Getting to the Heart of the Matter: Assessing the Impact of Hospital Competition on Cardiac Patients in Taiwan[*]

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Abstract:

This paper examines whether market competition affects treatment expenditure and health outcome of cardiac treatment in Taiwan. Our measure of treatment expenditure is the hospital expenditure paid at the index admission (short-term) and the sum of inpatient and outpatient expenditures paid in the subsequent year (long-term). Our measure of health outcome is the probability of death in 1 and 12 months after discharge from the hospital. Our measure of competition is the conventional “variable radius” Herfindahl-HirschmanI Index calculated at 75th percentile. Using data of patients hospitalized for Ischemic Heart Disease, Acute Myocardial Infarction or Congestive Heart Failure between 1997 and 2001 in Taiwan, we find that market competition lowers the short-term mortality rate, and has insignificant impacts on long-term health outcome. In terms of treatment expenditure, our results indicate that hospitals facing more competition incur higher inpatient expenditures, and the increase is persistent for the long-term expenditure. Contrary to the Medical Arm Race hypothesis arguing hospitals compete through the provision of inefficient medical technology, we find the higher inpatient expenditure is not associated the use of expensive diagnostic technology such as computer tomography and cardiac magnetic resonance imaging, but the increased use of more expensive and invasive techniques such as percutaneous transluminal coronary angioplasty and coronary arterial bypass graft.

Keywords: Hospital Competition; Universal Health insurance; Quality of care

JEL codes: I11; L13; L41

I. Introduction

In the last decade, Taiwan's hospital system has experienced a dramatic change. Approximately 25% of the acute care hospitals have closed in Taiwan, accompanied by an increase in the total number of hospital beds up to 40% in the same period. Similar movements toward hospital consolidation can be seen in the U. S. and Canada. In the U. S., 496 general hospitals closed between 1988 and 1998, resulting in a 12% decline in the number of hospital beds (Lindrooth et al, 2003). Likewise, 275 hospitals were closed, merged or converted in Canada over the period 1996 to 2001 (CIHI, 2001). Not surprisingly, in light of such the sizable change, health researchers in these countries are concerned with the impact on treatment expenditure and health outcomes resulting from these hospital consolidations.

The theory behind the social welfare impacts of hospital consolidation is well developed, though results of the empirical literature are often mixed. The underlying theory compares the cost synergy associated with hospital market consolidation to the accompanying price increase on services; that is, the society benefits if the cost reduction is able to offset the price hike (Gaynor and Vogt, 2000). While the theory sounds relatively simple, in reality the distinction is not easy to make. To begin with, a large portion of health care consumers are covered by insurance; their payment responsibility is either non-existent or relatively small. As a result, price competition is generally not as strong in the hospital market as it is in other markets. Next, it is difficult to measure treatment cost and health outcome. Treatment cost is usually difficult to measure because of treatment heterogeneity, even for patients with the same diagnoses. Health outcome is even harder to define per se, let alone measuring it precisely. Without reliable measures of treatment cost and health outcome, ascertaining the cost and benefit of hospital competition is difficult.

This standard is even more problematic when applying to the U. S. data. First, there are multiple payers; the presence of multiple payers increases the difficulty to collect price information since private payers often negotiate their payments privately with hospitals. Consequently, results of most competition studies are derived based on data of one large public payer (e.g.: Medicare or Medicaid). Nonetheless, there have been studies indicating that competition produces different effects for different payers, especially when private payers were involved (Gowrisankaran and Town, 2003)[1]; findings based on one payer may be difficult to generalize. Moreover, hospitals may shift their costs toward other payers in face of the price reduction of one payer (e.g. Dranove, 1988)[2]. In that case, the true impact of hospital competition is likely to be contaminated by the cost-shifting behaviors of hospitals.

The second problem relates to the payment system in the states. Beginning in 1987, following the practice of Medicare, almost all payers have replaced cost-based payment with prospective payment system (PPS). Although PPS is effective in containing the rising hospital expenditure, it also increases the extent of risk selection since hospitals are paid a fixed amount for each patient based on the patient's diagnosis, not by the hospital's actual treatment expenditure. This is especially prevalent for hospitals under severe competition pressure (Meltzer et al, 2002);[3] the strong incentive for hospitals to select healthy patients at admissions complicates the analysis, and distorts findings of hospital competition.

In this study we examine the effect of hospital competition on the treatment expenditure and outcome for patients admitted for Ischemic Heart Disease (IHD), Acute Myocardial Infarction (AMI), and Congestive Heart Failure (CHF) in Taiwan. We analyze the impact using Taiwan data because Taiwan is the latest developed nation to implement National Health Insurance (NHI). Because NHI employs the single payer, and pays hospitals on the fee-for-service basis, the data provide an excellent opportunity to isolate the impact of hospital competition. We use IHD, AMI

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[1] Gowrisankaran and Town (2003) found that competition for Medicare and HMO patients may have different impacts on hospital quality: the former reduced the welfare but the latter improves the welfare.
[2] Dranove (1988) found out that hospitals raised their prices for privately insured patients in response to the reduction of Medicare or Medicaid payments.
[3] Meltzer et al. (2002) found that increasing competition in the context of prospective payment is associated with selective reductions of expenditures for the most expensive patients.

and CHF because they are one of the most common non-communicable health conditions across the globe. In addition all three involve procedures and medicines which in many cases are performed and used on an emergency basis. This means the distribution of disease severity should be less correlated with an individual's residence location than other types of procedures. As will be seen below, this feature is important in defining the competition measure used in the analysis.

We use longitudinal hospital claims of NHI receipts diagnosed as IHD, AMI and CHF cases between 1997 and 1999. Because NHI is compulsory, we essentially have all related treatment for these conditions. To carefully investigate the effect on health spending, we measure the expenditure not only by the payment paid during the treatment episode (short-term), but also the total expenditure (inpatient and outpatient) paid in the year following the health shock (long-term). Likewise, we measure the short- and long-term health outcome using the incidence of death within 1 and 12 months after admission. For the competition measure, we use the conventional "variable radius" Herfindahl-HirschmanI Index (HHI) calculated using the standard of 75 percentile. Lastly, additional to a detailed set of patient's and hospital's characteristics, the estimation employs the hospital and patient's residence zip-code fixed effect to account for differences of patients' severity mix at admission and hospital's quality of care. This allows us to capture some unobserved quality differences (e.g. reputation). In other words, our identification comes from variations of HHI index for a given hospital over years.

Our findings indicate that higher market concentration (or lower hospital competition) results in lower short- and long-term treatment expenditures, and decreases the 1 month mortality rate. There is some evidence suggesting higher market competition increases the use of more expensive and invasive techniques such as percutaneous transluminal coronary angioplasty (PTCA) and coronary arterial bypass graft (CABG). Although our result may at first appear to be consistent with predictions of MAR hypothesis, the evidence of MAR is weakened by the almost zero effect of competition on the use of what in 1997 were very new diagnostic technologies:

computer tomography (CT) and cardiac magnetic resonance imaging (MRI). In addition, it is likely the use of the new technology for cardiac treatment improves patient's short-term health outcome.

This article is organized as follows. We begin in Section 2 with a discussion on previous literature on hospital competition. Section 3 briefly introduces NHI and the hospital market in Taiwan. Section 4 shows the econometric strategy we adopt and Section 5 describes the data and sample we analyze. In Section 6, we present basic results, robustness checks and possible mechanisms affecting treatment expenditure and health outcome. Section 7 concludes.

II. Previous literature on Hospital Competition

The dramatic change in the hospital markets in the U. S., Canada, and elsewhere around the world has instigated a variety of research related to the competitiveness of this industry (For comprehensive reviews, see Gaynor and Vogt, 2000; Dranove and White, 1994 and Dranove and Satterthwaite, 2000). Some researchers have been able to link competition among hospitals to reduced treatment cost and improved quality of service (Dranove et. al., 1992, 1993; Town and Vistnes, 2001). Others have argued there is insensitivity to price among health care consumers due to health insurance. They argue the prevalence of this insensitivity to price leads to a "medical arm race"(MAR) in which hospitals compete on differentiated treatment through the implementation of new technologies, a process which often subjects patients to unnecessary and often costly treatment (Robinson and Luft, 1985; 1987). Another vein of research has emphasized the informational imperfection in hospital markets. They note this informational asymmetry leads to higher costs and excess capacities in face of an increase in the number of health providers (Frech, 1996; Fisher et. al, 1999).

The results of the empirical research using the U. S. data can generally be divided into two groups by the time period studied. Studies using data prior to the mid-1980s found results that were more consistent with the predictions from the MAR hypothesis (e.g. Joskow, 1980;

Robinson and Luft, 1985, 1987; Robinson, 1988; Robinson et. al., 1988; and Noether, 1988) [4]. Studies using more recent data generally found that hospital competition results in effects consistent with the traditional views described in the textbooks (e.g. Gruber, 1994; Dranove, Shanley and White, 1993; Kessler and McClellan, 2000).

This division is generally tied to two important changes in the US hospital market which occurred in the mid to late 1980's. The first change in the market was the emergence of managed care such as health management organizations (HMO) or preferred provider organizations (PPO) after the mid-1980s. HMO's use financial incentives to get hospitals to limit utilizations. More importantly, managed care induces hospitals to engage in price competition through selective contracting (Dranove et al., 1993; Town. and Vistnes, 2001). Although the extent of price competition still depends on the information imperfections in the hospital market as well as the profit-maximizing incentives of hospitals, there is no doubt managed care has substantially increased the importance of price competition in the healthcare marketplace.[5] As a consequence, the welfare implications of hospital competition have now become somewhat mixed.

The second change occurred in 1987 when Medicare (and subsequently most other insurers) changed from a cost based fee-for-service system to the prospective payment system. Hospitals were now reimbursed a flat fee based on a patient's diagnoses which in theory would restrict the use of excessive care and costly technology. It is no less difficult to generalize the consequences of this change on hospital competition, as it has introduced a patient selection problem. Recent

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[4] Joskow (1980) found that higher market concentration leads to a lower reservation quality in hospitals, whilst studies based on 1972 data (Robinson and Luft, 1985) and 1982 data (Robinson and Luft, 1987), both found that average costs per admission, and costs per patient day, were substantially higher in those hospitals operating in more competitive markets. In addition, earlier studies had also revealed that hospitals located in more competitive markets were more likely to offer percutaneous transluminal coronary angioplasty (PTCA) and coronary-artery bypass surgery (CABG) (Robinson, Garnick and McPhee, 1987) as well as employ a substantially higher number of employees (Robinson, 1988).

[5] Dranove and Satterthwaite (1992; 2000) showed that the effect of competition on quality and price depends on the effect of competition on the price and quality elasticity of demand. When the information is imperfect, if competition increases the price elasticity alone, then market competition will decrease quality. If competition increases both elasticities of price and quality, then the effect on quality is ambiguous, depending on the relative magnitudes of elasticities.

studies have indicated this selection problem is more prevalent for hospitals in higher competition markets (Meltzer et al, 2002).

Because of the existence of multiple payers, researchers also run into additional difficulties in trying to estimate the impact of hospital competition on welfare. As a result a large portion of the literature focuses the impact of hospital consolidation on patients of a single payer, as this simplifies the multiple payer issue. The focus is usually on Medicare and Medicaid patients because data are more readily available for these patients, and the reimbursement structures for these programs are widely available. However some recent research has indicated that competition produces different effects for different payers, especially in studies looking at private payers (Gowrisankaran and Town, 2003)[6].

A major shortcoming in the previous research, as noted by Kessler and McClellan (2000), is the lack of examination of the effect of market competition on treatment cost and health outcome jointly. Without examining costs and benefits simultaneously, it is impossible to evaluate the welfare effect of market competition. Kessler and McClellan (2000) found prior to 1991 competition led to higher costs and lower rates of adverse health outcomes for elderly heart disease patients, but after 1991 competition led to both substantially lower costs and reduced rates of adverse outcomes. In other words, market competition unambiguously improves social welfare for the years after 1991. Other previous studies of the relationship between health outcomes and market competition were often mixed (e.g. Shortell and Hughes, 1988; Propper et. al. 2004).

III. Background

This section provides some institutional backgrounds of NHI and the healthcare market in Taiwan. We first briefly outline the universal health insurance implemented in 1995 and then describe the hospital market in Taiwan between 1997 and 1999.

[6] Gowrisankaran and Town (2003) found that competition for Medicare and HMO patients may have different impacts on hospital quality: the former reduced the welfare but the latter improves the welfare.

A. Brief introduction of NHI

In March 1995, Taiwan implemented national health insurance, providing insurance coverage to the entire population. Before the implementation, the health insurance coverage was primarily provided through three social insurance programs serving different populations: Labor Insurance for employees in the private sector, Government Employee Insurance for workers in the public sector, and Farmer Insurance for farmers. In total, these programs covered health insurance of 12.3 millions or 57% of the total population in 1994. Since nearly half of the total population was still uninsured, and a disproportionate share of these uninsured were children less than fourteen years old and the elderly over sixty-five, Bureau of National Health Insurance (BNHI) was established in January 1995. Two months later universal health insurance was instituted.[7]

The NHI is designed to accomplish two objectives: providing equal access to health care for all citizens, and maintaining total health spending at a reasonable level (CEPD, 1990). To achieve the first goal, the insurance premium is shared among three parties: enrollees, employers, and governments, with enrollees of lower income paying a smaller share.[8] In addition, NHI provides a comprehensive benefit package including preventive and medical services, prescription drugs, dental services, Chinese medicine, and home nurse visits. Cost sharing is modest: $5 co-payment for each outpatient visit to clinics, $8 for every visit to hospital outpatient clinics, and 10% coinsurance rate for inpatient care capped at 10% of the average national income per person, and again the poor are exempted from all cost sharing. Furthermore, every enrollee is free to go to almost all health providers.[9] Not surprisingly, with generous benefit package and low cost sharing,

[7] The inauguration of NHI was to a large extent initiated by the pressure of looming legislation election in the next year (1996). For more discussions, see Cheng (2003).
[8] For instance, workers in the private sector pay 30% of premium while their employers and the government pays 60% and 10% respectively. Farmers, the group that on average earns the lower income, pay 30% while the rest is covered by the government. Poor households do not have to pay a portion of their insurance premium. See Lu and Hsiao (2003) for a detailed description.
[9] The NHI contracted rate for hospitals is 96.72% and 96.90% in 1996 and 2002 respectively; the rate for clinics is 92.49% in 1996 and 92.90% in 2002. (data source: http://www.doh.gov.tw/statistic)

the insured rate grows at an astonishing speed---the rate jumped to 92% within less than a year, and has stayed above 97% since 1997.

Achievement of the second goal, however, has not been realized through NHI. Prior to the NHI's inception, the health spending per capita was rising at an average rate of 6-8% in real terms, about 2-3% higher than GDP's growth. One explanation for this rapid spending growth prior to NHI was the increased administrative work and cost associated with the multiple payer system, and this increased cost may have even been tempering spending growth to some extent by allowing shifting service costs among different payers. The implementation of NHI was intended to ease the extent of cost-shifting, and decrease unnecessary administration costs through standardized payments. Moreover, the single payer system is regarded as an effective tool to identify fraudulent claims and overcharges since better information can be used to build hospital and patient profiles. In spite of the ambitious aim of NHI, the average health spending still grows at a rate higher than originally planned. In response to this continual rise in health spending, BNHI adopted several new reforms on reimbursement schemes[10], and raised the insurance premium rate for the first time since its inception in 2003.[11]

B. Hospital Market in Taiwan

Consistent with experiences from other countries, the percentage of healthcare supplied by hospitals has increased over time in Taiwan. Its importance can be manifested from two aspects. First, the hospital share of NHI payment has gained over time, rising from 2.14% of GNP in 1997, to 2.46% in 2002.[12] Moreover, the number of hospital acute beds, as displayed on the left axis of

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[10] Beginning in 2002 for clinics and 2003 for hospitals, in order to contain the medical expenditures, NHI introduces Global Budgeting---the maximum cap that a government imposes on the increase of medical spending.

[11] The insurance rate was set as 4.25% from the inauguration of NHI, and raised to 4.55% beginning in 2003.

[12] Payment for outpatient and inpatient care to hospitals in 2002 is about $3.5 billions and $3.1 billions respectively. The hospital share of medical expenditures is calculated from Financial Resource and Allocation of National Health Expenditure, Year 1997 and Year 2002 obtained from Ministry of Health (data source: http://www.doh.gov.tw/statistic)

Figure 1, has increased over the years, rising from about 70,000 in 1989 to over 110,000 in 2002, over 50% of increase in ten years.

In spite of the consistent growth in the number of hospital beds, the hospital industry has experienced a structural change. Most notable is the *decline* in the number of hospitals. As one can read from Figure 1, more than 150 or approximately one fifth of the total seven hundred hospitals exited the market between 1989 and 2002. Additionally, the declining pattern accelerates after the implementation of NHI. To what extent and in what mechanism the introduction of NHI affects the hospital market is thus an important question.

To better examine the effect of NHI, Table 1 lists the number of hospitals by bed size (0-100, 100-300, and above 300) and ownership (public, nonprofit, and private) since 1997. The table shows there are two distinct trends. First, approximately one fourth of small hospitals, of which almost all are privately owned, exited the market; this trend to a large extent explains the decline of hospital numbers in Figure 1. Second, there is an increase in the number of large-sized hospitals, either from the expansion of medium-sized ones or entries of new hospitals. This explains why the total number of hospital beds continues to rise though many small hospitals exited the market. Obviously, the hospital market has undergone a significant change.

Why are these two distinct trends? Why do smaller hospitals exit and large hospitals prosper? So far there are no clear answers. One explanation is that universal coverage substantially squeezes the room for hospitals to engage in price competition. Consequently, small hospitals are adversely affected since they are less able to compete on the quality of care. Another explanation is that universal health insurance increases the demand of health care, which benefits medium-sized or above hospitals due to economies of scale.

The last, and perhaps the most important argument, is these trends are due to the reimbursement schemes of NHI. In Taiwan, hospitals are categorized by accreditations: major teaching hospital (medical center), minor teaching hospital (regional hospital), community and unaccredited hospital. To reflect differences in admitted severity mix and supplied quality of care, BNHI pay teaching hospitals higher rates for the same service. For example, the daily rate for the hospital stay in an ordinary bed (4-person occupancy in a room) is NT 512 for major teaching hospital, NT456 for minor teaching hospital, and NT395 for the remaining ones. It seems better accredited hospitals may prosper as a result of the reimbursement. Thus the increasing trend in the number of large hospitals over time may simply be due to the coincidence of better hospitals being bigger. This is demonstrated in Table 1 where we show the increase in the number of medical center and regional hospital and a sharp decline in the number of community and unaccredited hospitals across time. Of course a careful analysis is necessary to separate the relationship between hospital size and accreditations.

IV. Estimation

A. Market Definition and Competition Measure

The most widely used measure of competition in the literature is Hirschman-Herfindahl index (HHI); the index is defined as:

$$HHI_k = \sum_j s_j^2 I(d_{jk} \le R_k),$$

where d_{jk} is the distance between hospital *j* and *k*, R_k is the distance boundary that defines the hospital *k*'s market, and *I* is an indicator equaling one if hospital *j* were located within the distance boundary. Once the relevant competitors in the market are defined, the HHI index for hospital *k* simply equals to the sum of squares of each competitor's share in the market.

Although HHI is easy to calculate, applying this index involves two practical problems. First, one needs to define the competing services in the market. Hospitals offer a wide array of medical services, including outpatient, inpatient, and community services. Among these services, this analysis focuses on IHD, AMI, and CHF treatment. Because BNHI is the single payer in Taiwan, we are able to track almost all IHD, AMI and CHF cases treated at every hospital; this reduces the possible bias likely to occur from using data based on one payer in a multi payer system or a certain portion of hospitals in the region.[13]

Second, one needs to define the market boundary that includes relevant competitors (R_k). The majority of hospital patients, especially patients experiencing these heart conditions, cannot travel far to seek for help. As a consequence, a hospital often competes with other competitors located in the same town, or nearby areas. Conventionally, there are three ways to define market boundary: service area, fixed-radius, and variable-radius.[14] The first is a service area method that defines the market ad hoc using political or census divisions such as counties, metropolitan statistical areas (Joskow, 1980), health service areas or urbanized areas (e.g. Dranove, Shanley and Simon, 1992; Dranove, Shanley and White, 1993). The second and third approach defines the market using the distance between two hospitals. The fixed-radius approach defines a hospital's market boundary as a fixed radius, such as 5, 10 or 15 miles (e.g. Robinson and Luft, 1985; 1987; Robinson, 1988). The variable-radius approach moves even one step forward: defining the market radius that contains 75% or 90% of a hospital's actual patient flow (e.g. Phibbs and Robinson, 1993; Gresenz et al, 2004).[15] As a result, each hospital has a flexible and specific distance radius.

No single measure of a hospital's market is ideal for all research questions (Baker, 2001). In general, the service area is more problematic since it defines the boundary subjectively. For two methods using the distance as the measure, variable-radius method is considered to be superior for most research questions (Gresenz et al., 2004). Nonetheless, variable-radius method is still criticized since any measure based on the actual patient flow is not immune from endogeneity bias. For instance, high-quality hospitals may attract more patients from further away and thus face more competitors in the market. For that reason, several recent studies (Kessler and

[13] For instance, Kessler and McClellan (2000) limit their study to Medicare beneficiaries while Town and Vistnes (2001) and Gowrisankaran and Town (2003) limit their study to Southern California.
[14] Discussions about the advantages and disadvantages of alternative definitions of healthcare markets can be found in Dranove and White (1994), Baker (2001) and Wong et al. (2005).
[15] Some studies defined a hospital's market as the collection of geographic areas that collectively account for 40-95% of a hospital's discharges (e.g. Zwanziger and Melnick, 1988; Gruber, 1994).

McClellan, 2000; Town and Vistnes, 2001; Gowrisankaran and Town, 2003) have proposed using the predicted patient flow based on patient-level hospital choice models to create competition measures. Nonetheless, the predicted patient flow is not practically applicable since hospitals are highly concentrated in cities in Taiwan. In Taipei, for instance, six hospitals share the same zip-code on average; [16] such a high density of hospitals increases the difficulty of using the distance between hospitals as instruments in constructing the predicted patient flow. Thus, our study employs the HHI with the radius including 75 percent of actual IHD, AMI, and CHF patients as the competition measure[17]. Below we discuss how we control for the possible endogenous bias from the competition measure in the estimation.

B. Estimation Strategy

Let *i* be the patient hospitalized for IHD, AMI, or CHF treatment at hospital *k* in year *t*. Let Dep_{ikt} be the dependent variable that measures either a patient's treatment expenditure or health outcome. Because these conditions are likely to generate a lasting effect on patient's health, treatment expenditure is measured by the hospital expenditure paid at the index admission (short-term) and the sum of inpatient and outpatient expenditures paid in the year following the time of cardiac diagnosis (long-term). Likewise, we use 1 and 12 month mortality to evaluate a patient's short and long-term health outcome respectively. The estimation can be described as the following:

$$Dep_{ikt} = H_{kt}\alpha + X_{it}\beta + \gamma Comp_{kt} + \eta_i + \mu_k + \nu_t D(pop_i) + \varepsilon_{ikt}$$

where X_{it} is a vector of variables describing patient *i*'s severity at the admission year *t*; H_{kt} is a vector of admitted hospital's observed features; $Comp_{kt}$ is the HHI index for hospital k at year t; η_i and μ_k is the unobserved patient's and hospital's specific error respectively, ν_t is the year

[16] The total number of hospitals in Taipei is roughly within 48 and 58 between year 1997 and 2001.

[17] The HHI is calculated as the percentage of total patients treated at each hospital located within the radius around the hospital of interest. The radius is varies by hospital and is defined as the radius in which 75% of the hospital's IHD, AMI and CHF patients normally reside. Thus the radius used to measure the HHI is generally smaller in densely populated areas and vice versa.

effect, and ε_{ikt} is the random error assumed to be independent of all other error terms. Since the time effect is likely to differ with respect to city or rural areas, we further allow the year dummy to interact with dummies of the nearby population size around patient *i*'s residence ($D(pop_i)$).

To carefully investigate the effect of hospital competition, the estimation first controls a detailed set of observables of patients (X_{it}) and hospitals (H_{kt}). Aside from age and sex, we exploit a patient's utilizations in the preceding year prior to the hospital's admission, including the sum of total inpatient expenditures, inpatient admission numbers, and outpatient expenditures. Furthermore, we include two risk measures: the Charlson index, a risk index ranging between 0 and 6 indicating a patient's comorbidity conditions (Goldstein et al., 2004), as well as the DxCG risk coefficient, a risk index based on a patient's prior inpatient diagnoses (Zhao et al, 2005)[18], to account for patient's severity at the time of admission. For the hospital's features, we include a hospital's ownership status (public, private and nonprofits), teaching status (major, minor and non-teaching), along with the number of beds and physicians in a hospital. In spite of the fact that many observables of patients and hospitals are added in the estimation, the results may still be subject to biases if the unobserved errors (η_i, μ_k) are not carefully controlled. For instance, the quality of care may be difficult to fully represent by using only a hospital's observed characteristics. If those unobserved errors are correlated with market competition and treatment expenditure or health outcome at the same time, the estimated coefficient of HHI index is no longer consistent.

To overcome this difficulty, we employ the hospital and patient's residence zip-code fixed effect. A hospital's quality of service, though unobserved, is unlikely to vary substantially within a short length of time. In addition, patients usually acquire information by asking their relatives or

[18] DxCG includes various models that require different data inputs to help predict a person's medical spending. Because our data do not have information on the drug expenditures, we select the concurrent model employing age, sex, and inpatient diagnosis code (ICD9) as inputs. For details on the differences among various models, check the DxCG's website (www.dxcg.com).

friends in the same neighborhood; we expect patients residing in the same zip-code should have similar expectations over the hospital's quality of care. Furthermore, the residence choice of patients to some extent reflects his or her personal assessment over health risks; zip-code fixed effect should also help us control the unobserved patient's heterogeneity. By including hospital and residence zip-code dummies in the estimation, we are able to remove the effect brought by unchanged, but unobserved, hospital or patient factors. For some time-variant unobserved factors not eliminated by hospital or area fixed effects but correlated with both market competition and expenditure or outcomes, these endogenous errors are to a large extent captured by the remaining observables such as the hospital bed capacity or the number of practicing physicians.[19] Thus, the estimation should be able to sort out the effect brought by the hospital competition, and by all other factors correlated with hospital competition. Details of variables in the estimation are discussed below.

V. Data

A. Sources

We use four data sources in the study; all are obtained from National Health Insurance Data (NHID), maintained by National Health Research Institute. The first is the longitudinal medical claims (inpatient and outpatient) of NHI enrollees suffering from IHD, AMI, and CHF between 1996 and 2000. We limit the data to the year 2000 because the reimbursement for several cardiac surgical procedures (e.g. CABG or PTCA) changes from fee-for-service to case-payment in 2000.[20] Because NHI covers almost the entire population, we essentially have every one of these

[19] The inclusion of hospital bed capacity and number of physicians also controls for the existence of a significant positive correlation between the volume of health services provided by hospitals and physicians and the health outcome of patients that has been documented in a large body of research (e.g. Halm et al., 2002)

[20] The "case-payment" scheme is similar, but not identical to diagnostic related groups (DRG) implemented in the states. Case-payment sets up standard reimbursed rates for patients receiving PTCA or CABG treatment. Nonetheless, each hospital remains the right to report a certain portion of PTCA or CABG cases

cardiac cases in Taiwan. These claims record diagnoses of diseases, admission dates, discharge dates (for inpatient services), along with a detailed description of medical expenses (e.g. food, room, diagnoses, surgery, etc.) before and after co-payment. Virtually all cardiac-related treatment is covered by NHI, and few adjustments were made between claims. Most importantly, each claim record consists of three scrambled but unique IDs: Patient ID, Doctor ID, and Provider ID; these unique IDs enable us to link information of patients and providers from other sources.

The second source combines several different NHID health provider (hospitals) datasets spanning from 1996 to 2000.[21] From these datasets, we obtained a health provider's location, ownership and teaching status (for hospitals), as well as its facilities (e.g. departments, beds) and man-power (e.g. doctors, nurses, technicians). Moreover, we merge the provider's location with a file containing the latitude and longitude of each zip-code in Taiwan. As seen below, this information is the key to define a hospital's "market" in our analysis.

The third source is the eligibility file of all NHI enrollees covering between 1996 and 2000. The eligibility file reports an enrollee's basic demographics (sex and age), group of enrollment as well as the zip-code of enrollment. Because the file is kept in the log format----a new entry is added once there is a change in the enrolled unit, salary, or type---a covering period comprising of starting and ending dates is also included for each entry. For convenience, we match a patient's hospital claim with the last entry of eligibility file in the admitted year if multiple entries are found in that year.

With the help of the unique patient ID, we merge the eligibility file with medical claims, and extract three pieces of information. The first is a patient's sex and age. The second is the zip-code of enrollment; the information allows us to derive the distance between a patient's residence and

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(e.g. 15%), particularly the sever ones, at the rates higher than the standardized ones. The impact of this change in reimbursement schemes is complicated and is left to future research.

[21] Specifically, we use "Registry for Contracted Medical Facilities," "Supplementary Registry for Contracted Medical Facilities," "Registry for Contracted Beds," Registry for Medical Personnel," and "Registry for Contracted Specialty Services." For hospitals with incomplete or missing information in the data, we supplement with Hospital Registry Files and Hospital Service Files obtained from Ministry of Health.

admitted hospital. The third is the ending date of NHI coverage, used as the proxy of a patient's date of death after treatment in the analysis. Because NHI is compulsory, only on very few cases a person, especially a seriously ill one, is left uninsured, of which death is the most probable event.[22] In addition, given NHI premium is paid on the monthly basis, a person's insurance coverage can be easily dropped shortly after the death. Comparisons between the coverage's ending date and one's death records confirm the validity of this proxy (Lien, Chou, and Liu (2006)).[23]

B. Sample

Our study consists of IHD, AMI, and CHF cases that were aged over 35 years old and admitted between 1997 and 1999. We dropped the sample of 1997 for the convenience of calculating each cardiac patient's outpatient and inpatient expenditures in the preceding year. We excluded patients admitted after June, 1999 because BNHI introduced a new reimbursement scheme for several common cardiac treatment (e.g.: PTCA or CABG). Furthermore, we restrict our study to patients admitted to community hospitals or above that treat at least 20 cardiac cases in that year. Longer stays or higher expenditures are extreme cases. Hospitals with fewer cases are dropped because their performances are likely to be distorted by these extreme cases. Besides, given that our subjects are patients suffering severe illnesses, smaller hospitals are unlikely to be relevant competitors in our analysis.

About 40% of the sample is dropped to the absence of patient's residence information. While the eligibility file records information on the zip-code of enrollment, there are several practical difficulties to apply this information directly. Most problematic is that the zip-code of enrollment indicates the location from which an enrollee obtains his or her coverage, not that of a

[22] According to NHRI data manuals, an enrollee loses his coverage in one of the following five conditions: (1) died (2) sentenced or jailed (3) disappeared for over six months (4) served in the army (5) exceed the permitted stay or working permits; the last condition applies only to foreigners.

[23] Lien, Chou and Liu (2006) obtained the stroke patients' actual dates of death from their death records. Our comparisons show that, for those who died within one year after discharge, 90% of the sample have their dates of deaths identical to that of ending coverage; less than 5% has the difference larger than a week; and less than 2% larger than a month.

patient's household registry. Such the discrepancy is especially prevalent for those who do not co-reside with the ones who pay their insurance premiums (e.g. college students or the elderly). In addition, even for enrollees whose residences are identical to household registries, a substantial portion of them actually choose to live at places different than their household registries.[24]

We take three steps to ensure a patient's residence information. First, we select enrollees whose premiums are paid by themselves or spouses only, excluding the ones covered by third parties (e.g. children or relatives).[25] Second, we choose enrollees of three enrollment groups: obtaining coverage from office of household registry, farmer associations, and private employers. Zip-codes of enrollment for those enrollees are identical to that of their household registries or working places.[26] To further ensure that patients reside at places close to household registries, we drop the ones whose traveling distances to admitted hospitals are more than 50 km (around 30 miles). These cardiac conditions are often acute and are serious conditions, so few patients are likely to travel far to get treatment. Patients who take long distances to admitted hospitals either do not live nearby or have experience symptoms while traveling. In either case, those observations are dropped.

Table 2 outlines the exclusion restriction we imposed and the remaining number of observations after applying each exclusion criteria. In total, there are 229,089 new IHD, AMI, and CHF cases with valid hospital and patient information. About one quarter of hospitals are eliminated due to the hospital restriction. Because most of them are smaller ones, it only affects less than 2% of the total observation. Approximately 40% of sample is dropped due to constraints of premium supporters and groups of enrollment. The remaining 15% is dropped due to 50-km distance constraint. As a result, our final sample consists of 117,580 cases, roughly half of the

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[24] The discrepancy rate is estimated to be around 17%, that is, 17% of the families do not live at their household registries. See Shih et. al. (2004) for details.

[25] The restriction can ensure that an enrollee co-reside with the ones who pays his or her insurance premium.

[26] Enrollees obtaining coverage from farmers' associations or household registry offices in general have their zip-codes of enrollment identical to that of household registries. For those obtaining insurance from private employers, their zip-codes of enrollment are by the large identical to that of working places.

original size, of which very few are repeated observations of the same patient. Nevertheless, there is no strong evidence showing the exclusion constraint changes the severity mix of patients or type of admitted hospitals. As demonstrated at the lower part of Table 2, there is only a slight change in the portion of more severe patients (AMI and CHF).

C. Sample Statistics

To illustrate the extent of market concentration, Table 3 shows the change of HHI index since 1997. It is clear from the table that exits of small hospitals and entries of large hospitals indeed increases the market concentration. This can be seen from the upper part of Table 3 that the mean of HHI index increases from 0.210 in 1997 to 0.218 in 1999, about 4% increase in seven years. Since the value of HHI index is relatively difficult to interpret, we follow Kessler and McClellan (2000) by categorizing into three quantiles of market concentration (from here on referred to as quantiles) according to the HHI distribution across a three year period. Table 3 lists the distribution of these dummies over the sample period. As one could expect over such a short period of time, concentration does not change in any systematic way.

Table 4 further lists the number of hospitals experiencing inter-quantile change within two consecutive years, and their corresponding patient share in every sample year. We show these numbers because our estimation controls for the hospital fixed effect. Therefore, it is important to examine if enough inter-quartile variations over the sample years are available for identifications. About 40-55 hospitals have experienced changes in their quartiles, of which more than half switched into quartiles that are more concentrated than the preceding year. In term of patient share, the total number of affected share is about 10-15% in every sample year. Notice that the patient share in the table does not match the distribution change of concentration quantile dummies in Table 3 since the input from entries of new hospitals is not included.

Table 5 displays the summary of treatment expenditure and health outcome of new IHD, AMI, and CHF patients by three concentration quantiles. On average, a IHD, AMI, and CHF case costs NT56,656, NT28,673 and NT20,098 for treatment in low, medium, and high concentration respectively; the pattern is consistent using the total expenditure in the following year. By comparison, the short- and long-term health outcomes do not exhibit consistent patterns. While the one-month mortality rate for cardiac patients is 6.3%, 6.2, and 6.0% in the low, medium, and high concentration groups, the trend of one-year mortality rate reverses--- higher long-term mortality rates are associated with groups of higher concentration.

One explanation for cost and outcome difference is the difference of severity mix among patients. If hospitals in face of lower concentration (high competition) tend to provide better quality of care, those hospitals may attract high-risk patients, resulting in worse outcome. To examine this possibility, Table 5 shows the descriptive statistics of these cardiac patients by concentration quantiles. The summary statistics of patient variables provide mixed evidence of the effects of market concentration on patient severity mix. The portion of AMI patients in low concentration markets is 3-4% higher than the medium or high concentration markets. In addition, the outpatient and inpatient expenditure in the preceding year is higher for low concentration markets, while the Charlson indices are very similar across all three concentration quantiles.

Another explanation for such an expenditure and outcome difference is due to the difference in the hospital’s supplied healthcare. Other things being equal, better hospitals are likely to deliver good outcomes. Table 5 also shows the characteristics of hospitals by their concentration quantiles. As expected hospitals in low concentration markets tend to be larger in terms of beds and vice versa. Although large or better accredited hospitals are not associated with lower mortalities, hospitals in markets with different concentration quantiles have very distinct characteristics. Thus it is important to control the possible correlation between market concentration and the supplied health service in the estimation.

VI. Empirical Results

A. Basic Results

Table 6 shows the impact of market concentration on expenditures and outcomes, controlling for patient demographics and severity, hospital characteristics, year effect, along with the hospital and residence zip-code fixed effect. Because a hospital's characteristics are unlikely to change over time, the hospital fixed effect essentially removes the explanatory power of many hospital related variables. For the exposition purpose, we omit results of hospital variables that are unlikely to change over time (e.g. teaching and ownership status). From the table, it is clear patients of higher risk consistently incur higher expenditures and suffer from worse health outcomes; this applies to variables indicating patient's age, previous health utilizations as well as Charlson index. In addition, patients treated at hospitals with larger bed capacity seem to have systematically higher expenditures.

Our variable of interest is the competition measure. As stated earlier, the analysis employs concentration quantile dummies with the quantile cutoffs in all years based on the 1997-1999 pooled distribution of HHI. From Table 6, treatment of IHD, AMI, and CHF patients during the index admission in the most-concentrated market (high HHI) was lower cost than those in the least-concentrated areas, though this result was marginally significant at 10%. The magnitude of the expenditure effect of moving between the highest and lowest quantile of HHI was approximately 4.3%. The long-term expenditures were also smaller in the most-concentrated market, though the lower expenditure is only significant for the most highly concentrated markets. For health outcomes, patients from the most concentrated market (least competitive market) have higher one month mortality. In sum, our results suggest that competition increased short-term expenditures, and lead to lower short-term mortality outcomes.

To confirm our findings, we check whether the results are robust to different specifications. We consider two specifications. Instead of using non-parametric specifications of HHI, the first specification allows for the linear and quadratic terms in HHI in all regressions. The second specification allows for a flexible setting for each comorbidity embedded in the Charlson index. We do this because other studies have shown that the conventional score assigned to each comorbidity in Charlson index may be inappropriate and should vary with respect to various illnesses. Therefore, the estimation replaces Charlson index with a set of disease dummies so that the risk score of each comorbidity could vary in the estimation.[27]

Table 7 displays results from these different specifications. In contrast with results from the basic specification, there are some differences. First, in the non- parametric specification, the coefficients of concentration dummies are stronger when short term expenditures is the dependent variable, but they are only marginally significant when looking at the impact of concentration on long term expenditures. The non-parametic specification results also indicate there is no difference in short term mortality at higher competition quantiles, contrary to the finding in our FE OLS specification. Changing to the flexible setting with the Charlson indices does not impact our results.

B. Sources of higher hospital expenditure

So far our results suggest treatment of patients may be less expensive in the most concentrated market. Our findings related to cost suggest an increased use of technology in higher competition markets. However, the lower rate of mortality in these markets implies the use of technology is impacting patient health in a positive way, which is not consistent with the MAR hypothesis. Since our data contain detailed information on the expenditure component, we further examine the underlying mechanisms resulting in such differences in Table 8. To investigate the underlying factors, we replace the dependent variable with four other variables. First, we break the health expense into two components: length of stay and expense per day and check which one is affected most by market concentration. Next, we substitute hospital expenditure with the utilization and expenses of costly diagnostic equipment such as computed tomography (CT) or magnetic resonance imaging (MRI). If the MAR hypothesis is correct, we should expect that market concentration causes a substantial effect on this particular expenditure component.

[27] See Goldstein et. al (2004) that discussed that appropriate score assigned for stroke patients.

Our results in Table 8 show that difference in length of stay is probably not the cause of any of the difference in hospital expenditure. On average, length of stay in the most concentrated market was no shorter in the least concentrated market or in medium concentration markets. Also in contrast to what the MAR hypothesis, there is no direct evidence linking monopolistic competition among hospitals to the proliferation and duplication of expensive medical technologies and services. The main driver in cost differences seems to arise with differences in treatment intensity measured by expenditure per day. This per day expenditure is 3.6% lower in the highest concentration markets and 2.9% lower in the medium concentration markets when compared to the low concentration/high competition hospitals.

Why do hospitals in the market of low concentration have a higher expenditure per-day? One explanation is that hospitals facing higher competition treat patients with more advanced techniques. Another is that higher competition increases the treatment intensity but does not change the course of treatment. To distinguish these two possibility, we identify the use of four medical procedures in patients' inpatient records: PTCA, CABG, CT and MRI; the first two represent the use of advanced surgical procedures, while the latter two represent the use of expensive diagnostic tools. Our results indicate that patients in hospitals locating in the higher concentration market are less likely to receive CABG or PTCA surgery, showing that competition enhances the use of new treatment technology. Nonetheless, our result does not support the argument that higher competition leads to a higher use of CT and MRI. This finding contradicts the MAR hypothesis that hospital competition increases the use of expensive equipment.

VII. Discussion

This paper investigates the effect of hospital competition on treatment expenditure and health outcome for IHD, AMI and CHD treatment. Using the NHI enrollees hospitalized for these diagnoses between 1997 and 1999 in Taiwan, we examine whether hospitals facing different market concentrations incur different health expenditure or mortalities after treatment. We find market concentration affects patients' mortality rate, as patients in lower concentration markets have lower rates of one month mortality. For treatment expenditure, our findings suggest higher market concentration lowers the health expenditure at the index admission, and the effect is stronger when accounting for the total health expenditure in the subsequent year. Moreover, we investigate the sources causing differences in health expenditure. Our findings show that the main difference comes from treatment intensity and choice of treatments, but not from differences in use of expensive diagnostic equipment such as CT or MRI.

Our findings in cardiac care are similar to those in previous studies. Our findings in this paper confirm that higher competition results in higher expenditure, and higher utilization of expensive medical procedures. Lien et al (2006) find a similar increase in expenditure for stroke patients treated in high competition hospitals. Increases in expenditure in the stroke study were not accompanied by better patient outcomes. This difference in outcomes is probably due in part to the choice of outcome variables, namely 1 and 12 month mortality.[28]

A number of studies have reported that the implementation of NHI has encouraged the adoption and utilization of expensive medical technology in Taiwan, of which one likely reason is the quality competition among hospitals (e.g. Chou et al., 2004; Tsai and Li, 2002). We find this may be true for cardiac treatments (CABG and PTCA), but it does not seem to impact the use of novel cardiac diagnostic technologies (cardiac CT and MRI). While universal health insurance may contribute the adoption of new technology, the results of our study are somewhat mixed.

We now discuss several limitations of our study. First, the study employs the conventional "variable-radius" competition measure. Although this is probably the most widely used competition measure, the measure is likely to suffer from endogeneity bias despite controlling for

[28] This lower short term mortality did not stand up to robustness checks. The difference between the finding in the Lien et al (2006) and this one may also be explained by the differences in survival patterns among stroke patients and cardiac patients. As such our conclusions may only be applicable to cardiac treatment.

hospital fixed effect. Recent studies (e.g. Kessler and McClellan, 2000; Town and Vistnes, 2001; Gowrisankaran and Town, 2003) have proposed the use of predicted rather than actual patient flows as the competition measure to solve the problem of endogeneity. Unfortunately, due to the data constraint, this study cannot conduct the measure based on predicted patient flow. We caution readers on this potential bias.

Second, our focus of this analysis is limited to the diagnosis of three major cardiac conditions. The need to control for other technologies and different courses of treatment for these patients exists, and is left for subsequent work. Finally, and most importantly, we measure a patient's outcome by his mortality rate, not accounting for his or her health status. For cardiac patients, a valuation that incorporates the patient's mortality and subsequent symptoms may be a better outcome measure (e.g.: quality of adjusted year of life, subsequent heart attacks or severe angina). A more careful analysis that combines the patient's health status may be necessary to evaluate the effect of hospital competition on social welfare.

The main contribution of this paper is to add to the sparse literature providing empirical evidence as to how hospital competition affects treatment expenditure and health outcome in developing countries. Although a significant amount of attention has been paid over the past decade to the consequences of competition, the majority of them focus on the healthcare market in the U. S. that is difficult to generalize to health systems in other countries. By comparisons, our analysis uses data from Taiwan, and has implications for the short and long-term consequences of hospital competition. Our finding should be more applicable to other countries seeking to conduct health reforms through the introduction of market forces.

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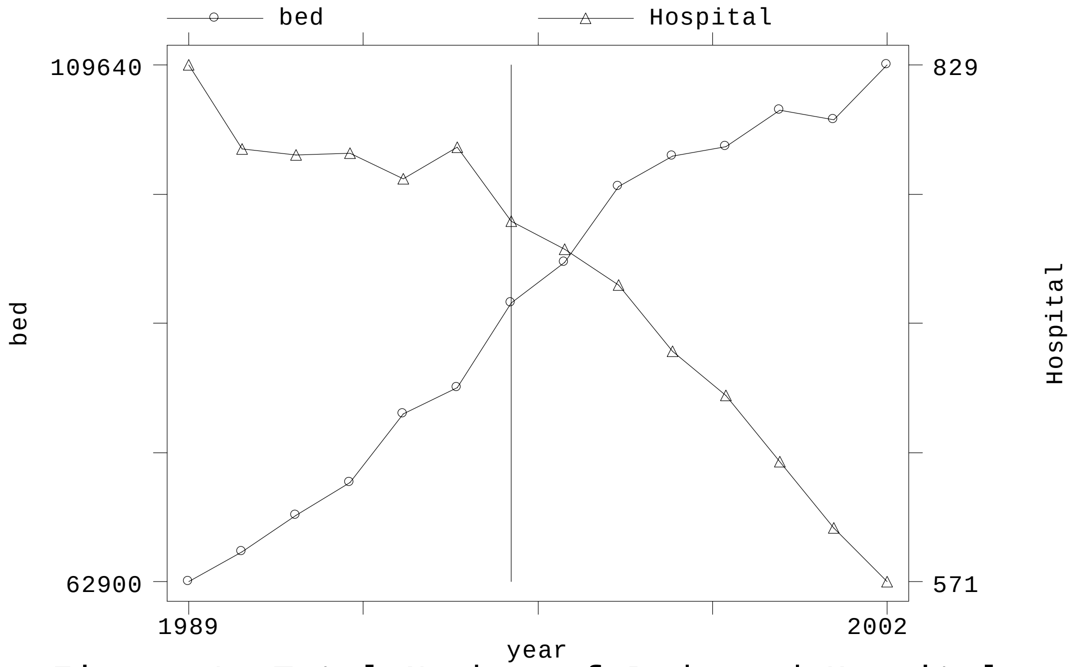

Figure 1: Total Number of Beds and Hospitals

Table 1: Summary of Hospital Characteristics Over the Sample Year[a]

Year	1997	1998	1999	2000	2001	2002
Number of Beds						
(0-100)	458	438	420	393	371	345
(100-300)	118	116	111	109	110	107
(300+)	96	102	111	118	116	124
Ownership						
Private	494	476	460	437	414	393
Nonprofit	78	79	80	81	82	83
Public	100	101	102	102	101	100
Accreditation						
Major Teaching Hospital	16	17	18	23	24	23
Minor Teaching Hospital	51	51	51	63	66	71
Community Hospitals	468	469	426	387	402	385
Others	137	119	147	147	105	97
Total Observations	672	656	642	620	597	576

[a]Values represent number of hospitals in each category

Table 2: Patients and Hospitals Used in the Analysis

Number of Hospitals

Year	new cases with valid hospital and patient information	…and enrolled into accredited hospitals with 20 cases a year	…with reliable residence information	.and who lived within 50 km of the index hospital
1997	528	374	374	374
1998	497	350	350	350
1999	445	289	289	289

Number of Patients

Year	new cases with valid hospital and patient information	…and enrolled into accredited hospitals with 20 cases a year	…with reliable residence information	.and who lived within 50 km of the index hospital
1997	86,188	83,021	50,078	44,803
1998	93,212	90,181	53,685	47,900
1999	49,689	47,216	27,881	24,877

Characteristics of Patients and Admitted Hospitals

	new cases with valid hospital and patient information	…and enrolled into accredited hospitals with 20 cases a year	…with reliable residence information	.and who lived within 50 km of the index hospital
Patients				
AMI	7.9%	7.9%	7.7%	7.6%
CHF	24.0%	24.1%	24.0%	23.8%
Male	54.8%	55.1%	58.7%	59.3%
Age	69.1	69.0	69.7	69.8
Hospitals				
Bed (0-100)	24.5%	22.9%	24.1%	25.3%
Bed (100-300)	26.8%	27.3%	27.8%	28.8%
Bed (300+)	48.7%	49.8%	48.0%	45.9%
For-Profit	38.5%	37.1%	39.1%	40.6%
Non-Profit	30.3%	30.7%	28.1%	26.7%
Public	31.2%	32.2%	32.9%	32.7%

Table 3: Measures of Market Concentration on Cardiac Patients[a]

	1997	1998	1999
HHI (Variable-Radius: 75 Percentile)			
Mean	0.210	0.216	0.218
	(0.198)	(0.199)	(0.197)
HHI (by Quantile)			
Low Concentration	51.49%	48.96%	50.54%
Medium Concentration	28.30%	30.27%	28.58%
High Concentration	20.21%	20.77%	20.88%

Standard deviations are in parentheses.

Table 4 : Number of Hospitals Experiencing Interquantile Changes by Year*

	Out of Low Quantile	Medium to High	High to Medium	Into Low Quantile
1998	29	16	13	15
	(6.89%)	(2.88%)	(2.31%)	(1.32%)
1999	23	16	7	25
	(5.00%)	(3.78%)	(1.34%)	(4.64%)

*numbers in parentheses represent the share of patients admitted to hospitals experiencing interquantile changes

Table 5: Summary Statistics of Cardiac Patients By Concentration Quartiles

	Market Concentration		
	High	Medium	Low
Expenditure and Mortality			
1 Month Mortality	6.0%	6.2%	6.3%
1 Year Mortality	17.7%	18.1%	16.9%
Index Admission Expenditure[a]	20098	28673	56656
	(34073)	(44909)	(75768)
1 Year Expediture[a]	79382	94873	135205
	(156309)	(180243)	(210679)
Hospitals [b]			
For-Profit	59.9%	45.6%	30.4%
Non-Profit	19.1%	23.5%	30.3%
Public	20.9%	31.0%	39.3%
Community Hospitals	90.5%	67.1%	26.9%
Minor Teaching Hospitals	9.0%	31.3%	36.4%
Major Teaching Hospitals	0.4%	1.6%	36.7%
Bed Number (0-100)	54.3%	33.3%	9.6%
Bed Number (100-300)	39.1%	39.7%	19.5%
Bed Number (300+)	6.5%	27.0%	70.9%
Patients			
Nearby Population (/0000, 10km)			
(20-)	77.6%	67.0%	53.4%
(20-50)	15.1%	22.7%	25.2%
(50-200)	7.3%	10.3%	21.4%
(200+)	2.0%	9.1%	22.3%
Demographic and pre-health status			
Male	54.3%	55.4%	63.5%
Ages (<50)	60.8%	61.3%	56.3%
Ages (50-60)	9.9%	9.9%	11.9%
Ages (60-70)	29.3%	28.8%	31.8%
Ages (70-80)	38.2%	38.2%	36.3%
Ages (>80)	17.4%	16.8%	12.3%
AMI	5.4%	6.1%	9.0%
CHF	24.8%	25.3%	22.4%
DxCG Risk Score	0.863	0.859	0.852
Charlson index	1.023	1.045	1.005
Preceding year's inpatient expenditure	2.0716	2.1848	2.2682
('0000)	(6.335)	(6.788)	(7.815)
Preceding year's outpatient expenditure	0.2813	0.3399	0.6582
('0000)	(1.411)	(2.003)	(2.821)
Observations	23692	33568	57835

Standard deviations are in parentheses.

[a]Expenditure are in NT dollars and deflated using CPI (2001=100)

[b]Percentage of hospitals in each category for the specified concentration level

[c]DxCG risk index is based on a patient's prior inpatient diagnoses (Zhao et al, 2005)

[d]Charlson index is a risk measure ranging between 0 and 6 indicating a patient's comorbidity conditions. For details, see Goldstein et al. (2004)

Table 6: Results of Competition on Expenditures and Outcomes (HHI: Variable Radius)

	Log(Expenditure)[a]		Mortality[a]	
	1 Month	1 Year	1 Month	1 Year
Medium Concentration	-0.032*	-0.015	-0.003	-0.004
	(0.017)	(0.018)	(0.003)	(0.005)
High Concentration	-0.043*	-0.048**	0.010**	0.008
	(0.022)	(0.024)	(0.005)	(0.008)
Bed Number (100-300)	0.030	0.104**	0.004	0.003
	(0.032)	(0.047)	(0.006)	(0.013)
Bed Number (300 above)	0.130***	0.163***	0.003	0.005
	(0.047)	(0.053)	(0.008)	(0.015)
Male	0.045***	0.149***	0.001	0.020***
	(0.006)	(0.008)	(0.002)	(0.002)
Age (50-60)	0.086***	0.099***	-0.002	0.000
	(0.015)	(0.019)	(0.003)	(0.005)
Age (60-69)	0.142***	0.204***	0.007**	0.025***
	(0.017)	(0.022)	(0.003)	(0.005)
Age (70-79)	0.167***	0.268***	0.027***	0.079***
	(0.019)	(0.023)	(0.004)	(0.006)
Age (80+)	0.248***	0.276***	0.090***	0.227***
	(0.021)	(0.026)	(0.005)	(0.007)
AMI	0.635***	0.354***	0.174***	0.134***
	(0.021)	(0.020)	(0.006)	(0.006)
CHF	0.089***	0.108***	0.063***	0.145***
	(0.013)	(0.012)	(0.003)	(0.004)
DxCG relative risk coefficient[b]	-0.232***	-0.130***	0.021**	0.045***
	(0.041)	(0.050)	(0.009)	(0.013)
Charlson Index[c]	0.052***	0.106***	0.016***	0.052***
	(0.003)	(0.003)	(0.001)	(0.001)
Previous year's outpatient expenses	0.009***	0.018***	0.001***	0.004***
('0000)	(0.001)	(0.001)	0.000	0.000
Previous year's inpatient expenses	-0.002*	0.041***	0.005***	0.006***
('0000)	(0.001)	(0.002)	(0.001)	(0.001)
N	117180	117180	117180	117180

*, **, *** Significant at the 10%, 5%, and 1% level (two-tail test).

[a] All regressions include zip-code and hospital dummies and interactions between years and population sizes. In addition, the regressions include hospital characteristics not reported in the table such as dummies of ownership and accreditation. Standard errors shown in parentheses accounted for hospital clusters. Intercepts are not shown.

[b] DxCG risk index is based on a patient's prior inpatient diagnoses (Zhao et al, 2005)

[c] Charlson index is a risk measure ranging between 0 and 6 indicating a patient's comorbidity conditions. For details, see Goldstein et al. (2004)

Table 7: Robustness Checks for Competition on Expenditures and Outcomes

	Log(Expenditure)[a]		Mortality[a]	
	Admission	1 Year	1 Month	1 Year
		HHI and its Square		
HHI (linear term)	-0.390***	-0.333*	0.033	-0.018
	(0.148)	(0.200)	(0.028)	(0.050)
HHI (quadratic term)	0.357**	0.172	0.013	0.05
	(0.161)	(0.234)	(0.026)	(0.048)
		Charlson Index (Flexible Setting)[b]		
Medium Concentrated	-0.032*	-0.015	-0.003	-0.004
	(0.017)	(0.018)	(0.003)	(0.005)
Highly Concentrated	-0.043*	-0.048**	0.010**	0.008
	(0.022)	(0.024)	(0.005)	(0.008)

*, **, *** Significant at the 10%, 5%, and 1% level (two-tail test).

[a] All regressions include zip-code and hospital dummies and interactions between years and population sizes. In addition, the regressions include hospital characteristics not reported in the table such as dummies of ownership and accreditation. Standard errors shown in parentheses accounted for hospital clusters. Intercepts are not shown.

[b] Instead of setting risk value for each illness, we include dummies of illnesses contained in Charlson index (e.g. ami, diabetes, pvd, etc). For details on the illnesses used in Charlson index, see Goldstein et. al (2004)

Table 8: Sources of Differences in Medical Expenditure at the Index Admission[a]

	Log (Length of Stay)	log(Per-Day Expenditure)	Use of CT or MRI	Use of PTCA or CABG
Medium Concentration	-0.003	-0.029**	-0.002	-0.002
	(0.015)	(0.012)	(0.002)	(0.002)
High Concentration	-0.007	-0.036**	-0.003	-0.005*
	(0.021)	(0.017)	(0.003)	(0.003)

*, **, *** Significant at the 10%, 5%, and 1% level (two-tail test).

[a] All regressions include zip-code and hospital dummies and interactions between years and population sizes. In addition, the regressions include hospital characteristics not reported in the table such as dummies of ownership and accreditation. Standard errors shown in parentheses accounted for hospital clusters. Intercepts are not shown.