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Hospital ownership and performance: Evidence from stroke and cardiac treatment in Taiwan☆

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ABSTRACT

This paper compares program expenditure and treatment quality of stroke and cardiac patients between 1997 and 2000 across hospitals of various ownership types in Taiwan. Because Taiwan implemented national health insurance in 1995, the analysis is immune from problems arising from the complex setting of the U.S. health care market, such as segmentation of insurance status or multiple payers. Because patients may select admitted hospitals based on their observed and unobserved characteristics, we employ instrument variable (IV) estimation to account for the endogeneity of ownership status. Results of IV estimation find that patients admitted to non-profit hospitals receive better quality care, either measured by 1- or 12-month mortality rates. In terms of treatment expenditure, our results indicate no difference between non-profits and for-profits index admission expenditures, and at most 10% higher long-term expenditure for patients admitted to non-profits than to for-profits.

1. Introduction

Since the seminal work by Arrow (1963), a vast amount of literature has attempted to identify the impact of ownership structures in the hospital industry. Although implications from ownership theories are clearly applicable to the hospital industry in various countries, the empirical evidence for the effects of ownership of hospital performance is largely confined to the studies based on U.S. data (see Sloan, 2000 for a review). However, due to the complexity of the U.S. health care market, it is not easy to disentangle the pure effect of hospital ownership from other institutional settings such as segmentation of insurance status or payers and payment types.

The main difficulty in applying this body of work to other countries' systems, according to Sloan (2000), is that each country differs in how they organize and finance their health care system. In some countries, hospitals of a certain ownership type may dominate the market, often either non-profits or public hospitals; comparing hospital performance between for-profits and other ownership types becomes impossible. Even in countries where for-profit hospitals comprise a significant share,

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the definition of ownership may not be identical to that in the United States. In this study, we revisit an old question with data from Taiwan: how does hospital ownership status (profit versus non-profit) affect performance in terms of treatment quality and health expenditures.

In Taiwan, for-profit hospitals can only be owned and operated by physicians that have rights to distribute earnings, not investor-owned companies seeking corporate profits. However, non-profit hospitals still enjoy the tax benefits and are subject to a nondistribution constraint, i.e. non-profit hospitals do not have the legitimate residual claimants. Therefore, the comparison of hospital ownership types, particularly for-profit (FP) versus not-for-profit (NFP), provides compelling results under this scenario. While Taiwan's experience may not be directly and immediately applicable to the U.S. market, such comparisons not only add one piece of work on this question, but also provide a good opportunity to uncover the pure effect of ownership that might be contaminated by the complex setting in the health care market in the United States.

Aside from the fact that for-profit and non-profit hospitals both comprise significant shares in the hospital industry in Taiwan, there are other distinct advantages in using Taiwan as the example. First, Taiwan implemented National Health Insurance (NHI) in 1995, the most recent country to adopt universal health insurance. Because NHI was a single payer, our measures of health expenditures will not be contaminated by potential cost-shifting behaviors of providers, negotiation between providers and payers, or different reimbursement schemes by various payers. Second, NHI sets its own fee schedule and pays hospitals on a fee-for-service basis. This mitigates the concern of patient selection in a prospective payment system, that is, hospitals may dump patients who are sicker and are likely to cost more than the reimbursement payment (i.e. Meltzer et al., 2002). Finally, Taiwan's NHI covers almost all medical services. As a result, we are not only able to compare the health expenditure at the hospital admission, but also the subsequent outpatient and inpatient expenditures following the admission.

More specifically, we consider how ownership status, particularly FP and NFP, affects treatment expenditures and quality of care for stroke and cardiac patients in Taiwan. We analyze stroke and heart disease in part because of their importance and cost – stroke and heart disease are leading causes of hospital admission and inpatient expenditures in Taiwan – but also because the severity of the illness is unlikely to be known by an individual prior to its occurrence.[1] Therefore, the distribution of disease severity is likely to be independent of an individual's residence location, which, as demonstrated below, is essential for instrumental variable (IV) estimation.

We use longitudinal hospital claims of NHI recipients diagnosed as new stroke and heart disease cases during 1996 and 2002, matched with comprehensive hospital data over the same period. Since NHI covers almost all related treatment for stroke and heart disease, the hospital's charge is very close to the actual treatment expenditure. Because stroke and heart disease are the second and the third leading causes of death in Taiwan, we measure the quality of care by the incidence of death within 1 and 12 months after discharge. Conceptually, we could compare medical expenditure and time of death after discharge among new patients admitted to hospitals of different ownership. In practice, however, such a comparison may be misleading since hospitals may be selected based on various differences related to ownership status. To overcome this selection issue, we employ IV method to correct for unobservable differences between the control and treatment groups. To make our control and treatment groups more similar, we match the two groups based on estimated propensity scores, and then perform IV estimation on this matched sample.

Adjusting for endogeneity arising from both observed and unobserved characteristics, we find that new stroke and heart disease cases admitted to non-profits have lower mortality rates than those admitted to other hospitals. On average, 1- and 12-month survival rates of non-profits are 2–5 percentage points higher than that of for-profit hospitals. In OLS and IV estimations, we find no discernible differences in the medical expenditure by hospital ownership in most of the cases. Nonetheless, we find that NFP hospitals incurred higher 1-year expenditures based on our most rigorous estimation—IV on a propensity score matched (PSM) sample.

This article is organized as follows. We continue in Section 2 with a discussion of theories of non-profit organization and previous empirical studies of non-profit hospitals. Section 3 briefly introduces NHI and the hospital market in Taiwan. Section 4 describes the data and the sample we analyze, and Section 5 shows the econometric strategy we adopt. In Section 6 we present results of OLS, IV and PSM estimations and discuss the robustness checks. We conclude in Section 7.

2. Theories and empirical studies on ownership

2.1. Theories on non-profits

Malani et al. (2003) have created a simplified taxonomy of three theoretical models of non-profit hospital behavior. The first is termed altruism model. This line of research postulates various sets of objectives such as quality of care (Newhouse, 1970), charity care (Frank and Salkever, 1991) or profit (Lakdawalla and Philipson, 1998) for non-profit firms assuming that the equity capital has been obtained through philanthropic donations, debt, and retained earnings. The primary prediction of the model is that non-profit hospitals will have a bias toward producing higher quality care or more charity care.

[1] Inpatient expenditure for cerebrovascular disease (stroke) is 4.8% of all inpatient expenditures in 2003, after heart disease (7.2%) and cancer (12.4%).

The second model, termed physician cooperative model, is one in which the physician fills the gap created by the absence of specific owners in non-profit hospitals and creates a cooperative with clinical staff to maximize the joint income (Pauly and Redisch, 1973). In this model, it is more difficult for physicians to control resource allocation in for-profit hospitals, because the residual claimants have incentives to compete with physicians for control over resource decisions within the hospital (Malani et al., 2003).

Starting with Arrow (1963), the remaining class of theoretical studies, termed the noncontractible quality model, emphasizes the importance of the asymmetric information between the consumer and producer in explaining the existence of non-profits. Because hospital care usually involves complex technology and complicated medical knowledge, patients have difficulties judging the quality of care in advance. Nondistribution constraints embedded in non-profit organizations – owners of for-profits have legitimate residual claimants while controllers of non-profits are prohibited from distributing earnings – reduces the incentive to engage opportunistic behaviors. Thus, non-profits will fill a market niche where consumers are not able to judge effectively the quality of received care.[2]

Other studies (e.g. Weisbrod, 1988; Gentry and Penrod, 2000; Lakdawalla and Philipson, 1998) attempt to provide a theoretical justification for the proliferation of non-profit firms by stressing the decision to trade-off between tax advantages allowed under non-profit status and unconstrained profit making under for-profit status. Hansmann (1980, 1987, 1996) further argued that the availability of extensive privileges, including various tax exemptions and charitable deduction, to non-profits is neither necessary nor sufficient for the initial development of non-profits. In any case, they all agree that the various subsidies to non-profits may influence the overall extent of non-profit activity thereafter.

2.2. Previous empirical studies

The empirical literature on the impact of hospital ownership predominately focuses on the health care market in the United States. Sloan et al. (2001) suggest that payments on behalf of Medicare patients admitted to for-profit hospitals during the first 6 months following a hospitalization due to stroke, hip fracture, coronary heart disease, or congestive heart failure were higher than those admitted to non-profit hospitals. Their findings are consistent with Grannemann et al. (1986) that for-profit hospitals had costs higher than not-for-profit hospitals and Silverman et al. (1999) that total per capita Medicare spending was higher in markets dominated by for-profit hospitals, but contradict earlier results that indicate non-profit hospitals have higher average expenses per day than for-profits but similar average expenses per patient (i.e. Institute of Medicine, 1986; Becker and Sloan, 1985).

On the quality front, several studies have suggested similarities between for-profits and non-profit hospitals in health outcomes (Keeler et al., 1992; Sloan et al., 2001; Ettner and Hermann, 2001). McClellan and Staiger (2000) find that for-profits have higher mortality among elderly patients with heart disease, but they explain that the difference could be confounded by the market characteristics. Nevertheless, their results are consistent with some recent studies on hospital conversion (e.g. Shen, 2002; Picone et al., 2002) which found adverse health outcomes increase after converting from non-profit to for-profit status. Overall, the empirical evidence has yielded mixed findings regarding the ownership effect on cost and quality of care. See Sloan (2000) for a detailed review on the impact of ownership status.

3. Background

3.1. Brief introduction of NHI

In March 1995, Taiwan implemented national health insurance for the entire population. Prior to this, health insurance was primarily provided through various social insurances covering 12.3 million or 57% of the total population in 1994.[3] Since nearly half of the total population was still uninsured, of which the majority were children under 14 or the elderly over 65, universal health insurance was first discussed in 1992 and finally implemented in 1995. By the end of 1995, the insured rate jumped to 92%, and the rate has stayed above 97% since 1997.[4]

[2] Hansmann (1980) first generalizes this notion and terms it "contract failure theory". Easley and O'Hara (1983) formally incorporate the idea into contract failure theory where they argue that for-profit organizations will produce no output and the manager will simply pocket the whole purchase price in situations where the outputs are unobserved. Consequently, the nondistribution constraint will be valuable and non-profits may be superior to for-profits. Similar arguments have been made by Hart et al. (1997) and Glaeser and Shleifer (2001) in which they argue that there are so many possible contingencies ex ante that it is impossible to anticipate all of them when forming a contract. Thus, for-profit firms are more likely to exploit noncontractible quality by cutting noncontractible cost to maximize return under incomplete contracts. The nondistribution constraint embedded in non-profit organizations, on the other hand, softens this incentive and assures higher quality of care.

[3] Three social insurance programs include labor insurance for employees in the private sector, government employee insurance for workers in the public sector, and farmer insurance for farmers. For details on health insurance provided by various social insurance programs prior to national health insurance, see Chou et al. (2003).

[4] The insured rate is calculated on the basis of being Taiwanese citizens. Under some exceptions, Taiwanese citizens are allowed to drop out the insurance coverage, of which the majority of cases are citizens residing in places other than Taiwan for over 6 months. The rate will be even higher (approximately 99%) when calculating at the resident basis.

The design of NHI is similar to Medicare in the United States. Each enrollee pays a premium equal to the product of: (i) the NHI insurance rate, (ii) the enrollee's salary, and (iii) the share of the enrollee's contribution.[5] In return, every enrollee enjoys a standard package of benefits that charges a fixed registration fee (about $3) and a low coinsurance policy ($5 for the primary care; 10% for inpatient care with a yearly cap of NT40,000 (or $1300)).[6] Because almost all hospitals and clinics have had contracts with NHI, every enrollee is free to go to any health provider.[7] Health providers are reimbursed for provided services according to the fee schedule set by NHI.

NHI differs from Medicare in at least three aspects. First, it covers an even wider range of services, including outpatient, inpatient, dental, mental health and even Chinese medicine; in other words, NHI covers almost all medical services. Second, NHI reimburses health providers, at least in the period we analyze, on a fee-for-service basis, while Medicare switched to a prospective payment system for hospital in 1984.[8,9] Finally, in Taiwan, hospitals are categorized into three groups based on their accreditations: major teaching hospitals, minor teaching hospitals, and community or unaccredited hospitals, and hospitals with higher accreditation are paid more generously.[10] For instance, the daily rate for an ordinary bed (4 persons in a room) is NT512 for major teaching hospitals, NT456 for minor teaching hospitals, and NT395 for community and unaccredited hospitals.

3.2. Hospital ownership in Taiwan

According to Taiwan's medical law, hospitals are broadly defined into three ownership categories: public hospitals managed by the government or public enterprise or universities, non-profit hospitals established by private universities or donations for purposes of charity or medical research, and proprietary hospitals owned by physicians (hereafter termed FP hospitals).[11] Investor-owned corporations are prohibited from owning hospitals in Taiwan.[12] In spite of this institutional difference, FP hospitals in Taiwan are distinguished from non-profit hospitals by a variety of legal and economic aspects similar to the distinctions in the United States. First and the foremost, FP hospitals are managed and controlled by physician(s) who own the organization and its profits. By comparison, NFP hospitals do not have owners, but have self-perpetuating boards that have control rights. Therefore, a NFP hospital is legally forbidden from distributing its net earnings, if any, to its board of directors, administrators, doctors, or anyone else.[13] Second, owners of FP hospitals have to pay personal income tax from net earnings. By contrast, NFP hospitals pay corporate income tax only if less than 80% of net earnings are not spent on purposes specified in the charter. Even in that case, the rate of personal income tax is much higher than that of corporate income tax.[14] Third, NFP hospitals also are exempt from land and property taxes. Finally, NFP hospitals are entitled to receive charitable contributions. Most NFP hospitals were initially established through large charitable donations, while most FP hospitals were initially established through non-tax-exempt personal debt. Further clarifications of these distinctions are provided in Table 1.

To demonstrate the importance of each type of hospital ownership, Table 2 shows the number of acute-care hospitals and the number of hospital beds by ownership between 1996 and 2002. From the upper half of the table, it is clear that the

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5 The insurance rate was set as 4.25% at the inauguration of NHI, and raised to 4.55% in 2003. The share of contribution is determined by an enrollee's type of enrollment. For instance, public employees pay 40% of the premium while the government contributes the remainder. Private employees pay 30%, their employers contribute 60%, and the government pays the remaining 10% of premium. See Chiang (1997) for a detailed description.

6 The co-payment policy for outpatient care differs with respect to the provider's accreditation. In 2002 the out-of-pocket expense was $10 for major teaching hospitals and $5 for the rest. For indigent households premiums and co-payments are completely subsidized by the government.

7 The contracting 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).

8 Selective procedures, such as vaginal delivery, cesarean section or artery bypass surgery, are reimbursed on the case-payment basis. Different from DRG system in Medicare, case-payment is reimbursed on a surgical procedure basis, rather than a diagnosis basis. Up to 2002 after the implementation of NHI, there are 50 case-payment procedures in total.

9 In 2002 for clinics and 2003 for hospitals, NHI introduced the Global Budgeting System; the system requires Bureau of National Health Insurance and health providers to negotiate in advance the maximum increase allowed for medical spending in the following year.

10 In Taiwan, there are four types of accreditation (medical center, regional hospital, district hospital, and unaccredited hospital) and three types of teaching hospitals (major teaching hospital, minor teaching hospital, and community hospital). Due to institutional reasons, the first three types of accreditation correspond almost identically to three types of teaching status. Therefore, in the paper we separate hospitals into three groups by teaching status: major teaching hospitals (medical center), minor teaching hospital (regional hospital), and community hospitals (district hospitals and unaccredited ones).

11 The definition of public, non-profit and for-profit is described in Taiwan Medical Treatment Law Articles 3, 4 and 5, respectively. Hospitals operated by public universities are categorized as government hospitals because they usually accept the government's subsidy, particularly when purchasing expensive equipment. This type of hospital includes National Taiwan University Hospital and National Cheng-Kung University Hospital.

12 To better understand the differences between for-profit hospitals in Taiwan and in the U.S., we follow Gray (1991) and distinguish proprietary and investor-owned organizations: "*Proprietary* institutions are characterized by direct involvement of the owners in the management and operation of the facility. . . .*Investor-owned* health care companies are managerially operated organizations that own multiple facilities and whose owners are connected with these facilities only by virtue of holding shares in the parent company." Small proprietary hospitals were very common in Europe and the U.S in the late 19th and early 20th century, but have declined in number throughout the 20th century. Nonetheless, proprietary establishments owned by individual physicians can still be found in France, Germany, and the Mediterranean countries (Gray, 1991; Glaser, 1987).

13 The law requires non-profit hospitals to allot at least 10% of the net earnings to conduct related R&D, professional training and health education, and at least 10% to community services.

14 The tax rates could be up to 40% for the personal income tax but only up to 25% for the corporate income tax.

Table 1
Distinctions between for-profit and non-profit hospitals in Taiwan

	For-profit hospitals	Non-profit hospitals
Owners of hospitals	Medical treatment establishments owned by physicians	Medical treatment establishments that do not have owners, but have boards which have control rights
Right of surplus distribution	Can distribute all profits (net revenues less expenses) to owners, i.e. physicians will be the residual claimants	Cannot distribute surplus to those who control the organization (i.e. board of directors, administrators, doctors, etc.)
Tax treatment—personal/cooperate income tax	Owners of hospitals have to pay personal income tax from earnings	Before 1995, non-profits were exempted from corporate tax. Since 1995, corporate income tax is not exempted if less than 80% of earning are not spent on purposes consistent with founding goals of this organization
Tax treatment—property/land tax	Not exempted from land and property tax	Exempted from the land and property tax
Sources of capital	Sources of capital include: equity capital from establishers; debt; retained earnings	Sources of capital include: charitable contributions; debt; retained earnings
Composition of revenue	Revenues derived from sale of labor and services	Revenues derived from sale of labor and services and from charitable contributions

Table 2
Number of hospitals and beds by ownership between 1996 and 2002

Year	Government	Non-profits	For-profits	Total
Number of acute-care hospitals				
1996	94	73	454	621
1998	97	74	423	594
2000	98	79	407	584
2002	95	82	370	547
Number of beds in acute-care hospitals				
1996	32,273	30,641	29,106	94,016
1998	36,807	32,995	30,116	101,916
2000	38,592	36,892	32,171	109,655
2002	41,646	40,058	33,512	117,218

number of hospital has decreased substantially over time: 74 or roughly 12% of hospitals exited the market between 1996 and 2002. While there were 621 hospitals in 1996, by 2002, only 547 hospitals remained, of which almost all the exits occurred among for-profits. By comparison, the number of public hospitals was almost unchanged, while that of non-profits increased from 73 in 1996 to 82 in 2002. Despite the rapid decline in hospital numbers, the hospital industry actually *grew* over time. The total number of beds rose from 94,016 in 1996 to 117,218 in 2002, about a 25% increase. Since for-profit hospitals are in general smaller, each type of hospital ownership has roughly an equal share. Over time, however, the bed share of non-profits has gradually overtaken that of for-profits.

4. Data

4.1. Sources

We use four data sources in the study; all, except the last one, are from the National Health Insurance Database (NHID). Our principal source is the longitudinal inpatient and outpatient claims of patients suffering from stroke (hemorrhage or ischemic) or heart (AMI or IHD) illnesses between 1996 and 2002. Because NHI covers almost the entire population, we essentially have every stroke or cardiac case in Taiwan. The hospital claim includes diagnoses of diseases and dates of admission and discharge, from which we can calculate the length of hospital stay, and construct variables indicating the presence of a patient's comorbidities (e.g. hypertension, diabetes, etc.) prior to or at the index admission. In addition, both inpatient and outpatient claims record a detailed description of medical expenses (e.g. drug, diagnoses, surgery, etc.) that a hospital or clinic submitted to the BNHI for reimbursement, from which we can calculate the medical expenditure at the index admission, and subsequent expenditure within the year following the admission.[15] More importantly, each claim consists of three scrambled but unique IDs: Patient ID, Doctor ID, and Hospital ID; each ID allows us to link with other files to obtain information regarding specific patients, doctors, or hospitals.

[15] In Taiwan, the difference between the charges and the actual reimbursement is very small; on average less than 3% for inpatient services during the sample years.

We link the Patient ID with patient eligibility files in the sample years to obtain an individual's basic information. Because the eligibility file is kept in the event-history format, a patient could have multiple entries in a single year if changes of enrollment status are made in that year. For convenience, we match the inpatient claim with the last entry in that year. Three important pieces of information are extracted from eligibility files. First of all, we obtain a patient's demographics, namely, sex and age. Second, we obtain the ending date of a patient's insurance coverage. Because NHI is compulsory, there are very few occasions that a patient, especially an ill one, can and will drop the insurance coverage, of which death is the most probable cause.[16] Moreover, given that the premium of NHI is paid on a monthly basis, the coverage can be easily dropped immediately after the death. Thus, as indicated by Lien et al. (2004), the ending date of coverage is a good proxy for a patient's survival.[17] Third, we obtain a patient's residence zip-code at the admission year. Due to institutional reasons, however, only half the sample has reliable residence information. In Appendix A, we explain in detail how we select patients with credible residence zip-codes.

Likewise, we extract a hospital's accreditation, ownership status, teaching status, location zip-code, and its bed size from 1997 to 2002 hospital basic and bed files, and match the information using Hospital ID in the claim data.[18] After combining this information with the patient's residence zip-code, we are able to calculate the travel distance between zip-code of patient's residence to that of any hospital. As seen below, these distance variables play a crucial role in the estimation. Lastly, to account for more patient characteristics, we link patients' residence zip-codes with area information obtained from different data sets, including average household income from 1997 to 2002 Family Income and Expenditure Surveys, and population figure from 1997 to 2002 Population Registries.[19,20]

4.2. Sample

Our primary subjects are new stroke or cardiac cases, who were over 35 years old, admitted between year 1997 and 2000, and stayed for less than 91 days with incurred payment less than NT500,000 (or $18,000)[21]; the time and payment limits are included to avoid extreme cases. Although inpatient claim data are available beginning in 1996, new cases are ascertained using a 1-year look back period, making 1997 the first sample year. We use the sample data up to year 2000 because the global budgeting system for clinics was implemented in 2001; extending the sample beyond the year 2000 creates a new problem in calculating the health expenditure within a year following the hospitalization.[22]

We restrict our sample for a number of reasons. First, we focus on hospitals greater than a certain size, since figures from small hospitals are likely to be distorted by one or a few cases. Thus, unaccredited hospitals or hospitals with fewer than 20 cases in a given year are dropped. Second, we select patients with certain enrollment types to ensure the credibility of their residence zip-codes. Finally, we eliminate patients whose travel distance between residence and admitted hospitals is more than 25 km; patients who travel more than 25 km are either having a heart or stroke problem during a trip or their residence zip-code is likely inaccurate.

Table 3 shows the number of hospitals and patients after each exclusion criteria by admission year. To gauge the effect of exclusion criteria on the sample composition, the bottom row displays summarized statistics of hospitals' characteristics, patients' demographics, the proportion of various illnesses, as well as a risk score designed by DxCG to account for the severity of inpatient admission. In each sample year there are about 130,000–150,000 new stroke or cardiac cases with valid hospital and patient information. About 20% of hospitals are eliminated due to our restrictions, but the impact is much smaller on patient numbers—fewer than 1% are dropped. There is almost no effect with respect to patient or hospital characteristics. By contrast, more than one-third of the sample is dropped for lack of credible residence zip-code information. Furthermore, an additional 15% are dropped due to the 25 km distance constraint. The remaining number of cases is about 60,000–70,000 per year, slightly less than half the original size. In spite of the loss in sample numbers during the selection process, there

16 According to regulations of Bureau of National Health Insurance, Taiwanese residents can drop coverage if one of the following five conditions occurs: (1) died, (2) sentenced or jailed, (3) disappeared for over 6 months, (4) served in the army, and (5) exceeded the permitted stay or working permits; the last condition applies only to foreigners.

17 Lien et al. (2004) compare the ending date of coverage with actual death records of stroke patients. For those who died within 1 year after discharge, 90% of the sample have no differences between these two dates, less than 5% have differences larger than a week, and less than 2% have differences larger than a month.

18 Specifically, we use "Registry for Contracted Medical Facilities," "Supplementary Registry for Contracted Medical Facilities," and "Registry for Contracted Beds," and "Registry for Contracted Specialty Services."

19 The Family Income and Expenditure Survey is maintained by the General Budget, Account, and Statistics; the survey interviews around 14,000 households (or 43,000 persons) every year to collect information on family income and expenditure. To avoid the case that the random sampling process might overlook small zip-codes, the income number is calculated on the county basis for 24 (out of 26) counties and on the zip-code basis for two largest counties (Taipei City and Kaohsiung City).

20 The Population Registry is maintained by the Ministry of Internal Affairs; the data record the number of population in the household registry at a given zip-code on a yearly basis. Because a person may not reside in the zip-code listed in the household registry, the numbers here are further adjusted using two waves of census data (1990 and 2000) so that these figures reflect more accurately the actual number of residents in that zip-code.

21 For patients admitted to more than one hospital, i.e. transferring to another hospital, we count only the expenditure and length of stay at the hospital incurring higher medical payment.

22 Under the global budgeting system, calculating the health expenditure requires multiplying the submitted payment by the "point value", i.e. the conversion ratio between payment points and NT dollars. In practice, the "actual" point value may take up to 2 or 3 years to finalize.

Table 3
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 25 km of the index hospitals
1997	515	409	409	409
1998	489	381	381	381
1999	480	369	369	369
2000	480	357	357	357

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 25 km of the index hospitals
1997	127,623	126,628	74,788	59,514
1998	137,086	136,085	79,952	63,995
1999	145,577	144,795	84,308	66,890
2000	149,160	148,211	85,855	67,681

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 25 km of the index hospitals
Patients				
AMI	5.7%	5.7%	5.6%	5.4%
CHF	17.1%	17.1%	17.2%	17.2%
IHD	46.3%	46.2%	47.2%	48.3%
Hemorrhage stroke	7.6%	7.7%	7.2%	6.6%
Ischemic stroke	23.3%	23.4%	22.8%	22.5%
Male	55.9%	55.9%	59.5%	60.3%
Age	68.91	68.91	69.59	69.69
DxCG risk score[a]	2.66	2.66	2.73	2.74
Hospitals				
Public	26.9%	27.0%	27.9%	27.8%
Non-profit	39.5%	39.7%	37.0%	34.5%
For-profit	33.6%	33.2%	35.1%	37.7%

[a] DxCG risk index is derived from patient's age and sex using commercial concurrent model (Zhao et al., 2005).

are only modest changes in patient characteristics, such as the DxCG risk score and the proportion of various illnesses. The largest change associated with the selection is the decline of patient-share admitted to non-profits, from 39.5% to 34.5%, and the increase of patient-share admitted to for-profits, from 33.6% to 37.7%.

4.3. Sample statistics

Table 4 displays health expenditure and treatment outcome of our sample by hospital ownership. Our measure of health expenditure includes the CPI-adjusted incurred NHI payment for the index hospitalization. To examine the impact over a longer horizon, we also include the total NHI payment (outpatient and inpatient) within a year following the index admission. Because NHI covers almost all related treatment for stroke and cardiac illnesses, the NHI-payment is a good measure of actual health expenditure. Likewise, our measure of treatment outcome is a patient's survival time, measured in terms of the probability of ending one's coverage within 1 month and 1 year after discharge, respectively.[23] As shown from the observation in the table, each type of ownership makes up almost one-third of the sample size, though the share of for-profits is a little bit higher. On average, the incurred expenditure for treating one stroke or cardiac patient is about NT60,000 (or $1800) for the index hospitalization, and NT95,000 (or $2700) for 1-year expenditure if admitted to government hospitals, roughly the same as that of non-profits, but much higher than those admitted to for-profits. Nonetheless, the difference in mortality across various ownerships is relatively small—less than 1% either measured by 1- or 12-month mortality.

One explanation for the large expenditure gap among various types of hospital ownerships is that their characteristics differ. To examine this possibility, the middle part of Table 4 presents a hospital's bed size, teaching status, and market

[23] Some studies (e.g. Sloan et al., 2001) use time after the index shock, i.e. time after admission, as the quality indicator. Our results are insensitive to various definitions of the quality indicator.

Table 4
Summary statistics by ownership status of admitted hospitals

	Public	Non-profit	For-profit
Expenditure and mortality			
One-month mortality	7.1%	7.9%	7.6%
One-year mortality	19.1%	19.6%	20.1%
Index admission expenditure[a]	60,845 (100,902)	63,863 (101,912)	30,913 (63,370)
One-year expenditure[a]	95,707 (164,719)	98,681 (157,512)	52,299 (113,463)
Hospital characteristics			
Teaching status			
Major teaching hospitals	37.8%	33.3%	0.0%
Minor teaching hospitals	32.4%	49.1%	19.6%
Community hospitals	29.8%	17.6%	80.4%
Bed number			
0–100	6.9%	4.5%	49.6%
100–300	31.9%	19.7%	32.2%
300–600	23.7%	38.1%	13.8%
Over 600	37.4%	37.7%	4.4%
Herfindahl index (per 10,000, 10 km)[b]	0.206 (0.152)	0.227 (0.147)	0.263 (0.179)
Demographic and pre-health status			
Male	70.5%	59.6%	53.4%
Age (40–60)	13.5%	21.0%	16.3%
Age (60–70)	24.6%	27.5%	26.1%
Age (70–80)	45.8%	35.4%	37.9%
Age (≥80)	16.1%	16.1%	19.6%
Acute myocardial infarction	5.9%	6.5%	4.0%
Congestive heart failure	16.6%	16.7%	18.2%
Ischemic heart disease	51.4%	41.2%	52.5%
Hemorrhage stroke	5.9%	9.1%	4.7%
Ischemic stroke	20.2%	26.4%	20.6%
DxCG risk score[c]	2.861 (0.671)	2.649 (0.752)	2.732 (0.686)
Charlson index[d]	0.958 (1.242)	0.926 (1.238)	0.984 (1.254)
Nearby elderly population (per 1,000,000, 10 km)	6.363 (5.809)	5.388 (5.487)	2.812 (3.294)
Average household income (per 10,000, county/town)[e]	108.933 (24.039)	105.002 (22.444)	98.223 (14.855)
N	71,766	89,084	97,230

Standard errors are in parentheses.
[a] Variables of expenditure are in NT dollars and deflated using CPI health component (2001 = 100).
[b] The Herfindahl index is calculated according to each hospital's admitted heart and stroke cases in every year.
[c] DxCG risk index is derived from patient's age and sex using commercial concurrent model (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).
[e] The household income is the average zip-code income of Taipei and Kaohsiung, and the average county income for the rest of Taiwan.

competition measured by Herfindahl–Hirschman Index (HHI, 10 km radius). Indeed, for-profit hospitals are quite distinct from others. To begin with, there were virtually no major teaching hospitals operated by for-profit organizations. In addition, for-profit hospitals in general have smaller numbers of beds, and operate in areas where markets are less competitive. By comparison, the difference between non-profit and government hospitals is relatively limited, though non-profits on average have larger bed capacity.

Another explanation is that patients admitted to for-profits are different from those in other hospitals. The bottom row of Table 4 shows mixed evidence of this. On the one hand, on average, patients admitted to for-profits reside in the least populated areas, with lower average household incomes. On the other hand, for-profit hospitals admit fewer severe patients (AMI or HS) than the other two types of hospitals. In addition, patient severity indicators, such as Charlson index, DxCG score, or age distribution, suggest for-profits may have a more favorable case-mix. The true impact of ownership therefore requires a multivariate analysis.

5. Estimation

5.1. OLS estimation

Consider patient i admitted at year t for stroke treatment. Let Dep_{it} be the dependent variable that is either an expenditure or a quality measure. Because the health expenditure is heavily right-skewed, the expenditure variable is replaced by the natural logarithm of charged payment in the estimation. Quality measures are binary variables indicating whether the patient died within 1 month and 1 year after discharge. Given the large sample size, we fit linear probability models rather than logit or probit when quality indicators are the dependent variables.[24]

Let Pub be public ownership, NFP be non-profit, and for-profit be the reference group. We consider the following OLS estimation:

$$\mathrm{Dep}_{it} = \alpha + \beta_0 H_{it} + \beta_1 Z_{it} + \beta_2 X_{it} + \gamma_p \,\mathrm{Pub}_{it} + \gamma_n \,\mathrm{NFP}_{it} + \mu_i + \nu_t + \varepsilon_{it}. \quad (1)$$

H_{it} is the vector of hospital characteristics, including dummies for a hospital's teaching status and size. Z_{it} is a vector of measures of market condition, including the total population (10 km radius), HHI index (10 km radius), and average household income (county/town). X_{it} is a set of patient demographics and severity measures, including age and sex, as well as two measures of patient risk prior to admission. DxCG risk score is a risk index based on patient age and gender to account for patient risk at the time of admission (Zhao et al., 2005). Charlson index is a risk index ranging between 0 and 6 indicating a patient's comorbidity conditions (Goldstein et al., 2004). The county (μ_i) and year dummies (ν_t) are also included to control for regional fixed effects and time trends. Finally, the estimation allows the clustering corrections of error (ε_{it}) to account for correlated observations within hospitals and years.

5.2. Instrumental variable method

If unmeasured variables affecting outcomes are correlated with ownership status (e.g. patient severity), results of OLS estimation are likely to be biased. To ensure consistent estimates of ownership status variables, we re-estimate (1) employing IV estimation using two sets of distance variables. The first set of instrumental variables includes the nearest distances to NFP and public hospitals and their squared terms; the second set includes distance differentials – the difference in the distances to the nearest NFP or public hospital and the distance to the nearest hospital – and their squared terms; both sets of distance instruments have been used extensively in various articles (i.e. McClellan et al., 1994; McClellan and Newhouse, 1997; Sloan et al., 2001).[25] All other things equal, patients generally prefer closer hospitals. Therefore, conditional on the locations of patients and hospitals, the distance measure is plausibly uncorrelated with unobserved individual characteristics, particularly a patient's severity upon admission. Given that both sets of distance variables are valid instruments, both are employed to ensure our results are not sensitive to a specific set of instruments.

One issue arising in employing IV estimation is how to characterize the effect of distance instruments on the probabilities of patients admitted to hospitals of various ownership types. Because patients are free to choose among non-profits, for-profits or public hospitals, it seems unreasonable to assume that distance variables affect the ownership probabilities linearly and independently; such an approach obviously violates the fact that ownership categories are mutually exclusive. Therefore, instead of adopting the conventional GMM method, in the first stage we estimate the hospital ownership variable using a multinomial logit model. Then we employ predicted probabilities from the MNL as instruments. In this way, we also avoid the problem of inconsistent standard errors when applying two-stage least squares. Below, we also perform Durbin–Wu–Hausman endogeneity test.

5.3. IV estimation on PSM sample

As stated earlier, hospitals of different ownership status differ substantially. To test the robustness of our results, we carried out the IV estimation using a sample where for-profits are matched with non-profits using a PSM method. Pairing treatment and control units that have similar observable attributes eliminate potential bias from a misspecified functional form. IV estimation can then remove the bias due to unobservable characteristics.

To reduce the difficulties of matching based on high dimensionality of the observable characteristics, we first estimate the propensity score using the logit model that a patient chooses between non-profit and for-profit as a function of the pre-treatment characteristics (Imbens, 2000).[26,27] The model is then used to predict the propensity (probability) of entering the hospital. Then we match each observation from a non-profit hospital (the treatment group) with an observation from a for-profit hospital (the control group) with replacement based on the nearest propensity scores. IV estimation is performed on this matched sample.

[24] Probit or logit models yield very similar results to the OLS estimations.

[25] McClellan et al. (1994) and McClellan and Newhouse (1997) find that distance to a hospital with the capacity to provide intensive cardiac treatment is an important predictor of whether a heart attack victim is treated in such a hospital. Sloan et al. (2001) use state hospital ownership market shares as proxies for the differential distances to different types of hospitals for the patients. McClellan et al. (1994) and McClellan and Newhouse (1997) use the differential distance to reach a hospital with the given characteristics (e.g. catheterization hospital) beyond the distance to the nearest hospital which is similar to our second set of instrumental variables. Ettner and Hermann (2001) use the distances to the nearest NFP hospitals, which are similar to our first set of instrumental variables, to predict the profit status of the treating hospital.

[26] The instrumental variables are not included in the estimation. Results are available upon request.

[27] Rosenbaum and Rubin (1983) show that matching on the basis of multidimensional vector of pre-treatment characteristics X is equivalent to matching based on the propensity score p(X). The propensity score gives the conditional probability of receiving a treatment given pre-treatment characteristics X. Thus, conditional on p(X), the assignment to the treatment and control groups is random (assumption of ignorability) and matching methods will yield an unbiased estimate of the treatment effect on the treated.

Table 5
Basic regression results[a]

Dependent variables	Payment		Mortality	
	Admission	1 year	1 month	1 year
Ownership				
Non-profit	0.013 (0.027)	0.023 (0.026)	−0.010*** (0.002)	−0.010*** (0.003)
Public	0.084*** (0.025)	0.070*** (0.025)	−0.008*** (0.002)	−0.010*** (0.004)
Hospital characteristics				
Teaching hospital	0.263*** (0.034)	0.272*** (0.033)	−0.003 (0.003)	0.002 (0.005)
Bed number (100–300)	0.342*** (0.020)	0.357*** (0.021)	0.013*** (0.003)	0.015*** (0.004)
Bed number (300–600)	0.649*** (0.038)	0.643*** (0.036)	0.017*** (0.004)	0.014** (0.006)
Bed number (over 600)	0.975*** (0.041)	0.943*** (0.040)	0.014*** (0.004)	0.013** (0.007)
Patient's pre-health status				
Male	0.020*** (0.005)	0.025*** (0.006)	−0.001 (0.001)	0.016*** (0.002)
Age (60–70)	0.047*** (0.009)	0.057*** (0.009)	0.005** (0.002)	0.019*** (0.003)
Age (70–80)	0.092*** (0.011)	0.049*** (0.012)	0.024*** (0.003)	0.077*** (0.004)
Age (≥80)	0.191*** (0.014)	−0.011 (0.013)	0.087*** (0.003)	0.236*** (0.005)
DxCG risk score	−0.007 (0.006)	0.036*** (0.006)	0.003* (0.001)	0.010*** (0.002)
Charlson index	0.086*** (0.002)	0.081*** (0.002)	0.021*** (0.001)	0.064*** (0.001)
Herfindahl index (per 10,000, 10 km)	−0.102* (0.054)	−0.112** (0.050)	−0.009* (0.005)	0.003 (0.009)
Total population (per 1,000,000, 10 km)	0.000 (0.002)	0.002 (0.002)	0.000 (0.000)	0.000 (0.000)
Average household income (county/town)	−0.001** (0.001)	−0.001* (0.001)	0.000 (0.000)	0.000 (0.000)
N	258,080	258,080	258,080	258,080

Standard errors are in parentheses. Intercepts are not shown. Huber or robust standard errors on which they are based allow for hospital/year clustering.
[a] Regressors also include 21 county dummies as well as year dummies (Pingtung, Taitung, and Hualien share the same dummy due to small inpatient cases in these three counties).
* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.

For comparison purposes, we also used kernel matching estimation. Kernel matching is a nonparametric matching estimator that uses the weighted average of all individuals in the control group to construct the counterfactual outcome. Comparing with other matching methods, such as the nearest neighborhood matching, because more information is used, the kernel matching method will yield a smaller variance. A drawback is that some poor matches will be used. Hence, we have to impose the common support condition for a kernel matching estimation. The kernel matching estimator is given by

$$\tau^k = \frac{1}{N^{\mathrm{T}}} \sum_{i \in \mathrm{T}} \left[Y_i^{\mathrm{T}} - \frac{\sum_{j \in \mathrm{C}} Y_j^{\mathrm{C}} G((p_j - p_i)/h_n)}{\sum_{k \in \mathrm{C}} G((p_k - p_i)/h_n)} \right]$$

where $G(.)$ is a kernel function, T and C indicate treatment and control, and h_n is a bandwidth parameter. In kernel matching, all treated, as well as all controls units, will be used (Becker and Ichino, 2002).

6. Empirical results

6.1. OLS regression results

After controlling for patient and hospital characteristics, as well as year and city/county fixed effects, non-profits on average experienced better outcomes: the mortality rates at 1 month and at 1 year after discharge were 1 percentage point lower than for-profits (see Table 5).[28] To our surprise, patients admitted to non-profits did not incur higher medical expenditures than others. On the other hand, public hospitals incurred higher health care expenditures than for-profits (about 7–8%), but experienced significantly lower mortality rates. The OLS results may be subject to bias due to the endogeneity of ownership status. Below, we examine this more closely using IV and the propensity score matched sample. Also, we will concentrate on the comparison between FP and NFP hereafter; thus, we only report the coefficients of NFP in the following analyses.

[28] There are 24 counties/cities on the main island of Taiwan. However, not all counties have hospitals of three different ownership types. As a result, we combine three small counties (Pingtung, Taitung, and Hualien) into one and include 21 county/city dummies in the estimation.

Table 6
Results of instrumental variable estimation[a]

	Payment		Mortality	
	Admission	1 year	1 month	1 year
IV (distances)/MNL[b]				
Non-profit	−0.074 (0.056)	0.000 (0.051)	−0.022*** (0.008)	−0.031*** (0.012)
Durbin–Wu–Hausman endogeneity test, $\chi^2_{(2)}$	32.147	34.768	6.312	7.990
Reject the null?	Yes***	Yes***	Yes**	Yes**
IV (distance differentials)/MNL[b]				
Non-profit	−0.065 (0.056)	−0.003 (0.051)	−0.021*** (0.007)	−0.025** (0.011)
Durbin–Wu–Hausman endogeneity test, $\chi^2_{(2)}$	19.159	22.679	6.841	6.948
Reject the null?	Yes***	Yes***	Yes**	Yes**
N	258,080	258,080	258,080	258,080

Huber or robust standard errors on which they are based allow for hospital/year clustering. Standard errors are in parentheses.
[a] Partial results are reported. We control for all explanatory variables listed in Table 4 and its footnote.
[b] Regressors include variables used in OLS estimation, 21 county dummies, year dummies as well as diseases dummies.
** Significant at 5% level.
*** Significant at 1% level.

We briefly discuss other variables of interest. In line with our expectation, elderly male patients with higher DxCG risk scores and Charlson index (the higher the score or index, the sicker the patient) incurred higher expenditures and experienced worse outcomes. Teaching and larger hospitals had higher expenditures. Hospitals located in more competitive areas incurred higher expenditures, but there were no clear mortality rate effects.

6.2. Instrumental variables method

Before discussing results of IV estimation, it is important to first ensure our instruments meet two important criteria: the exclusion restriction and monotonicity assumption (Angrist et al., 1996). Partial results of the first-stage regression of IV/MNL in Appendix B shed some light on the quality of our instruments. In either distances or distance differentials, we include the distances to nearest NFP and public hospitals and their squared terms.

All the instrumental variables have statistically significant impacts on the choice of ownership type. We test the monotonicity assumption nonparametrically by creating five mutually exclusive and roughly equal distance dummy variables to the nearest public hospitals and five distance dummies to the nearest non-profit hospitals in the multinomial logit estimation.[29] Monotonicity is valid in our estimates—increasing the distance to the nearest hospital or increasing each of the distance differentials to the nearest hospital results in a more negative marginal effect on the probability of being admitted to that type of hospital. In other words, people treated in a non-profit hospital lived closer to non-profit hospitals, while those treated in a public hospital lived closer to public ones. The exclusion restriction might fail if some beneficiaries move closer to the treated hospitals since distance variables now affect expenditures and health outcomes through channels other than ownership variables. We mitigate this concern by limiting the sample to new cardiac and stroke admissions.

Table 6 presents the results of IV estimation using two different sets of distance instruments. Our purpose is to examine if there is a correlation between unobserved characteristics and ownership status. Indeed, the IV/MNL results reported in the table indicate the ownership variables are endogenous—all the Durbin–Wu–Hausman tests strongly reject the null, regardless of dependent variables and set of instrumental variables. The table does not include a test of over-identification because the IV estimation is exactly identified. This is because the predicted probabilities of ownership status, not distance variables, are used as instruments.

Accounting for endogeneity, IV/MNL yields results slightly different from those found in OLS. The difference is primarily on the treatment quality, not program expenditure. Nonetheless, estimates employing either nearest distance or distance differential instruments are quite similar. In terms of treatment quality, the probability of death in 1 month for patients of FP hospitals versus the probability for patients of NFP hospitals is roughly twice the OLS estimates regardless of the instrumental variables used. The difference is even larger when employing a 1-year mortality rate; the reduction is approximately 1.5 percentage points for the average patient or three times larger than the OLS estimate.

One likely explanation for larger IV estimates is that they reflect the marginal rate of return of the group affected by the instruments, as opposed to the average effect. Because different individuals may face different treatment returns due to unobserved characteristics, the marginal rate of return for those who were admitted to closer hospitals may be larger than

[29] Specifically, we use distance dummies: 0–4 km, 5–10 km, 11–15 km, 16–20 km, 21 km and above, with 0–4 km as the reference group. Results are available from the authors upon requests.

Table 7
Results of propensity score matching and IV estimation

	Payment		Mortality	
	Admission	1 year	1 month	1 year
PSM/Kernel[a]				
Non-profit	0.131*** (0.029)	0.146*** (0.009)	−0.025*** (0.008)	−0.034*** (0.011)
N	173,642	173,642	173,642	173,642
PSM/one-to one matching + IV (distance)/GMM[a,b]				
Non-profit	0.006 (0.055)	0.115** (0.056)	−0.025*** (0.009)	−0.049*** (0.014)
Durbin–Wu–Hausman endogeneity test, $\chi^2_{(2)}$	0.003	11.960	4.785	15.508
Reject the null?	No	Yes***	Yes**	Yes***
Over-identification test	9.781	5.905	3.937	4.490
Reject the null?	No	No	No	No
N[c]	165,566	165,566	165,566	165,566

Standard errors are in parentheses. Intercepts are not shown. Huber or robust standard errors on which they are based allow for hospital/year clustering.
[a] PSM estimation includes all variables used in the basic regression except for ownership variables. Notice that distance variables are excluded. In addition to common supports, the one-to-one matching allows selecting the control group with replacement.
[b] IV estimation includes all variables used in the basic regression except for ownership variables.
[c] The number includes only the "matched" observations of non-profit and for-profit hospitals.
** Significant at 5% level.
*** Significant at 1% level.

the average population (Imbens and Angrist, 1994; Angrist et al., 1996). This is particularly likely for heart and stroke patients since timely treatment could extend a patient's life by a matter of years.[30,31]

6.3. IV estimation on PSM sample

To confirm our findings, we first show the results from the kernel matching estimation.[32] As seen from Table 7, kernel matching yields similar mortality results to those of the OLS and IV estimation: non-profit hospitals had significantly higher survival rates, both in terms of 1-month or 1-year mortality. The magnitudes of the coefficients are in line with those of the IV estimation. However, unlike the OLS and IV estimations, the incurred expenditures are higher at non-profit hospitals under the kernel matching estimation. On average, patients treated at non-profits incur health expenditures about 13% higher for the index admission, and 15% higher for 1-year expenditure.

The second row of Table 7 displays the results of IV estimation (with the nearest distances as instruments) based on the matched sample. Given the matched sample includes those admitted only to for-profits and non-profits, both a Durbin–Wu–Hausman test and an over-identification test are performed and displayed at the end of the table.[33] Except for the expenditure at admission, the χ^2 values of endogeneity test show that non-profit status is likely to be endogenously determined.

It is evident from the table that the non-profit hospitals continue to have lower mortality even using a matched sample. On average, patients admitted to non-profits have lower 1-month mortality, with the size roughly the same as those obtained from an unmatched sample. The difference between the matched and unmatched samples is greater in regard to 1-year mortality. As for health expenditures, we observe higher expenditures for NFP hospitals in the coefficient of 1-year expenditures, but not on the hospital admission.[34]

[30] For example, the biggest hurdle to the use of intravenous recombinant tissue plasminogen activator (rtPA) for treatment of patients with acute ischemic stroke is time; the narrow window of opportunity is within 3 h after stroke (Mitka, 2003).
[31] Ettner and Hermann (2001) use the same set of IVs as we did in this paper, but found IV estimates similar to OLS results. Nevertheless, they focus on psychiatric patients who are unlikely to benefit substantially from immediate medical treatment due to closer hospitals; that is, the marginal return of the group affected by instruments is possibly similar to the average return of the population.
[32] PSM results based on local linear regression method have also been conducted; their estimates are similar to what we have found in kernel estimation.
[33] To pass the over-identification test, we dropped distance squared terms as the instrumental variables in estimating the expenditure at admission. To further confirm our results that the non-profit status is not endogenous in the expenditure at admission, we also employed eight distance dummies that used to test the monotonicity as instrumental variables. We were able to pass the over-identification test, and the Durbin–Wu–Hausman test still suggested no endogeneity of non-profit status.
[34] Results using eight distance dummies on the matched sample indicate that no significant differences in health expenditure between non-profits and for-profits either at the admission or within 1 year, but differences in 1-month and 1-year mortality between ownership continues to exist.

Table 8
Robustness checks for PSM + IV estimation[a,b]

Dependent variables	Payment		Mortality		N^c
	Admission	1 year	1 month	1 year	
Flexible Charlson index dummies					
Non-profit	0.008 (0.057)	0.101* (0.056)	−0.022** (0.009)	−0.042*** (0.014)	165,566
Drop major teaching hospitals					
Non-profit	−0.061 (0.053)	0.021 (0.050)	−0.024*** (0.009)	−0.045*** (0.013)	114,796
Patients with heart diseases					
Non-profit	−0.066 (0.060)	0.006 (0.059)	−0.024*** (0.009)	−0.044*** (0.014)	106,533
Patients with strokes diseases					
Non-profit	0.083 (0.069)	0.154*** (0.054)	−0.026* (0.015)	−0.054** (0.022)	52,769

Standard errors are in parentheses. Intercepts not shown. Huber or robust standard errors on which they are based allow for hospital/year clustering.
[a] PSM estimation includes all variables used in the basic regression except for ownership variables. In addition to common supports, the one-to-one matching allows selecting the control group with replacement.
[b] IV estimation includes all variables used in the basic regression except for ownership variables.
[c] The number includes only the observations of non-profit and for-profit hospitals.
* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.

6.4. Robustness check

Aside from performing IV estimation on a matched sample, we conducted four other checks to examine the sensitivity of our results to different specifications or samples. For the purpose of comparison, results reported in Table 8 are obtained in the same fashion as IV estimation in Table 7. We first allow a flexible setting for the Charlson index in the estimation, because Charlson indices may impact the heart and stroke diseases differently. Thus, the estimation includes a set of disease dummies contained in the Charlson index so that the risk value could vary by each disease.[35]

Next, we excluded patients admitted to major teaching hospitals from the sample because virtually no major teaching hospitals exist among for-profit hospitals. Given that teaching hospitals have special missions of teaching and research, it is possible that our results are driven by the difference in their teaching status. In the second row of Table 8, we test if our results hold with respect to the exclusion of major teaching hospitals.

Lastly, we carried out the analyses separately for heart and stroke patients to examine whether our findings are specific to patients of a certain disease. From the results of Table 8 it is clear that allowing flexible Charlson indices does not have much impact on our results, though the significance level of non-profit status coefficient drops to 10% for 1-year expenditures. Likewise, results excluding patients admitted to major teaching hospitals are consistent with our previous findings on treatment quality. Ultimately, however, the effect on 1-year expenditures becomes insignificant. As for the individual effect on cardiac and stroke patients, NFPs still provide better quality of care in terms of lower mortality rates. However, higher 1-year expenditures for NFP hospitals appear to be concentrated among stroke patients. Because patients suffering from strokes generally need to spend substantial time and efforts to restore their functional abilities, our results may suggest that NFP hospitals better support patients with the provision of follow-up outpatient rehabilitation.

7. Conclusion

In this study we examined the impact of ownership status on program expenditure and treatment quality of stroke and heart disease treatments in Taiwan, the most recent country to adopt universal health insurance. After adjusting for endogeneity of hospital ownership, we find that patients treated at non-profit hospitals received better quality of care in terms of survival rates than patients admitted to for-profits. This finding is robust to various estimation methods and model specifications. On average, the 1- and 12-month mortality rates for non-profits are 2–3 percentage points lower than for-profits. Our findings on medical expenditure are less robust. In OLS and IV estimations, we find no differences in medical expenditure between non-profits and for-profits. Nonetheless, we find higher expenditures incurred at non-profit hospitals within 1 year when using IV on the propensity score matched sample. This result is largely coming from more expensive treatment on stroke patients.

Given our findings, one interesting question that emerges is whether the results are able to test the plausibility of altruism, noncontractible quality, and the physician cooperative model. Both altruism and noncontractible quality models yield virtually identical predictions that NFP hospitals provide better quality of care. While the altruism model predicts no differences in expenditures across ownership form, the noncontractible quality model predicts that NFPs incur higher expenditure in

[35] The estimation includes 13 disease dummies in all, such as type 1 and 2 diabetes, hypertension, cancer, end-stage renal disease, etc.

Table B1
First-stage multinomial logit results (IV: distance)[a]

	Mean (S.D.)	Public vs. for-profits	Non-profit vs. for-profits
Distance to the nearest government hospital	5.835 (6.173)	−0.069*** (0.003)	−0.075*** (0.003)
Distance to the nearest non-profit hospital	6.030 (6.482)	−0.101*** (0.004)	−0.040*** (0.003)
Product of the above two distances terms		0.000 (0.000)	−0.005*** (0.000)
Distance to the nearest government hospital (squared)		−0.003*** (0.000)	0.004*** (0.000)
Distance to the nearest non-profit hospital (squared)		0.003*** (0.000)	−0.001*** (0.000)
Log-likelihood		−183,586.7	
N		258,080	

Standard errors are in parentheses. Intercepts not shown.
[a] Partial results are reported. We control for all explanatory variables listed in the basic regression.
*** Significant at 1% level.

Table B2
First-stage multinomial logit results (IV: distance differentials)[a]

	Mean (S.D.)	Public vs. for-profits	Non-profit vs. for-profits
Distance differential to the nearest government hospital	4.240 (5.452)	−0.130*** (0.004)	−0.056*** (0.003)
Distance differential to the nearest non-profit hospital	4.437 (5.740)	−0.016*** (0.004)	−0.066*** (0.004)
Product of the above two distance differentials terms		−0.005*** (0.000)	−0.004*** (0.000)
Distance differential to the nearest government hospital (squared)		0.001*** (0.000)	0.005*** (0.000)
Distance differential to the nearest non-profit hospital (squared)		0.001*** (0.000)	−0.003*** (0.000)
Log-likelihood		−183,321.34	
N		258,080	

Standard errors are in parentheses. Intercepts not shown.
[a] Partial results are reported. We control for all explanatory variables listed in the basic regression.
*** Significant at 1% level.

order to provide better quality of care (Malani et al., 2003). Consistent with predictions of altruism and noncontractible quality models, our results find patients admitted to NFP hospitals indeed receive better quality of care. However, due to the mixed results on expenditures from different estimation methods or different model specifications, we are less confident about distinguishing these two models.

It is even more difficult to say that our results support predictions of a physician cooperative model. It is true that NFP hospitals in Taiwan have several elements consistent with the physician cooperative model described by Pauly and Redisch (1973). For instance, most physicians in NFP hospitals in Taiwan are employed by hospitals and receive salaries and bonuses directly from their employers.[36] Also, the law requires that over a certain percentage of the board members should be licensed physicians. Therefore, physicians in NFP hospitals might have incentives to cooperate with other staff members to maximize their net incomes. However, in Taiwan the majority of physicians working in FP hospitals also are paid on the basis of salaries and bonuses. Attributing the differences between NFP and FP hospitals simply to cooperative behaviors of NFP physicians is thus inappropriate. More importantly, according to Malani et al. (2003), testing the physician cooperative model demands many more outcome variables (e.g. output per physician) than are available in our study.

The past decade has witnessed the growth of empirical interest in comparing differences between NFP and FP health care providers. However, there is still a pressing need to fill the void in the literature by discussing the impact of hospital ownership in countries other than the United States. On one hand, the research on other countries could be used to test the robustness of the economic theory of organizations with different ownership status. On the other hand, the results of this extensive U.S. research may not apply to other healthcare systems which have different financial schemes and different organizational structures. We have presented evidence showing the impact of hospital ownership on treatment expenditure and health outcome using Taiwan data. Nonetheless, given every country have some unique features in its health system, we caution readers hoping to generalize our results to account for differences in health systems.

Appendix A

The patient eligibility file preserves several key pieces of enrollment information: demographics (sex and age), type of enrollment, salary, residence zip-code, as well as ID of the enrollee and his/her support, i.e. the one who pays the insurance premium.[37] If an enrollee obtains his coverage from the registry office at or near his residence zip-code, then the zip-code of enrollment can be used as the proxy for patient's residence. However, there are two practical problems to directly employ

[36] In order to effectively motivate physicians to provide appropriate medical services, there are usually two elements to their salaries: the normal contracted annual salary and an additional bonus based on the level of services provided (e.g. the number of patients treated, the severity of cases, and so on).
[37] For instance, if a father pays the premium of the whole family, he will be the supporter for every family member.

such information. First, except for demographics, the eligibility file records enrollment information of the supporter, not that of the enrollee. Hence, the zip-code information is inappropriate for those who do not co-reside with supporters. Second, for some types of enrollment, the insurance regulations do not require enrollees to obtain coverage through local offices; the zip-code of enrollment for these types may be very different from their actual residence.

We take three steps to ensure the residence information. First, we select enrollees whose premiums are self or spouse paid only, excluding the ones covered by third parties not necessarily living together (e.g. children or relatives). Second, we choose three types of enrollment whose zip-codes of enrollment are identical to those of household registries or working places. Specifically, enrollees obtain coverage through office of household registry or farmer associations or private employers.[38] To ensure these enrollees actually reside in the zip-code of household registries, we further restrict the study to patients whose traveling distance from residence to admitted hospitals is less than 25 km[39]; patients with distant traveling distances are thus eliminated.

Appendix B

See Tables B1 and B2.

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[38] Enrollees obtaining coverage from farmers' associations or household registry offices are required to apply enrollment through local offices; their zip-code of enrollment in general is identical to that of residence. Enrollees obtaining coverage from private employers by large have the zip-code of enrollment identical to that of working places.

[39] According to Shih et al. (2004), there are approximately 17% of households do not live at their registered addresses.

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