An Investigation of Economic Efficiency in California Hospitals

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ABSTRACT: This paper investigates variations in hospital behaviors and performance outcomes due to ownership type. Conventional economic theory predicts economic efficiency benefits from for-profit control type; however, a broad review of hospital performance literature provides empirical evidence that primarily favors nonprofit hospitals. This paper extends a theoretical model of nonprofit hospitals and develops hypotheses that predict nonprofit hospitals perform better in terms of price, cost, and service volume when compared to for-profit hospitals. Specifically, private nonprofit hospitals provide the highest volume of patient services, whereas public hospitals offer the lowest average price for a comparable service among all hospitals. Examination of a short-term, general acute care hospital sample from the state of California generally supports such conjecture. Managerial implications are also discussed.

Keywords: ownership type; performance; nonprofit; hospitals.

INTRODUCTION

There is an increasing interest in literature on the subject of relative performance of for-profit (FP) and nonprofit (NP) hospitals.¹ In theory, for-profit firms are more cost efficient and productive than nonprofit firms because of their profit-maximizing objective and market-generated incentives (Cutler and Horwitz 2000). However, existing studies in healthcare offer mixed or contradictory empirical evidence (Rosenau 2003; Schlesinger and Gray 2006; Shen, Eggleston, Lau, and Schmid 2007). So far few studies have offered a theoretical explanation for such phenomenon (Newhouse 1970; Dranove and Satterthwaite 2000; Gaynor and Vogt 2003).

¹ NP hospitals include both private nonprofit and public hospitals.
Harrison and Lybecker 2005; Chang 2014). Chang's (2014) analytic model proposes that NP hospitals can be more economically efficient than FP hospitals in a monopolistic competitive environment with differential patients’ preferences, contrary to the conventional wisdom. Specifically, she suggests that NP hospitals would incur lower costs while providing more patient services at a lower price than that of FP hospitals, thus increasing economic welfare and exploiting economies of scale.

This study extends Chang’s (2014) theoretical framework in that it explicitly discusses the behavioral differences between private nonprofit and public hospitals derived from similar but subtle differences in their missions and objectives. In this study, we compare FP hospitals to two types of NP hospitals, private nonprofit and public hospitals, in terms of price, cost, and service volume performance. It develops the hypotheses that predict private nonprofit hospitals would provide the highest volume of patient services and public hospitals would offer the lowest average price for a comparable service among all hospitals. Using a sample from short-term, general acute care hospitals in the state of California during a period of 2005–2014, we find strong empirical support for these predictions after controlling for hospital operating characteristics and market environment. Therefore, this study resolves the inconsistency between conventional wisdom and empirical evidence that is often present in the literature by providing theoretical reasoning and empirical evidence of efficiency benefits from NP hospitals relative to FP hospitals.

This study has important practical implications and therefore will be of interest to academia, hospital administrators, and healthcare policymakers. Historically, the healthcare industry has experienced drastic structural and operational changes following every major healthcare reform because it is heavily regulated through government sponsored programs such as Medicare and Medicaid. For example, the Prospective Payment Act of 1983, which changed the hospital reimbursement scheme for Medicare patients from cost-plus to fixed-fee based, created tremendous cost pressures on healthcare providers, which in turn triggered many hospitals to reorganize their governance structure including ownership conversion due to financial distress and increased competition in the hospital market (Burns, Shah, and Sloan 2001). The 2010 Affordable Care Act (ACA), or Obamacare, also included a provision for a “pay-for-performance” scheme that increasingly underscores the demand for hospitals to reduce costs while improving quality. The Trump administration’s ongoing efforts to repeal Obamacare cast a shadow over healthcare

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2 The Medicare Prospective Payment System (PPS) changed the hospital reimbursement scheme from cost-plus to fixed-fee based on the diagnosis-related group (DRG) for Medicare inpatient service. The purpose of PPS was to encourage operating efficiency and market competition, and ultimately curb a rapidly increasing trend in public healthcare spending. The Balanced Budget Act (BBA) of 1997 eliminated the cost-reimbursement portion that remained in the program for post-acute, long-term hospital services and for hospital outpatient departments. Private insurers soon followed and negotiated discounted fee-for-service or capitated payments under health maintenance organizations.

3 The ACA relies on a number of pay-for-performance (P4P) schemes, which offer financial incentives to healthcare providers (physician, medical groups, hospitals, etc.) that achieve specified goals in terms of quality and efficiency. Such incentives are paid on top of the traditional fee-for-service or capitated payments if the provider meets or exceeds certain performance matrices. For example, the value-based purchasing program offers financial incentives to hospitals for improving the quality of care (starting October 2012) and physician payments will be tied to the quality of care they provide (starting January 2015). Additionally, P4P programs often withhold a percentage of traditional payments for failure to reach quality and cost benchmarks. Therefore, the goal of P4P incentives is to reduce the cost and improve the healthcare quality delivered to individuals who are covered by both public and private insurers. The limitation of our data prohibits empirically testing this effect on performance. However, we control the year fixed effect for 2010–2014 in the model to partially account for any possible effect arising from the ACA implementation in the state of California.
reform, which in turn heightens the need for healthcare research that is consistent between theory and empirical evidence.

The following section describes the economics model and develops the hypotheses. The third section discusses the methodology for empirical testing. The fourth section presents the results and discussion. The fifth section concludes with limitations and future research directions.

**HYPOTHESES DEVELOPMENT**

**Background**

The conventional wisdom grounded in owners’ own interests, incentive compatibility, and property rights theory predicts a higher level of efficiency from for-profit firms in comparison to other control types. In principle, the specification of individual rights within the contract determines how costs and rewards will be allocated among participants, which in turn affects economic behavior and firm performance. Proponents of for-profit hospitals argued that incentive incompatibility implied in the NP form was “a major reason why hospital costs are increasing at their present rate” (Baird 1971, 57). Clarkson (1972) suggested that NP hospital managers were less efficient in utilizing market information and performing tasks when compared to for-profit hospital managers.

However, an extensive body of empirical studies on relative hospital performance presented contradictory and mixed results. For example, Rosenau (2003) reviewed 149 empirical, peer-reviewed journal articles from 1980–2002 and found that about 60 percent of studies reported NP hospitals performed better than FP hospitals in all performance categories including profit, cost, access, and quality. Shen et al. (2007) conducted a meta-analysis of 40 studies on hospital cost, revenue, profit margin, and efficiency performance and concluded that the extent of variations in ownership’s effect on hospital financial performance may be partially explained by the research focus and methodology. The empirical evidence that is generally in favor of NP hospitals may be one of the reasons why today U.S. healthcare services are dominantly supplied by nonprofit institutions in this competitive hospital market (American Hospital Association [AHA] 2017).

Theoretically, Arrow (1963) and Weisbrod (1975) argued that the asymmetric information between consumers and producers in certain circumstances made it necessary to use the nonprofit control type to correct the problem of market failure. Healthcare is clearly one of these circumstances—physicians or hospitals always have more information than patients at the point of service, and patients are usually incapable of selecting the best value service and evaluating the proposed course of treatment because they have neither sufficient information for the product/service, nor sufficient time to compare various providers on the market in the case of emergency. In such a case of an “incomplete” contract, given the right incentives, FP hospital managers would have stronger incentive than their NP counterparts to exploit the situation in order to maximize profits.

Nonprofit firms have multiple objectives in addition to keeping themselves financially profitable, such as maximizing the quality or quantity of services. Hansmann (1980, 1987) identified the principle of non-distribution of residual earnings as the key characteristic of NP firms that influenced organizational behaviors with respect to goals and efficiency. The absence of property rights to residual earnings for NP firms would reduce the incentive for their managers to

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4 Based on a 2015 AHA annual survey, about 78 percent of U.S. community hospitals are operating as not-for-profit and state or local government hospitals, while 22 percent are operating as for-profit hospitals.
engage in the opportunistic behaviors that are frequently present in FP firms. Others claimed that the key difference between FP and NP firms is that individuals make a conscious decision to work in each type of firm. The altruistic nature of NP managers behaves differently from FP managers when facing the same decisions in a similar market environment. For example, NP managers would have a bias toward allocating resources to expand services, including charity care, at a higher quality level (Lakdawalla and Philipson 1998). Finally, public firms are not self-sustaining as other nonprofits and must rely on tax revenue and government subsidies to fund their basic operations.

In the U.S. healthcare industry, NP hospitals are divided into two categories, private nonprofit and public hospitals. One would expect that public hospital managers might have a stronger sense of mission to maximize the social well-being of the community they serve than those in private nonprofit hospitals. Similar but subtle differences in the mission statements and financial support from distinctly different sources would ultimately result in different market outcomes for private nonprofit and public hospitals.

### Economic Model

The model is based on the theoretical framework developed in Chang (2014), but with significant refinement. It expands the discussion on NP hospital behavior—in particular, the difference between private nonprofit and public hospitals. Below we describe the model and offer economic insights. The mathematical model is provided in Appendix B. Based on the model implications, we propose the hypotheses for empirical testing.

The U.S. hospital market is generally characterized as monopolistic competition such that hospitals set prices by differentiating their services based on multiple dimensions such as location, services, quality, and technology (Dranove and Satterthwaite 2000; Gaynor and Vogt 2003). Therefore, the model assumes that (1) hospitals provide similar but differentiable services so that an individual hospital faces a downward sloping demand curve; (2) technology is equally available for all hospitals in the market so a hospital faces the same cost function as others (regardless of control type) in the market; and (3) the market has free entry and exit.

On the demand side, patients differ in their insurance coverages and income levels. They have differential price elasticities of demand and reservation price. Intuitively, patients with better insurance coverage or higher income can afford more expensive treatment options and therefore are less price elastic. Patients from middle-income families with inadequate health insurance coverage or insurance with high out-of-pocket expenses are more price elastic. Others like low-income patients may not purchase any health insurance at all; they have to go to a public hospital.

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5 The principle of non-distribution, a provision contained in the chart of nonprofit organizations, specifically states that benefits and profits may not inure to the benefit of any private shareholder or individual (U.S. IRC Sec. 501c(3)).

6 Appendix B provides related mathematical equations and proofs that are relevant to the model discussed here. Please reference Chang (2014) for a more comprehensive theoretical development of the model and its variations.

7 U.S. hospitals are subjected to regulatory pricing as well as private insurance pricing that is a multiple of regulatory pricing, and the bargaining power of hospitals in setting prices for various service offerings is rather limited compared to other industries. In other words, the institutional payors have exerted greater influence on hospital pricing decisions. Nevertheless, hospitals and/or hospital networks have some latitude in negotiating price with government agencies, healthcare management organizations, and private insurers. In addition, hospitals generate revenues from multiple payors including the government, insurance companies, and individual patients.
to seek treatment in case of medical emergency and rely on hospital write-offs to reduce their payments or to cover the cost.

On the supply side, hospitals vary in their objectives and missions across control types. Whereas FP hospitals are assumed to maximize profits, NP hospitals are assumed to maximize output subject to financial sustainability given their multiple objectives. In addition, there are noticeable differences in priorities specified in the mission statement for private nonprofit and public hospitals.

**FP Hospitals**

The behavior and performance outcome of an FP hospital are standard. The objective of an FP hospital is to maximize profit:

$$\max_{q_{FP}} \pi_{FP} = \rho_{FP}(q_{FP})q_{FP} - c(q_{FP})$$

where $\pi_{FP}$, $\rho_{FP}(q_{FP})$, and $q_{FP}$ denote the profit, the price charged, and the quantity provided by an FP hospital, respectively. $c(q_{FP})$ is its cost function.

To maximize profit, FP hospitals tend to establish their operations in more affluent neighborhoods and target patients with higher income and better insurance coverage (Horwitz 2005). Their patients have a higher reservation price and are more price insensitive. Let the demand function of a patient in this group be $p = f(q)$, and $f' < 0$. Reservation price, the intercept of the demand curve with the vertical axis (i.e., $f(0)$), measures the patient’s affordability and is the maximum price he or she can pay for the service. Let the number of price-insensitive patients be $n$. The aggregate demand for medical care in this market equals $nq$. The number of FP hospitals in the market is $m$, each hospital is assumed to be identical with equal share of the market. Then, the quantity demanded of an FP hospital is $q_{FP} = qn/m$. The corresponding price an FP hospital can charge is $\rho_{FP} = f(qn/m)$.

Assume technology is equally available for all hospitals in the market, then each hospital would have the same quadratic cost function defined as $c(q_{FP}) = F + v(q_{FP})$, where $F$ is the fixed cost or sunk cost, and the variable cost is convex $v > 0$, $v'' > 0$. The optimal output for an FP firm in the short run is $q_{FP}^*$, derived from the first-order condition $\rho_{FP} + \rho'_{FP} q_{FP}^* = c'(q_{FP}^*)$. At this quantity, the FP firm charges the price $\rho_{FP}^* = f(q_{FP}^*)$.

Because of free entry and exit in the market, in the long-run equilibrium, the demand function $f$ for each hospital shifts so it earns zero economic profit, that is, $\rho_{FP} q_{FP} = c(q_{FP})$. The number of FP hospitals that would remain in in the market is $m^*$, whereas the corresponding long-run equilibrium output and price are denoted by $q_{FP}^*$ and $\rho_{FP}^*$, respectively.

The economy of scale is reached at the minimum average total cost (ATC), where the slope of ATC equals 0: $\dot{\rho}\text{ATC}/\dot{q}_{FP} = 0$. The quantity and price associated with the economy of scale are denoted by $\hat{q}$ and $\hat{\rho}$, respectively.

There are two issues characterizing an FP hospital in this state that are consistent with the standard theory. First, an FP hospital marks up the price over the marginal cost: $\rho_{FP}^* > c'(q_{FP}^*)$, which implies an allocative inefficiency or deadweight loss. Second, the hospital produces less than the output at economy of scale: $q_{FP}^* < \hat{q}$, which implies the excess capacity problem and productive inefficiency.\(^8\)

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\(^8\) This is a standard interpretation in microeconomics with respect to excess capacity, because the firm has not fully utilized its capacity to further reduce the unit cost.
NP Hospitals

Prior literature suggests that a NP hospital generally has multiple objectives, such as maximizing output and/or prestige in addition to maximizing profit (Newhouse 1970), fulfilling a demand for public goods (Weisbrod 1988), and meeting unmet local needs (Frank and Salkever 1991). Here, the primary objective for a NP hospital (private or public) is defined as maximizing the quantity of patient services, subject to the financial constraint that total revenue is equal to or greater than total cost:

$$\text{max}_{q_{NP}} q_{NP} \quad \text{s.t. } p_{NP}(q_{NP}) \cdot q_{NP} \geq c(q_{NP})$$  \hspace{1cm} (2)

where $q_{NP}$ is the quantity provided and $p_{NP}$ is the price charged by a NP hospital. Private nonprofit and public hospitals are more likely to target and serve different patient groups as a result of distinct priorities in their missions and different financial sources.

Private nonprofit (PNP) hospitals. A PNP hospital has a charitable mission and largely relies on patient revenues to support its operation. It cares about the patient’s ability to pay to the extent of break-even to avoid insolvency caused by potentially huge write-offs. Therefore, PNP hospitals tend to serve a group of patients who are financially well off but more price elastic than those served by FP hospitals. Let the demand of the patients served by PNP hospitals be $p = g(q)$, with $g' < 0$.

Public hospitals. The mission of a public hospital is to serve the community without considering the patient’s ability to pay for the medical care services. It is owned by the district, city, or county government and its revenue mainly consists of tax revenues and government subsidies. Therefore, a public hospital is obligated to treat patients without consideration of their income status. Because the patient pool has a large share of uninsured patients, as well as indigents, it is likely to receive additional subsidies such as disproportional share hospital (DSH) payments from the state Medicaid program to offset its medical care costs.\(^9\) Therefore, it is reasonable to assume that public hospitals serve a group of patients with the lowest affordability and that are most price elastic. The demand of this patient group is $p = h(q)$, with $h' < 0$.

Now we have three types of hospitals (i.e., FP, PNP, and public) serving three distinct groups of patients. By assumption, patients in each group have different price elasticities of demand and reservation prices. That is, $|\frac{p}{g h(q)}| > |\frac{p}{g g(q)}| > |\frac{p}{g f(q)}|$, and, $h(0) < g(0) < f(0)$.\(^{10}\) It can be demonstrated that a PNP or public hospital will produce a larger quantity of services and at a lower price for a comparable service than an FP hospital in this environment.

Figure 1 illustrates the quantity-maximizing behavior of a NP hospital (either private nonprofit or public) and the market equilibrium it reaches under monopolistic competition. The economy of scale is at point $E$ where the marginal cost curve intersects the minimum of ATC. Assume a NP hospital targets price-sensitive patients and faces the demand curve $g$. In the short run, the quantity serviced by a NP hospital depends on where the demand curve intersects the ATC at which it can financially break even. It could be smaller than point $E$, as at point $C$, or greater than point $E$, as at point $B$.

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\(^9\) Federal law requires that state Medicaid programs make disproportionate share hospital (DSH) payments to qualifying hospitals that serve a large number of Medicaid and uninsured individuals. Detailed information is available at: https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/dsh.html

\(^{10}\) In reality, the patient mix for each type of hospital will be predicated by other factors such as quality, specialized service offerings, technology, ambiance, etc., in addition to price. For simplicity, we assume that there is a clear tendency for hospitals with different objectives and missions to target specific groups of patients as prescribed in the model.
Suppose a NP hospital is initially facing the demand curve $g$ and operating at point $C$ (Figure 1). This is the required volume of services to break even for this hospital; however, the hospital faces competition from new entrants entering the market. The neighboring points along the ATC curve to the right of point $C$ represent more output at a lower price while still satisfying the break-even constraint, say, point $E$. This presents an incentive for new or other incumbent NP hospitals to offer a lower price for the same service at point $E$ as they attempt to increase output. As a result of losing some price-sensitive patients to these competitors, the demand curve for this hospital shifts to the left. This causes the demand curve $g$ not to touch the ATC curve, which implies that the hospital would incur losses. Eventually the hospital would be forced out of the market either by closure or by merging with another hospital, and thus reducing the number of total surviving hospitals in the market. As this hospital exits, the demand curve for other surviving NP hospitals would shift to the right. This process would continue until each surviving NP hospital is at point $E$, at which the economy of scale is reached and the unit price is the lowest while still breaking even.

Similarly, if a NP hospital is initially at point $B$, with corresponding price set above the minimum ATC, then there is an incentive for new NP hospitals entering the market to offer a lower price, say at point $E$, and attract price-sensitive patients away from the incumbent hospital. As a result of losing patients, the demand curve for the incumbent NP hospital shifts to the left and it would be forced to reduce the price. This process would continue until point $E$ is reached at which the price cannot be further reduced without incurring losses.

In summary, because the market has free entry and exit, the demand curve for a NP hospital, regardless of its initial position, would shift toward and finally settle at the position of economies of scale in the long-run equilibrium. This long-run equilibrium output and price of a NP hospital at point $E$ are denoted by $q_{NP}^{*}$ and $p_{NP}^{*}$, respectively. Then $q_{NP}^{*} = \bar{q}$ and $p_{NP}^{*} = \bar{p}$. At point $E$, the marginal cost curve intersects the NP demand curve, which means the sum of total consumer and producer surpluses is maximized, thus implying allocative efficiency. At point $E$, the unit cost reaches the minimum point at which a NP hospital achieves its economies of scale, thus implying the productive efficiency. Therefore, a NP hospital is both allocatively and productively efficient at point $E$.

Notice that the profit is not maximized for a NP hospital at point $E$ because it operates at a point where MC is greater than MR. This may be considered to be “inefficient” from the accounting perspective.
perspective because the hospital is operating at a loss from the last marginal patient. However, it is efficient from the point of view of the economy or society.

The objective of a public hospital is similar to a PNP hospital, that is, to maximize the output subject to the break-even constraint. However, in addition to patient revenues, a public hospital has other sources of revenues, such as tax revenues and government subsidies, to cover or reduce its operating costs, often in the form of a lump-sum fund transfer. The cost function of a public hospital is, therefore:

\[ c(q_{PUB}) = F + v(q_{PUB}) - S, \]  

where \( S \) denotes a lump-sum subsidy or tax revenue, and \( q_{PUB} \) is the service provided by public hospitals. This would lead to different market outcomes, as shown in Figure 2.

Figure 2 illustrates the long-run equilibrium for a public hospital. As the public hospital receives the lump-sum subsidy \( S \) to deflate its costs, it would shift down the average total cost (compensated by subsidy \( S \)) curve ATC, but the marginal cost curve MC remains the same. Because the upward sloping MC has to intersect with the minimum of the new ATC, the economies of scale of the new ATC at \( E_0 \) would be located to the lower left of \( E \). This implies that in the long-run equilibrium, the public hospital would offer a lower price \( (p_{PUB}^*) \) and provide a smaller quantity \( (q_{PUB}^*) \) than a PNP hospital.

Figure 3 compares the price and quantity-provided outcomes for hospitals in the long-run equilibrium. A FP hospital operates at \( A \), a PNP hospital at \( E \), and a public hospital at \( E' \). In terms of the price, the FP hospital charges the highest price \( p_{FP}^* \) and public hospitals charges the lowest price \( p_{PUB}^* \) among hospitals. A public hospital is able to offer a lower price for a comparable service than a PNP hospital because of receiving additional federal or state government subsidies. With respect to quantity provided, we know \( q_{FP}^* < q_{PUB}^* < q_{PNP}^* \), which implies that a PNP hospital provides the largest volume of services among hospitals across control types. However, it is unclear from the model if the quantity provided by a public hospital would be greater or smaller than that of an FP hospital.

\[ \text{FIGURE 2} \]

The Behavior of a Public Hospital Receiving Lump-Sum Funds

In the case of government funding, which is based on number of patients served, the marginal cost curve can also shift. Based on general observations, we consider that the form of lump-sum subsidy is dominant and its effect dominates the shift of the marginal cost curve.
Based on the discussion above, we propose the following hypotheses:

**H1a:** FP hospitals charge higher prices than NP hospitals for a comparable service.

**H1b:** Public hospitals offer the lowest price in the market.

**H2:** FP hospitals incur the highest average costs for a given level of output.

**H3:** Given the same level of investment and capacity, PNP hospitals provide the largest quantities of patient services among all hospitals.

### RESEARCH METHOD

#### Data Sample and Variables

**Sample**

A panel dataset from California short-term general acute care hospitals with various control types is used. The sample excludes (1) hospitals belonged to Kaiser Foundation Health Plan, Inc. (Kaiser Permanente), an integrated HMO system that admits only patients with Kaiser-run insurance plans and does not report financial data; (2) federal government hospitals, which do not report financial data; (3) state hospitals that provide specialized care; (4) long-term care and specialized care facilities, due to the consideration of different production functions, patient mixes, and reimbursement systems; (5) hospitals with missing data; and (6) closed hospitals. The final sample consists of 346 hospitals and 3,073 hospital-years for the period of 2005–2014.

**Dependent Variables**

In order to compare the average price and average cost per patient day across various hospitals, the case-mix index (CMI) value of a hospital is used to adjust its daily flow of patients in determining resource allocation to treat the patients in a diagnosis-related (MS-DRG) group. The
resulting adjusted average price per day and adjusted average cost per day would reflect the price and cost reported for the types of cases treated in that year, respectively.12

\( N\text{RevPD} \), measured as total patient revenues after deductions and adjustments scaled by adjusted equivalent patient days, is used to proxy for the average price per day, taking into account different pricing strategies and bad debt collection efforts across hospitals. Subsidies from the state Medicaid program and other private sources are excluded. \( ExpPD \), measured as total operating cost scaled by adjusted equivalent patient days, is used to proxy for the average cost per day. Note, \( ExpPD \) measures the operating cost, thus it is not compensated by the subsidy \( S \) in Equation (3). \( AdjPD \) is used as a proxy for patient service volume (i.e., quantity of output) because it is adjusted to compensate for outpatient visits, whereas hospital discharges consider only inpatient service volume. The adjustment involves a two-step process: (1) inpatient days is adjusted by multiplying by a factor based on total inpatient and outpatient revenue relative to inpatient revenue to convert outpatient visits into inpatient equivalent days (Office of Statewide Health Planning & Development [OSHPD] 2004); and (2) the variable of inpatient equivalent days is then multiplied by a hospital case-mix index value to reflect the level of clinical complexity and resource needs of patient services.

**Independent Variables**

For-profit (\( FP \)), private nonprofit (\( PNP \)), district (\( DIST \)), and city/county (\( CCTY \)) hospitals were investigated in order to test the hypotheses. \( FP \) is a binary indicator variable that takes a value of 1 for for-profit hospitals, and 0 otherwise. \( DIST \) is a binary indicator variable that takes a value of 1 for district hospitals, and 0 otherwise.13 \( CCTY \) is a binary indicator variable that takes a value of 1 for county- or city-owned hospitals, and 0 otherwise. We test public hospitals separately in the model because district hospitals have a unique board governance structure and their revenue sources are different from city/county hospitals. The PNP hospital group, serving as the reference group, is an omitted group in the regression analysis. Therefore, the coefficients on control type dummy variables reflect the sensitivity of \( FP \) or public hospitals to performance measures relative to PNP hospitals.

As illustrated in the previous section, on average, FP hospitals would charge higher prices (H1a) while incurring higher operating costs (H2) for similar services than PNP hospitals, implying there is a positive relationship between \( FP \) and \( N\text{RevPD} \) or \( ExpPD \). Public hospitals would offer lower prices than private hospitals (H1b), thus a negative relationship between the \( N\text{RevPD} \) and \( DIST \) or \( CCTY \) dummy is expected. However, we are silent on the relative cost performance between PNP and public hospitals. On one hand, PNP hospitals may be more cost conscientious than public hospitals, especially city/county hospitals, because they face high pressure to be self-sustainable. On the other hand, district hospitals could be more cost efficient because their publicly

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12 CMI is a relative value assigned to a diagnosis-related group (DRG/MS-DRG) of Medicare patients. Patients are classified into DRG groups having the same condition, complexity, and needs. Each MS-DRG has a “weight” reflecting the national average hospital resource consumption by patients for that MS-DRG relative to the national average hospital resource consumption of all patients. Therefore, the CMI of a hospital reflects the diversity, clinical complexity, and the needs for resources in the population of all the patients in the hospital. Detailed information is available at: [http://www.healthandhospitalcommission.com/docs/May26Meeting/CasemixIndexDefinition.pdf](http://www.healthandhospitalcommission.com/docs/May26Meeting/CasemixIndexDefinition.pdf)

13 California’s healthcare districts are public entities established to meet the needs of local communities throughout the state. District hospitals are governed by a publicly elected board of directors and are subject to the requirements of the Ralph M. Brown Act. Detailed information is available at: [http://www.dhcs.ca.gov/provgovpart/Documents/Waiver%20Renewal/DHLF%20Workgroup%20Briefiing%200032910.pdf](http://www.dhcs.ca.gov/provgovpart/Documents/Waiver%20Renewal/DHLF%20Workgroup%20Briefiing%200032910.pdf)
elected boards advocate for low operating costs while providing quality services (Eldenburg and Krishnan 2003). With respect to service volume, we expect that the sign of coefficients on all control type dummies is negative because PNP hospitals would provide the largest service volume when capacity is controlled (H3).

Control Variables

Firm size (Size), system membership (System), and teaching orientation (Teach) are used to control structural factors on hospital performance. Size, measured as the logarithm of total assets, is used to control the scale of hospital operation. Large hospitals generally have more financial resources to support a variety of service offerings and technology upgrades, which in turn positively affect hospital performance. However, because of a high fixed cost commitment, large hospitals may provide services at a higher cost, especially during a period of under-utilization of in-house healthcare facilities.14 System is a binary variable indicating whether a hospital belongs to a large healthcare network or system. Relative to stand-alone hospitals, system-affiliated hospitals have more flexibility to access resources available within the network when facing changes in market conditions. Teaching hospitals are those that have approved residency programs. Teach is a binary variable that takes a value of 1 for teaching hospitals, and 0 for non-teaching hospitals. It is used to control for market power because teaching hospitals have the ability to offer advanced and more sophisticated or specialized services (H. Chang, W.-J. Chang, Das, and Li 2004).

Patient mix (%Medicare and %MediCal), disproportional share payments per patient day (DSHPD), case severity (CMI and ALOS), occupancy rate (OR), charity ratio (Charity), and debt-to-equity ratio (Leverage) are used to control hospital operational characteristics. %Medicare and %MediCal, measured as a fraction of total patient days that are from Medicare and Medicaid patients, respectively, are used to control for the mix of patient pools. Hospitals serving a large share of Medicare and Medicaid patients would be negatively affected financially by the fixed-fee-based reimbursement scheme that is normally lower than the reimbursement rates from third-party insurers. However, qualified DSH hospitals could receive payments from a state Medicaid program to compensate for the cost of providing care to indigents and Medicaid patients. Therefore, the interaction effect of DSH payments and patient mix on cost and volume performance is also examined.

Case severity includes case-mix index (CMI) and average length of stay (ALOS). CMI is a relative measure of hospital service intensity based on the acuity of patients treated. Hospitals with a higher case-mix index often incur higher patient care costs related to increasing severity of illness and complexity of care. ALOS is an efficiency proxy to measure the ability of hospitals to control the costs of operation. OR is the actual utilization indicator that measures the degree to which hospital beds have been utilized, even though the number of beds available for use may have changed during the year. Charity, measured as uncompensated care (sum of bad debt and charity care) multiplied by a cost-to-charge ratio, reveals the usage of hospital resources in activities that do not generate profits. Unlike FP hospitals that have a mature equity capital market, NP hospitals turn to donors and issuance of bonds to raise capital to meet their operational and

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14 Healthcare services, especially hospital services, are not typical normal goods as in a manufacturing setting. The demand for healthcare services may not proportionally increase with better economic conditions as in other industries. The cost benefit derived from the scale of operation may be less subtle in healthcare as compared to other industries. In fact, large hospitals are more likely located in urban areas and have a residency program. Therefore, the cost of operation would be higher for large hospitals relative to small hospitals.
capital investment needs (Conrad 1984). Therefore, Leverage is included to control for the potential effect of hospitals’ long-term debt-paying ability on performance.

Finally, hospital location (Rural), the intensity of competition (Competition), and median household income (Income) of the community are used to control for hospitals’ external operating environment. Rural is a binary variable that takes a value of 1 for hospitals located in rural areas, and 0 otherwise. Prior studies suggest that size and factor price variations among hospitals bear a direct relationship to hospital location (Vitaliano 1987). In general, rural hospitals are smaller and have relatively lower fixed cost structure when compared to urban hospitals. Urban hospitals are more expensive than rural ones (Rosko 1996), and a high fixed cost structure contributes negatively to hospital performance (Liu, Forgione, and Younis 2012). Therefore, a positive relationship between performance and the location variable is expected. Competition is a competitive measure that equals 1 minus Herfindahl-Hirschman Index (HHI), where HHI is a commonly accepted market concentration ratio. It is calculated by squaring the market share of each hospital based on the hospital referral regions (HRRs). Following Robinson (2011), market share for a hospital and its competitors is determined by dividing the number of staffed beds for the hospital by the total number of beds available within the market. Then, a hospital squared market share is added to those from its major competitors to calculate HHI, where a major competitor is defined as any other hospital that captures 10 percent or above of the market share. Moreover, because hospitals belonging to the same healthcare system will presumably not compete with each other, HHI is also system adjusted by adding together staffed beds for hospitals that are affiliated with the same healthcare system within the region in calculating the market share.

Economic theory suggests that healthcare service is a normal good—that is, higher income would generally increase demand for both medical care and elective procedures. Therefore, median household income (Income) by zip code is used to control the income effect on hospital performance.\footnote{The information for median household income by zip code is obtained from the United States Census Bureau website “American FactFinder” under selected economic characteristics (DP03 file), which is based on 2007–2011 American Community Survey Five-Year Estimates and Census 2010. Detailed information is available at: https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml}

Empirical Model

To empirically test the hypothesized relationship between control types and hospital performance, the following equation is examined:

\[
\text{Performance} = \alpha + \beta_1 (FP) + \beta_2 (DIST) + \beta_3 (CCTY) + \beta_4 (Controls) + \beta_5 (Year) + \zeta
\]

where Performance consists of three dependent variables: average service price (NRevPD), average operating cost (ExpPD), and patient service volume (AdjPD). FP, DIST, and CCTY are independent variables. The remaining covariates (Controls) are designed to control for structural, operational, and market factors that might have affected hospital pricing and cost performance (see Appendix A for variable definitions). The model also controls the potential effect of the ACA implementation period on hospital performance for years 2010 through 2014.

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\footnote{HRRs represent regional healthcare markets for tertiary medical care that generally require the services of a major referral center. The regions are defined by determining where patients were referred for major cardiovascular surgical procedures and for neurosurgery. Detailed information is available at: http://www.dartmouthatlas.org/data/region/}
RESULTS AND DISCUSSION

Table 1 shows descriptive statistics for the variable of interest by hospital type. About 72 percent of hospital-year observations in the sample are NP hospitals, consistent with the fact that the majority of U.S. hospitals are operating as nonprofit institutions (AHA 2017). FP and district hospitals are similar in terms of size, capacity, and performance. PNP and city/county hospitals are larger in size and capacity and have substantially higher service volume. Investor-owned FP hospitals, on average, have the longest in-patient stays, tend to be located in wealthier neighborhoods, and have experienced the most intense competition among all hospitals. Public hospitals perform more charity services than do FP and PNP hospitals. Finally, over 51 percent of city/county hospital patients versus 47 percent of district hospital patients are Medicaid patients. This is expected as public hospitals play an important role in the provision of care to the indigent population. However, the amount of DSH payments to district and city/county hospitals is strikingly different. On average, the state Medicaid program made approximately $55 million DSH payments (or $410 per day) to city/county hospitals versus only $0.41 million DSH payments to district hospitals, consistent with the finding that Medicaid DSH payments tend to significantly favor large government hospitals (Choi and Lim 2017).

Table 2 reported the Pearson and Spearman rank correlations between control types, performance, and selected control variables used in the analysis. Overall, correlations are at appropriate levels that do not raise any concerns over multicollinearity between the variables of interest. The relationship between control type dummies and performance variables is generally significant at the 1 percent level with varying signs.

Table 3 reports the OLS regression results examining the association between control types and hospital performance in terms of price, cost, and service volume. The overall model fits nicely, evidenced by an adjusted $R^2$ of 44 percent or above and strongly significant F-statistics ($p \leq 0.001$) for all tested models. The coefficient of the DIST and CCTY dummies on NRevPD are both negative and strongly significant at the 1 percent level, suggesting that public hospitals charge significantly less relative to PNP hospitals for the same service. Therefore, the hypothesis that predicts public hospitals charge the lowest price per day among all hospitals is strongly supported (H1b).

The coefficient on the FP dummy is statistically insignificant, suggesting that private hospitals charge similar prices for a comparable service. Notice that we excluded subsidies (i.e., DSH payments from state Medicaid programs and other private or public subsidy payments) from patient revenue in calculating the average price per day (NRevPD). It is possible that FP hospitals price their services at a competitive price in an attempt to lure more financially well-off patients from PNP hospitals, or that the average cost curve has the curvature that makes the tangent point with the demand line positioned at a point that is not substantially higher than the minimum of ATC. In summary, the hypothesis (H1a) that predicts FP is more expensive on a comparable service is not supported at a desired level of significance. It makes sense that private hospitals are strategically pricing their services at a level that would be sustainable in order to maximize profit for FP hospitals or to cross-subsidize unprofitable services for PNP hospitals. In the presence of FP hospitals, PNP hospitals are increasingly becoming more competitive (Horwitz and Nichols 2009).

The second hypothesis, which predicts that FP hospitals will have the highest operating costs among all hospitals, is not supported, evidenced by an insignificant coefficient on FP. The results suggest that the operating costs for FP and PNP hospitals are comparable for a given level of output. Similar to the reasons stated for the pricing model, FP and PNP hospitals attempt to manage operating costs, respectively, to maximize profit and provide more services. Additionally,
| Variables     | For-Profit (n = 868) |                  | Nonprofit (n = 1646) |                  | District (n = 425) |                  | City/County (n = 180) |                  |
|---------------|-----------------------|------------------|-----------------------|------------------|-------------------|------------------|-----------------------|------------------|
|               | Mean | Med. | Q1   | Q3   | Mean | Med. | Q1   | Q3   | Mean | Med. | Q1   | Q3   | Mean | Med. | Q1   | Q3   | Mean | Med. | Q1   | Q3   |
| **AdjPD (thousands)** |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Mean          | 562.71 | 432.47 | 270.56 | 758.55 | 1106.10 | 896.11 | 387.92 | 1473.89 | 581.40 | 423.75 | 220.98 | 857.87 | 1409.15 | 1054.93 | 630.12 | 2128.35 |
| **NRevPD (thousands)** |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Mean          | 17.40 | 16.38 | 10.42 | 22.50 | 22.95 | 17.80 | 28.15 | 15.99 | 11.41 | 4.79 | 19.80 | 147.38 | 105.49 | 13.63 | 22.26 |
| **ExpPD (thousands)** |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Mean          | 17.36 | 17.03 | 11.68 | 21.70 | 22.78 | 18.27 | 27.55 | 16.85 | 13.06 | 5.15 | 21.55 | 22.95 | 17.01 | 13.63 | 22.26 |
| **CMI** | 1.39 | 1.20 | 1.00 | 1.50 | 1.22 | 1.19 | 1.05 | 1.35 | 1.02 | 0.98 | 0.90 | 1.13 | 1.07 | 1.05 | 0.95 | 1.19 |
| **Competition** | 0.89 | 0.91 | 0.85 | 0.98 | 0.84 | 0.83 | 0.78 | 0.94 | 0.80 | 0.82 | 0.75 | 0.86 | 0.86 | 0.85 | 0.80 | 0.98 |
| **%Medicare** | 0.50 | 0.49 | 0.36 | 0.62 | 0.47 | 0.48 | 0.39 | 0.56 | 0.32 | 0.30 | 0.14 | 0.48 | 0.17 | 0.14 | 0.10 | 0.21 |
| **%Medicare** | 0.28 | 0.25 | 0.09 | 0.43 | 0.25 | 0.21 | 0.13 | 0.33 | 0.47 | 0.45 | 0.21 | 0.75 | 0.51 | 0.53 | 0.41 | 0.58 |
| **Size** | 17.63 | 17.71 | 16.81 | 18.43 | 18.88 | 18.94 | 17.99 | 19.78 | 17.60 | 17.34 | 16.52 | 16.69 | 19.06 | 19.27 | 18.67 | 19.78 |
| **Charity (%)** | 0.69 | 0.48 | 0.19 | 0.97 | 0.96 | 0.82 | 0.54 | 1.19 | 2.06 | 1.59 | 0.94 | 2.67 | 2.09 | 1.80 | 0.21 | 3.37 |
| **OR** | 57.58 | 57.60 | 44.80 | 69.80 | 59.18 | 59.80 | 50.00 | 69.70 | 60.40 | 63.70 | 49.10 | 74.95 | 63.98 | 66.30 | 54.80 | 74.90 |
| **ALOS** | 8.60 | 4.70 | 6.10 | 4.38 | 4.30 | 3.80 | 4.80 | 4.12 | 3.80 | 3.10 | 4.30 | 5.64 | 5.10 | 4.40 | 5.78 |
| **DSH ($Million)** | 1.64 | 0.00 | 2.40 | 0.47 | 0.00 | 0.00 | 0.00 | 0.41 | 0.00 | 0.00 | 0.00 | 54.85 | 50.34 | 46.74 | 99.89 |
| **Capacity** | 4.88 | 4.95 | 3.45 | 5.34 | 5.21 | 5.40 | 4.66 | 5.87 | 4.44 | 4.43 | 3.56 | 5.14 | 5.55 | 5.66 | 5.15 | 6.12 |
| **Income** | 458.05 | 418.87 | 318.75 | 574.61 | 473.83 | 435.57 | 352.82 | 580.13 | 403.25 | 369.38 | 317.97 | 470.31 | 450.29 | 487.44 | 330.40 | 553.21 |
| **CMAdm (visits)** | 72.40 | 52.04 | 27.78 | 97.60 | 145.16 | 116.98 | 45.38 | 208.15 | 52.09 | 18.91 | 4.79 | 55.14 | 142.90 | 120.40 | 61.92 | 212.90 |

*All continuous variables are winsorized at 99 percent to reduce the effect of possibly spurious outliers.*
### TABLE 2
Correlations Matrix (Selected Variables)
Pearson (above Diagonal) and Spearman (below Diagonal)

|       | AdjPD  | NRevPD | ExpPD  | FP     | PNP    | DIST   | CCTY   | %Medicare | %MediCal | Size    | Charity | OR     | ALOS   | DSHPD |
|-------|--------|--------|--------|--------|--------|--------|--------|----------|----------|---------|---------|--------|--------|--------|
| AdjPD | 0.006  | 0.032  | -0.247 | 0.255  | -0.149 | 0.148  | -0.153 | -0.059   | 0.731    | -0.128  | 0.425   | -0.002 | 0.069  |
| NRevPD| 0.044* | 0.945**| -0.169 | 0.282  | -0.155 | -0.053 | 0.068  | -0.348   | 0.329    | -0.071  | 0.362   | -0.300*| 0.126* |
| ExpPD | 0.061**| 0.929**| -0.199 | 0.220  | -0.146 | 0.128  | -0.005 | -0.269   | 0.353    | -0.014  | 0.327   | -0.311*| 0.193* |
| FP    | -0.236**| -0.204**| -0.255**| -0.657**| -0.245**| -0.154**| 0.199**| -0.062**| -0.323**| -0.237**| -0.063**| 0.337**| 0.041**|
| PNP   | 0.256**| 0.392**| 0.321**| -0.657**| -0.419**| -0.261**| 0.151**| -0.264**| 0.381**| -0.139**| 0.001   | -0.232**| -0.193**|
| DIST  | -0.165**| -0.264**| -0.243**| -0.245**| -0.419**| -0.098**| -0.245**| 0.307**| -0.214**| 0.357**| 0.030   | -0.106**| -0.108**|
| CCTY  | 0.147**| -0.058**| 0.162**| -0.154**| -0.261**| -0.098**| -0.346**| 0.232**| 0.120**| 0.230**| 0.073**| 0.003  | 0.654**|
| %Medicare | -0.090**| 0.165**| 0.061**| 0.163**| 0.157**| -0.228**| -0.316**| -0.777**| 0.036**| -0.441**| -0.144**| 0.334**| -0.370**|
| %MediCal | -0.017 | -0.358**| -0.247**| -0.077**| -0.219**| 0.248**| 0.251**| -0.759**| -0.286**| 0.469**| 0.194**| -0.172**| 0.317**|
| Size  | 0.819**| 0.439**| 0.446**| -0.339**| -0.203**| 0.140**| -0.009**| -0.173**| 0.293**| -0.157**| 0.100**|
| Charity | -0.192**| -0.057**| -0.005 | -0.318**| 0.007 | 0.331**| 0.113**| -0.359**| 0.432**| -0.179**| -0.015 | -0.151**| 0.221**|
| OR    | 0.512**| -0.289**| -0.292**| -0.071**| -0.010 | 0.050**| 0.082**| -0.200**| 0.159**| 0.293**| -0.055**| 0.269**| 0.068**|
| ALOS  | 0.428**| -0.269**| -0.218**| 0.206**| -0.071**| -0.264**| 0.144**| 0.119**| -0.046**| 0.223**| -0.261**| 0.346**| -0.039**|
| DSHPD | 0.009 | -0.072**| -0.005 | 0.065**| -0.217**| -0.016 | 0.365**| -0.500**| 0.623**| -0.072**| 0.292**| 0.064**| 0.075**|

**, * Indicate the correlation is significant at the 0.01 and 0.05 level (two-tailed), respectively.
### TABLE 3
OLS Regression Examining the Association between Control Type and Hospital Performance

\[ \text{Performance} = \alpha + \beta_1(\text{FP}) + \beta_2(\text{DIST}) + \beta_3(\text{CCTY}) + \beta_4(\text{Controls}) + \beta_5(\text{Year}) + \xi. \]

| Variables   | Expected Sign | Average Price (NRevPD) | Average Cost (ExpPD) | Service Volume (AdjPD) |
|-------------|---------------|------------------------|----------------------|------------------------|
| FP          | +/−           | 0.018                  | −0.004               | −0.055***              |
|             |               | (1.027)                | (−0.219)             | (−5.157)               |
| DIST        | +/−           | −0.082***              | −0.036**             | −0.029***              |
|             |               | (−4.812)               | (−2.148)             | (−2.713)               |
| CCTY        | +/−           | −0.073***              | −0.007               | −0.022*                |
|             |               | (−4.382)               | (−0.338)             | (−1.731)               |
| System      |               | 0.083***               | 0.065***             | 0.003                  |
|             |               | (5.516)                | (4.480)              | (0.307)                |
| Rural       |               | 0.038**                | 0.024                | 0.130***               |
|             |               | (2.015)                | (1.272)              | (9.895)                |
| Teach       | −0.023        | 0.041**                | 0.258***             |                       |
|             |               | (−1.350)               | (2.254)              | (23.777)               |
| Size        |               | 0.295***               | 0.379***             | 0.142***               |
|             |               | (13.626)               | (14.612)             | (7.896)                |
| CMI         | −0.165***     | −0.142***              | 0.232***             |                       |
|             |               | (−7.531)               | (−6.499)             | (16.940)               |
| DSHPD       | NA            | −0.653***              | −0.227***            |                       |
|             |               | (−5.940)               | (−3.267)             |                       |
| %Medicare   | −0.366***     | −0.320***              | −0.283***            |                       |
|             |               | (−14.096)              | (−12.484)            | (−17.251)             |
| DSHPD * %Medicare | NA     | 0.121***               | 0.075***             |                       |
|             |               | (3.776)                | (3.723)              |                       |
| %MediCal    | −0.560***     | −0.573***              | −0.195***            |                       |
|             |               | (−19.899)              | (−19.956)            | (−10.009)             |
| DSHPD * %MediCal | NA   | 0.765***               | 0.026                |                       |
|             |               | (8.612)                | (0.469)              |                       |
| OR          | −0.283***     | −0.278***              | 0.155***             |                       |
|             |               | (−16.352)              | (−16.106)            | (14.524)              |
| ALOS        | −0.033        | −0.065***              | −0.032***            |                       |
|             |               | (−1.531)               | (−3.037)             | (−2.420)              |
| Charity     | 0.067***      | 0.073***               | 0.066***             |                       |
|             |               | (3.878)                | (4.334)              | (6.243)               |
| Leverage    | 0.004         | 0.009                  | 0.002                |                       |
|             |               | (0.270)                | (0.666)              | (0.256)               |
| Competition | −0.105***     | −0.091***              | −0.030***            |                       |
|             |               | (−6.982)               | (−6.228)             | (−3.203)              |
| Income      | −0.034**      | −0.043***              | −0.033***            |                       |
|             |               | (−2.220)               | (−2.822)             | (−3.527)              |
| CMAadm      | NA            | −0.136***              | NA                   | 0.571***              |
|             |               | (−5.293)               |                       | (33.444)              |

(continued on next page)
the results suggest that city/county hospitals may have lower operating costs per day when compared to PNP hospitals, but the relationship is statistically insignificant after controlling the main effect of DSH payments and its interactive effect with patient mix. Notice that city/county hospitals charge a lower price for comparable services when compared to PNP hospitals, largely because they treat a large proportion of Medicaid patients (about 51 percent) whose services are billed (to the Medicaid program) at a lower rate than third-party insurers.

However, the coefficient on the DIST dummy is negative and statistically significant at the 5 percent level, suggesting that the operating costs for district hospitals are significantly lower than PNP hospitals. A possible explanation is that the board members of district hospitals are publicly elected rather than appointed. Prior literature suggests that district hospitals have stronger incentives to control operating costs because the priority of the board is to reduce administrative costs (Eldenburg and Krishnan 2003). Although district hospitals are independent taxing healthcare entities in the state of California, they receive a very small fraction of total revenue from community tax support when compared to city/county hospitals. It is possible that a combined goal of increasing patient revenues and controlling operating costs enables district hospitals to achieve a lower average cost per day than PNP hospitals.

The third hypothesis states that PNP hospitals, at a given level of capacity, provide the highest level of medical service volume among all hospital types. This prediction is strongly supported, evidenced by a negative and statistically significant coefficient on the FP, DIST, and CCTY dummies, with the first two at the 1 percent level and the last at the 10 percent level. It can be seen that FP hospitals provide the least service volume (−0.055) as compared with the volumes serviced by district (−0.029) and city/county (−0.022) hospitals. We also observe that city/county hospitals, which treated 27 percent more patients per day compared to PNP (as shown in Table 1), provide significantly less service volume than PNP hospitals when hospital capacity and other covariates are controlled. This agrees with Figure 3 that illustrates the downward shift of the ATC curve for public hospitals as a result of the lump-sum subsidy would reduce service volume to the equilibrium (E’).

The results are generally consistent with the expectations for structural, operational, and market environment control variables. For example, large hospitals are able to charge higher price, incur more costs per day, and provide higher service volume than small hospitals. Rural hospital status appears to positively associate with more service volume due to lack of competition in the areas they normally serve. Compare to small and rural hospitals, large urban hospitals have a high fixed cost structure. Urban hospitals are more expensive (Rosko 1996), and those with a high fixed cost structure perform worse (Liu et al. 2012). A teaching hospital incurs higher cost per day because of its tendency to recruit the best qualified physicians and keep up with technology.

### TABLE 3 (continued)

| Variables | Expected Sign | Average Price (NRevPD) | Average Cost (ExpPD) | Service Volume (AdjPD) |
|-----------|---------------|------------------------|----------------------|------------------------|
| Adjusted R² | 0.439*** | 0.478*** | 0.792*** |

***, **, * Indicate significant at the 10 percent, 5 percent, and 1 percent level, respectively. t-statistics in parentheses.

The sample size is 3,076 hospital-year observations from 346 California short-term, general acute care hospitals between 2005 and 2014. Intercepts are not reported. The coefficients for year 2010–2014 are all positive and significant at the 1 percent –5 percent level (not reported) for all models tested.

See Appendix A for variable definitions.
advancement. It also attracts more patients than a non-teaching hospital because of a wider range of technically advanced, specialized patient service offerings. A larger proportion of Medicare and Medicaid patients lowers the average price as expected because Medicare and Medicaid programs reimburse hospitals at a lower rate than third-party insurers. Because the marginal cost curve is upward sloping, the lower price decreases the service volume and probably reduces the reported cost as well. With respect to cost performance, the main effect of Medicaid patient mix and its interaction effect with DSHPD remain significantly positive, suggesting that a DSH-qualifying hospital will increase its cost per day by serving a large proportion of Medicaid patients despite DSH payments from Medicaid to compensate for the revenue loss. Finally, more intense competition in the market reduces the average price, average operating cost, and service volume.

**CONCLUSION**

Using a sample of California general hospitals, this paper attempts to address the inconsistency between theory and empirical evidence found in the prior literature with respect to the relative performance among hospitals across control types. It extends Chang’s (2014) model of nonprofit hospitals by providing theoretical reasoning and empirical evidence to support the prediction that NP hospitals are more economically efficient than FP hospitals in the hospital market. In this context, we further compare the performance of two types of nonprofit hospitals, private nonprofit and public hospitals. Public hospitals offered patient services at the lowest average price by passing the subsidies on to the patients, whereas PNP hospitals provided the highest volume of patient services among all hospital types. Such findings contradict conventional wisdom in economic theory, but are consistent with the results of many empirical studies that primarily favor NP hospitals (Rosenau 2003). Therefore, this study has provided both a theoretical explanation and empirical evidence for the economic efficiency benefits from NP hospitals.

There are some limitations of the current study. First, the hospital market is not a typical textbook monopolistic market. Between healthcare providers and patients, there are government regulations, managed care, and private insurance networks. Second, unlike a manufacturing product, the healthcare service is not a pure private good. Additionally, the information between providers (i.e., hospitals, physicians, etc.) and patients is grossly asymmetric with high transaction costs. These issues unique to the hospital market could affect the demand and supply functions, and hospital behaviors thereto, thus potentially influencing the final outcomes. It will be of academic interest in future studies to investigate hospital behavior while taking into account these unique characteristics of healthcare products or services.

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### APPENDIX A

#### Variable Definitions

| Variable       | Definition                                                                                                                                                                                                 |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Dependent Variable** |                                                                                                                                                                                                 |
| AdjPD          | Adjusted patient days = inpatient days \* ((inpatient revenue + outpatient revenue)/inpatient revenue) \* case-mix index.                                                                                |
| NRevPD         | Net revenue per adjusted patient day = (total revenue – deductions and adjustments)/adjusted patient days, where DSH and like-kind payments are excluded from adjustments.                                       |
| ExpPD          | Average total cost per adjusted patient day = total operating expenses/adjusted patient days.                                                                                                               |
| **Independent Variables** |                                                                                                                                                                                                 |
| FP             | A binary variable that takes value of 1 for private nonprofit hospitals, and 0 otherwise; for-profit hospitals are treated as reference group.                                                                |
| DIST           | A binary variable that takes value of 1 for district hospitals, and 0 otherwise; for-profit hospitals are treated as reference group.                                                                       |
| CCTY           | A binary variable that takes value of 1 for city or county hospitals, and 0 otherwise; for-profit hospitals are treated as reference group.                                                                    |
| **Control Variables** |                                                                                                                                                                                                 |
| Size           | Nature log of total assets.                                                                                                                                                                                  |
| System         | A binary variable that takes value of 1 for a hospital that is a member of a large healthcare system, and 0 otherwise.                                                                                      |
| %Medicare      | Fraction of Medicare patient days in total patient days = Medicare days/total patient days.                                                                                                                  |
| %MediCal       | Fraction of Medicaid patient days in total patient days = Medicaid patient days/total patient days.                                                                                                       |
| DSHPD          | Medicaid disproportionate share hospital payments scaled by adjusted patient days.                                                                                                                        |
| CMI            | Case-mix index = MS-DRG weights/total number of discharges; provided by OSHPD.                                                                                                                             |
| ALOS           | Average length of stay; provided by OSHPD.                                                                                                                                                                |
| OR             | Occupancy rate; provided by OSHPD.                                                                                                                                                                         |
| Competition    | Market competition = measured as 1 – Herfindahl Hirschman Index (HHI), the sum of the squared market shares of a hospital and its major competing hospitals in the market.                                      |
| Charity        | Charity ratio = uncompensated care/gross patient revenue, where uncompensated care = (bad debt + charity charge) \* cost-to-charge ratio, where cost-to-charge ratio is total operating expense excluding bad debts divided by sum of gross patient revenues and other operating revenue. |
| Leverage       | Net long-term debt/total equity.                                                                                                                                                                           |
| CMAadm         | Case-mix adjusted admission = number of discharges \* case-mix index.                                                                                                                                      |
| Capacity       | Nature log of hospital beds available.                                                                                                                                                                     |
| Rural          | A binary variable that takes value of 1 for rural hospitals, and 0 otherwise.                                                                                                                               |
| Teach          | A binary variable that takes value of 1 for hospitals that have residency program, and 0 otherwise.                                                                                                          |
| Income         | Household median income by hospital zip codes.                                                                                                                                                             |
APPENDIX B
Economic Model

Assuming technology is equally available to all types of hospitals in the market, each hospital has the cost function $c(q_{FP}) = F + q^2_{FP}$, where $F$ is the fixed cost.

**FP Hospitals**

The objective of an FP hospital is: $\max_{q_{FP}} \pi_{FP} = p_{FP}(q_{FP}, \Omega_{FP})q_{FP} - c(q_{FP})$, where $\pi_{FP}$, $p_{FP}(q_{FP}, \Omega_{FP})$, and $q_{FP}$ denote the profit, the price charged, and the quantity provided, respectively. $\Omega_{FP}$ denotes a vector of other factors that would shift the demand curve. The demand function for a price-insensitive individual patient is $p = a - bq$. The number of price-insensitive patients is $n$. The aggregate demand for medical care in this market equals $nq$. Assume that there are $m$ FP hospitals in the market; each hospital is assumed to be identical with an equal share of the market. Then, the quantity demanded of an FP hospital is:

$$q_{FP} = \frac{n}{m} q = \frac{n}{m} (a - p) = \frac{n}{mb} (a - p)$$

(5)

$$p_{FP} = a - \frac{mb}{n} q_{FP}$$

(6)

$$ATC = \frac{c(\sqrt{F})}{\sqrt{F}} = 2\sqrt{F}.$$  

(7)

The minimum average cost (ATC) can be derived from $\frac{d^{\text{opt}}\text{ATC}}{dq_{FP}} = -Fq^2_{FP} + 1 = 0$, so the quantity provided at the economy of scale is $q_{FP} = \sqrt{F}$, where the unit of quantity $q_{FP}$ is normalized to secure $w = 1$ from the more general form $c(F, w, q_{FP})$ without any loss of generality.

The optimal corresponding output and price in the short-run equilibrium are:

$$q_{FP}^* = \frac{an}{2(mb + n)}$$

(8)

$$p_{FP}^* = a - \frac{mb}{n} q_{FP}^* = a - \frac{mb}{n} \cdot \frac{an}{2(mb + n)} = \frac{a(mb + 2n)}{2(mb + n)}$$

(9)

Because of free entry and exit in the market, hospitals are earning zero economic profit in the long-run equilibrium, that is, $p_{FP}q_{FP} = c(q_{FP}) = F + q^2_{FP}$. The number of FP hospitals that will remain in the market will be $m^{**} = \frac{n}{b} \left(\frac{a^2}{4F} - 1\right)$. The long-run equilibrium output and price of an FP hospital are:

$$q_{FP}^{**} = \frac{an}{2(m^{**}b + n)} = \frac{an}{2\left[\frac{b}{a} \left(\frac{a^2}{4F} - 1\right)b + n\right]} = \frac{2F}{a}$$

(10)

$$p_{FP}^{**} = a - \frac{mb}{n} q_{FP}^{**} = a - \frac{n}{b} \left(\frac{a^2}{4F} - 1\right) \frac{b}{n} \cdot \frac{2F}{a} = \frac{a + 2F}{a}$$

(11)

The price markup of an FP hospital is:
\[
p_{FP}^* - \frac{\partial c}{\partial q_{FP}}_{q_{FP}^*} = a + \frac{2F}{a} - 4F = a - \frac{2F}{a} = a\left(\frac{1}{2} - \frac{2F}{a^2}\right) > 0
\]  
(12)

An FP hospital produces less than the output at economies of scale, \( q_{FP} = \sqrt{F} \):

\[
q_{FP}^* - \sqrt{F} = \frac{2F}{a} - \sqrt{F} = \frac{\sqrt{F}}{a}(2\sqrt{F} - a) < 0
\]  
(13)

**Private Nonprofit Hospitals**

Assume the primary objective of a private nonprofit hospital is defined as follows: \( \max q_{PNP} \quad \text{s.t.} \quad p_{PNP}(q_{PNP}, \Omega_{PNP}) \cdot q_{PNP} \geq c(q_{PNP}) \), where \( q_{PNP} \) is the quantity provided and \( p_{PNP} \) is the price charged by a NP hospital. Therefore, the long-run equilibrium output and price charged for a NP hospital are \( q_{PNP}^* = \sqrt{F} \) and \( p_{PNP}^* = 2\sqrt{F} \), respectively.

\[
q_{PNP}^* - q_{FP}^* = \sqrt{F} - \frac{2F}{a} > 0,
\]  
(14)

\[
p_{PNP}^* - p_{FP}^* = 2\sqrt{F} - \left(\frac{a}{2} + \frac{2F}{a}\right) = \frac{1}{2a}(4a\sqrt{F} - a^2 - 4F) < \frac{1}{2a}\left[4(2\sqrt{F})\sqrt{F} - (2\sqrt{F})^2 - 4F\right]
\]

\[
= \frac{1}{2a}[8F - 4F - 4F] = 0.
\]  
(15)

**Public Hospitals**

The primary objective of a public hospital is similar to a private nonprofit hospital: \( \max q_{PUB} \quad \text{s.t.} \quad p_{PUB}(q_{PUB}, \Omega_{PUB}) \cdot q_{PUB} \geq c(q_{PUB}) \), where \( q_{PUB} \) is the quantity provided and \( p_{PUB} \) is the price charged by a public hospital. Let the lump-sum subsidy received by a public hospital be \( S \), hence the cost function of the public hospital is modified to be:

\[
c(q_{FP}) = F + q_{FP}^2 - S
\]  
(16)

The long-run equilibrium output and price charged for a NP hospital are \( q_{PUB}^* = \sqrt{F - S} \) and \( p_{PUB}^* = 2\sqrt{F - S} \), respectively. Obviously:

\[
q_{PUB}^* - q_{PNP}^* = \sqrt{F - S} - \sqrt{F} < 0,
\]  
(17)

\[
p_{PUB}^* - p_{PNP}^* = 2\sqrt{F - S} - 2\sqrt{F} < 0.
\]  
(18)