durbin-Watson Statistic	1.64	1.50

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

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

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

Note: Robust standard errors, clustered by target market, are in parentheses. Each regression includes the following variables which do not appear in this table: a constant term; 3-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. For ease of presentation, the indicators of significant differences from zero (***,**,*) are not presented for any of the "year relative to acquisition" variables.

Table 4: Acquirer Market Share in Target Markets (Balanced Panel)

	CABG Share to Acquirer (1)	CABG Share to Acquirer (2)	PTCA Share to Acquirer (3)	PTCA Share to Acquirer (4)
Primary Market of Target x				
2 Years Pre-Acquisition	0.00648	-0.05340 ***	0.00622	-0.06650
	(0.0326)	(0.0161)	(0.0306)	(0.0448)
1 Year Pre-Acquisition	0.01359	-0.04743	0.01347	-0.05097 ***
	(0.0252)	(0.0295)	(0.0118)	(0.0170)
Year of Acquisition				
1 Year Post-Acquisition	0.00381	0.01022	0.03140	0.07234 ***,¥¥¥
	(0.0182)	(0.0272)	(0.0210)	(0.0272)
2 Years Post-Acquisition	0.07411 ***,¥	0.06364 **,¥¥¥	0.13852 ***,¥¥¥	0.15983 ***,¥¥¥
	(0.0249)	(0.0259)	(0.0405)	(0.0441)
3 Years Post-Acquisition		0.08734 **,¥¥		0.19241 ***,¥¥¥
		(0.0420)		(0.0535)
Female (As Percentage of CABG Cases)	0.03086	0.06908	0.02116	-0.06516
	(0.0639)	(0.1142)	(0.0888)	(0.0751)
HMO (As Percentage of CABG Cases)	-0.11301	0.00565	-0.22401	-0.19988
	(0.1513)	(0.1883)	(0.1803)	(0.2508)
Medicaid (As Percentage of CABG Cases)	-0.01071	0.05242	-0.05868	-0.59240 *
	(0.2231)	(0.1791)	(0.2007)	(0.3119)
Average Value of Dependent Variable Prior to First Acquisition	0.161	0.184	0.165	0.236
N	36	18	35	17
NT	180	108	175	102
Adjusted R^2	0.916	0.930	0.902	0.922

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

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

Note: Robust standard errors, clustered by target market, are in parentheses. Each regression includes the following variables which do not appear in this table: a constant term; 3-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: 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 ** (0.0047)	-2,297 *** (577.8)		
ln(Lagged Annual PTCA Cases at Facility)			0.0096 (0.0082)	-2,200 *** (211.5)
Patient Age	-0.0044 *** (0.0005)	-932 *** (73.2)	-0.0016 *** (0.0003)	-373 *** (21.9)
(Patient Age)^2/100	0.0041 *** (0.0004)	1,032 *** (57.3)	0.0015 *** (0.0003)	375 *** (17.8)
Hospital Fixed Effects?	Yes	Yes	Yes	Yes
Year Fixed Effects?	Yes	Yes	Yes	Yes
Clinical Risk Covariates?	Yes	No	Yes	No
N	89,359$^¥$	110,177	40,114$^¥$	116,556
Adjusted R^2	0.067	0.118	0.122	0.137

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

¥ The total number of CABG cases in the CSRS database for the years from 1992 through 1996 is 90,130. Subtracting the 771 records with a missing value for at least one covariate yields the total number of 89,359 included in the regression. For PTCA, the total number of cases in the CARS data for 1994 and 1995 is 40,265. Subtracting the 151 cases missing at least one covariate yields the total of 40,114.

Note: Results in Columns 1 and 3 are based on data from the CSRS and CARS databases. 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 6: Calculation of Approximate Annual Change in Total Mortality and Cost for
CABG and PTCA Due to All New York Acquisitions, 1992-1999**

	Full Sample	*Balanced Panel*	
	To 3 Years Post-Acquisition	To 2 Years Post-Acquisition	To 3 Years Post-Acquisition
CABG			
Simple Redistribution			
Change in Mortality	-	-3.50	-
Change in Cost	-	-	-
Volume-Outcome Effects			
Change in Mortality	-0.01	-0.02	-0.03
Change in Cost	-$2,249	-$4,935	-$6,828
Total Change in Mortality	*-0.01*	*-3.52*	*-0.03*
Total Change in Cost	*-$2,249*	*-$4,935*	*-$6,828*
PTCA			
Simple Redistribution			
Change in Mortality	4.16	-	5.99
Change in Cost	-	-	-$3,477,118
Volume-Outcome Effects			
Change in Mortality	-	-	-
Change in Cost	-$4,892	-$23,929	-$45,812
Total Change in Mortality	*4.16*	*0.00*	*5.99*
Total Change in Cost	*-$4,892*	*-$23,929*	*-$3,522,929*

*Note: Calculations represent total changes across all acquisitions in New York from
1992 through 1999. Figures are based on coefficients from versions of (1) with
hospital-specific quality and cost intercepts, respectively, as the dependent
variable (for simple redistribution) and Table 5 (for volume-outcome effects).
Data on the average annual volume of procedures at local acquirers, non-local
acquirers, and non-acquirers is for 2000. Dashes denote cases where the
relevant coefficients used to calculate values are not statistically significant at
better than the 10% level.*

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. The CAC provides the following caveat with respect to the use of the indicator for chronic obstructive pulmonary disease (COPD): "Prior to 1993, the definition used for COPD was considered subjective, and irregular frequency distributions across institutions were noted. The definition was changed in 1993 to include documentation of objective clinical criteria. However, the wide range in COPD rates reported across hospitals remains, presumably due to practice patterns among various providers with regard to utilizing objective testing for COPD."