Nonprofit vs. For-Profit Healthcare Competition:
How Service Mix Makes Nonprofit Hospitals More Profitable

Jihwan Moon
University of New South Wales Business School, Sydney, NSW 2052, jihwan.moon@unsw.edu.au

Steven M. Shugan
Warrington College of Business, University of Florida, Gainesville, Florida 32611, sms@ufl.edu

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Abstract

This paper studies the intersection between the largest U.S. industry – healthcare and $1 trillion nonprofit sector. Using analytical and empirical analyses, the authors reveal the marketing strategies helping private nonprofit hospitals achieve higher output, prices, and profits than for-profit hospitals. Nonprofit hospitals, focusing on both profits and output, obtain these outcomes by expanding their service mix with high-priced premium specialty medical services (PSMS) while, for basic services, for-profit hospitals can be more profitable with higher prices. Competition increases the differences between nonprofit and for-profit hospitals in PSMS breadth, output, and prices. Nonprofit hospitals lose their competitive advantage when competing with other like nonprofits; i.e., for-profit presence broadens available nonprofit PSMS. With broader service mixes, nonprofits focus more on national advertising than for-profits because PSMS (e.g., pediatric trauma, neurosurgery, heart transplants, oncology) require larger geographic markets than local basic services (e.g., laboratory, diagnostics, nursing, pharmaceutics). Exogenous, heterogeneous state regulations restricting for-profit hospital entry help econometric identification (i.e., markets prohibiting for-profits act as controls). Service mix may be a key difference between nonprofit and for-profit hospitals.

Key words: healthcare; hospitals; not-for-profit; for-profit; service mix; medical care; competitive strategy; nonprofit objective; investment; empirical; game theory; national; local; advertising

We study the intersection between the largest U.S. industry – healthcare and $1 trillion nonprofit sector. Overstating the importance of healthcare markets is difficult. In 2018, the U.S. spent $3.7 trillion ($11,193 per capita) or 18.2% of the U.S. gross domestic product (GDP) on healthcare (www.cms.gov). Healthcare spending exceeds all federal tax receipts despite record high tax receipts (www.whitehouse.gov/omb). Healthcare spending dwarfs spending in other sectors; e.g., it is almost 8 times total consumer e-commerce spending (www.census.gov). The U.S. spends more per capita on healthcare than almost every country both in total and as percentage of GDP (Anderson et al. 2005). Also, healthcare employment vastly exceeds that in retailing and manufacturing. Healthcare creates one-third of all new jobs, growing faster than any other major industry including information services (www.bls.gov). Healthcare research is just emerging in the marketing literature (Ma, Ailawadi, and Grewal 2013; Hagen, Krishna, and McFerran 2017; Liu, Liu, and Chintagunta 2017; Mehta et al. 2017; Dahl, Gorn, and Weinberg 2018; Fajardo, Townsend, and Bolander 2018; Gupta et al. 2018).

Hospitals are the largest healthcare submarket with one-third of both healthcare spending and employment. Hospitals annually admit 35 million patients, deliver 4 million babies (more than the Los Angeles population), and spend $1 trillion. Every hospital dollar supports $2.30 of additional business. Each hospital job creates two additional jobs (American Hospital Association 2017).

For-profit vs. Nonprofit Hospitals

Private hospitals are either for-profit or nonprofit hospitals. For brevity, we call them for-profits and nonprofits. The demarcation is strictly legal. For-profits can distribute their accounting profits to their founders, investors, and owners. Hence, hospital founders who seek future profit and to retain organizational control usually establish for-profits. Note that many teaching hospitals are for-profits (e.g., St. Petersburg Bayfront, Detroit Sinai-Grace).

In contrast, nonprofits cannot distribute profits to founders. Thus, founders with altruistic motives and no desire for future control found nonprofits. For example, the Spectrum Health Butterworth Hospital in Grand Rapids Michigan began in 1875 by the St. Mark's Episcopal Church to care for the elderly, homeless, and ill. Maintaining nonprofit tax status requires supplying often ill-defined community benefits (e.g., education, training, charity care). In return, nonprofits enjoy federal, state, and local tax relief (Gentry and Penrod 2000) and tax-exempt bond financing. This tax benefit was $24.6 billion in 2011 (Rosenbaum et al. 2015).

Research Objectives

Our research objectives are threefold: (1) to explain some interesting empirical observations on private hospitals by developing an analytical healthcare model, (2) to derive additional predictions from that model, and (3) to check those predictions using a large healthcare database.

Prior research implies that for-profit firms (not necessarily hospitals) charge higher prices than nonprofit organizations (Newhouse 1970; Dusansky and Kalman 1974; Frank and Salkever 1991; Krug and Weinberg 2004; Liu and Weinberg 2004; Harrison and Lybecker 2005; Bayindir 2012); see Liu and Weinberg (2009) for a review. Past assumptions (e.g., nonprofit objectives) are possibly consistent with many nonprofit organizations relying on dues or donations (e.g., churches, political organizations, volunteer services, charities, labor unions, etc.). However, their price implications are inconsistent with empirical observations in hospital markets.

Our empirical analyses reveal that nonprofit hospitals have higher (not lower) average prices (i.e., total patient revenue divided by total patients including uncompensated care) and larger (not smaller) profits than for-profit hospitals. Table 1 shows that 7 of the 10 most profitable hospitals are nonprofit, representing 73% of their total profits; each earns over $163 million (Bai and Anderson 2016; Meyer 2016). Of the 90 most profitable hospitals, 64% are nonprofit. In Massachusetts, the 6 most profitable hospitals are nonprofits (Herman 2013). On average, nonprofits have 29% greater profits than for-profits. These findings hold after accounting for investment costs, nonprofit tax benefits, and other factors. Moreover, nonprofits have higher average prices, and the difference is increasing over time (see Table 2). Surprisingly, nonprofit hospitals achieve greater profits with higher average prices than for-profit hospitals.

[Insert Tables 1 and 2 about here]

Tables 3 and 4 provide a foundation for our explanation. Table 3 shows nonprofits provide 45% more clinical services (e.g., epilepsy, neurosurgery, oncology, neonatal care, etc.), achieving greater output on multiple measures and 54% larger patient revenue than for-profits. The premium specialty medical services (PSMS) are much more expensive than basic services. For example, an ordinary nursery room is $1,195 per day. However, a neonatal intensive care room is $8,935, and a pediatric critical care room is $10,140 per day (www.uhhospitals.org). Adding PSMS raises average pediatric prices dramatically even when existing prices are unchanged. Hence, investment in PSMS may help explain higher average nonprofit prices and profits.

Table 4 reveals similar observations in markets with two competing hospitals (duopoly markets). Nonprofits have a greater breadth of clinical services (PSMS), higher average patient payments, and greater output than for-profits. Adjusting for the number of inpatients (discharges), nonprofits still have more patient days and employees consistent with having more PSMS. Note that the correlations between hospital profits and the number of basic service beds are 15% and 82% for nonprofits and for-profits, respectively. Hence, the profitability of for-profits seems to depend on basic services but less so for nonprofits. This difference between hospital types does not exist for PSMS beds, where the correlations are 76% and 78% for nonprofits and for-profits, respectively. Hence, both hospital types' profits may increase with more PSMS; however, we will show that nonprofits provide more PSMS.

Table 4 also shows PSMS breadth depends on whether the competitor is nonprofit or for-profit. Nonprofits have larger numbers of services and departments in mixed markets competing with for-profits while for-profits have larger numbers of services and departments in pure markets competing with other for-profits; for-profits appear less aggressive competitors than nonprofits. This indicates that competition is crucial to explain hospital decisions on PSMS investment which influence output, average prices, and profits. Thus, we focus on hospitals' PSMS competition to explain our empirical observations (Tables 1-4).

[Insert Tables 3 and 4 about here]

Contribution

We develop a duopoly model to help explain the empiric tables (Tables 1-4) and observations in the popular press (e.g., nonprofit hospitals have greater profitability) while examining the roles of service mix (basic services and PSMS) and competition (Web Appendix A shows our findings can generalize beyond duopolies). Our later empirical analysis of a large healthcare database shows the consistency of our duopoly model's predictions with observed duopoly markets and generalizes our findings beyond duopoly markets while controlling for factors outside our model.

We show analytically and empirically that the nonprofits' competitive advantage involves their investment in PSMS (not basic services). Although care quality (e.g., mortality, readmission rates) can influence hospital prices and profits, the literature conflicts on how and whether quality differs between nonprofits and for-profits (e.g., Rosenau and Linder 2003). Research often shows there is no systematic difference in quality by hospital status (e.g., Sloan et al. 2001). However, interestingly, we show nonprofits and for-profits do differ in PSMS breadth, and our service mix model can explain the observations in Tables 1-4 and some previously unobserved interaction effects (e.g., the effect of competition on the difference between nonprofits and for-profits). Finally, we explore the effects of service mix on hospital advertising.

No previous research studies how nonprofit hospital status influences service mix, PSMS breadth, output, price, and profits in competitive markets. Horwitz and Nichols (2009) exogenously classify 45 hospital services by profitability and empirically find nonprofits provide more profitable services (e.g., angioplasty) in markets with more for-profits. We shed light on this surprising observation and provide a more complete picture of hospital decisions (e.g., PSMS investment, PSMS breadth) and outcomes (e.g., price, profits) considering various exogenous factors (e.g., PSMS costs, competitive intensity). Liu and Weinberg (2004) model nonprofit organizations relying on donations. However, nonprofit hospitals obtain substantial revenue from services (private healthcare and Medicare) sold for fixed or negotiated reimbursements like nonprofit financial and educational services. Without considering service mix, Liu and Weinberg (2004) find nonprofit organizations always have lower prices than for-profit firms and charge higher prices competing with another nonprofit than a for-profit, which conflicts with our findings on hospital markets.

Some Key Findings

We find that for-profit and nonprofit hospitals have different marketing strategies.

- Nonprofits invest more aggressively in high-priced PSMS allowing them to obtain higher average prices than for-profits (see our pediatric care example).
- Despite higher average PSMS prices, nonprofits enjoy greater output and profits than for-profits due to minimal PSMS cannibalization (e.g., liver transplants do not substitute for heart transplants).
- The differences between nonprofits and for-profits increase as competition intensifies, where we measure competitive intensity using hospital substitutability.
- The differences between nonprofits and for-profits increase as technological advances decrease the costs of existing PSMS. For example, Block Imaging International Corporation is currently selling positron emission tomography-computed tomography (PET/CT) scanners for $100,000-$400,000, but old versions (PET only) previously cost $4 - $5 million (Hinz 1991). Not surprisingly, more

hospitals now have PET/CT scanners. We show that, as existing PSMS costs decrease over time, nonprofits invest even more in PSMS than for-profits, and the price gap between nonprofits and for-profits increases, consistent with Table 2. Of course, healthcare costs can still increase when new expensive PSMS emerge (Goyen and Debatin 2009).

- Both nonprofits and for-profits provide more PSMS and output having higher average prices and profits when competing with for-profits than when competing with nonprofits.
- Nonprofits focus more on national advertising than for-profits given the large geographic draw of PSMS.

Our findings are relevant to healthcare researchers, developers of PSMS technologies, employers providing healthcare plans, hospital administrators, patients, government policy makers, insurance companies, and others. The last section discusses the healthcare implications of our findings.

Analytical Analysis

Model

We study (1) why nonprofits and for-profits differ in service mix, output, prices, and profits, and (2) how competition affects those differences. Our model explains these differences (Tables 1-4) and provides new predictions on hospitals' competitive interactions. Our subsequent empirical analysis verifies these predictions and shows that our findings hold in more general settings.

To develop the implications of hospital service strategy while not being distracted by millions of different medical procedures, we partition hospitals' services into basic services and PSMS. Basic services (e.g., pharmaceutics, laboratory, diagnostics, physician-assistance, ward facilities, nursing) are cheaper, require less investment, and rely on local markets because patients prefer local care for basic services. Conversely, high-priced costly PSMS (e.g., robotic surgical procedures, treatment for mental disorders, obesity programs, implants, spinal cord injury programs, atherosclerosis treatment, magnetic resonance imaging, transplants, cosmetic surgery, neurosurgical intensive care, advanced cancer treatments including particle acceleration, trauma intensive care, 3-D mammography, tumor programs, etc.) require more skilled labor forces, advanced suppliers, and wider geographic markets because only a small fraction of locals need PSMS.

Like past nonprofit hospital research (Ellis 1998; Lien 2002), our service mix model is Cournot-Nash (i.e., output-setting) for several reasons. (1) Hospitals are capacity constrained making Cournot models more appropriate (Kreps and Scheinkman 1983). (2) Most empirical hospital studies use the Herfindahl index that assumes Cournot behavior (e.g., Dranove, Shanley, and White 1993; Gaynor, Ho, and Town 2015). (3) Although hospitals post prices, PSMS mix directly influences Medicare reimbursement rates which affect actual payments and effective prices (e.g., Reinhardt 2006). (4) The same reasoning holds for negotiated healthcare network reimbursement rates. (5) Cournot-Nash is more consistent with our empirical analysis than Bertrand-Nash (see Web Appendix B).

Hence, we model a Cournot duopoly, where two hospitals ($i = 1, 2$) set PSMS breadth (M_i) and the output of basic services (q_i^B) and PSMS (q_i^P). These hospital decisions determine the average basic service price (p_i^B) and PSMS price (p_i^P) hospital i obtains, where our average prices reflect actual average payments. Equation 1 shows the hospitals' average prices:

$$(1) \quad \begin{aligned} p_i^B &= \alpha_B - (q_i^B + \theta_B q_{\sim i}^B), \\ p_i^P &= \alpha_P + M_i - \theta_M M_{\sim i} - (q_i^P + \theta_P q_{\sim i}^P), \text{ for } i = 1, 2, \end{aligned}$$

where $\alpha_B, \alpha_P > 0$ are the intercepts for basic (B) and PSMS (P), respectively; $0 < \theta_M, \theta_B, \theta_P \leq 1$ capture hospital substitutability. A larger θ_l indicates that the two hospitals are more substitutable and thus more competitive for $l = M, B, P$, i.e., the rival's decisions on PSMS breadth and output have greater effects on the prices that hospital i obtains. For example, hospitals may have lower negotiated healthcare network prices when similar hospitals offer many PSMS (note, hospitals do not necessarily have the same PSMS). Let $\theta_M = 1$ for simplicity; Web Appendix C shows that our results hold in general. Table 5 provides our notation.

[Insert Table 5 about here]

Although Equation 1 is a standard inverse demand function, its interpretation in the healthcare context is worthwhile. In our Cournot model, when hospitals are committed to greater output (e.g., number of beds), the hospitals must accept lower average negotiated prices, for example, to attract larger healthcare networks having many patients. However, when hospitals increase PSMS breadth, they add new high-cost PSMS, commanding higher average prices without loss of output (see our pediatric care example).

From Equation 1, hospital i's profits from basic and PSMS (π_i^B, π_i^P) are given by

(2)
$$\pi_i^B = (p_i^B - c_B)q_i^B, \\ \pi_i^P = (p_i^P - c_P)q_i^P - kM_i^2, \text{ for } i = 1, 2,$$

where $c_j < \alpha_j$ denotes the marginal costs of hospital services for $j = B, P$ (e.g., labor, patient care supplies, radiographic films, medication, foods, laboratory reagents), and kM_i^2 denotes hospital i's fixed costs when investing in PSMS at level M_i (e.g., facilities, equipment, training, networking). PSMS often require specialty departments called wards that allow hospitals to provide PSMS (e.g., oncology, neurosurgery, obstetrics, pediatrics, orthopedics, critical intensive care). Advanced PSMS also require costly technology (e.g., Okpala 2018; Clemens 2017). We capture those costs with a quadratic PSMS cost function. For simplicity, let $\tilde{\alpha}_j = \alpha_j - c_j > 0$ for $j = B, P$. Constraining $k > 2$ ensures optimal finite solutions.

Now consider the model features.

First, we focus on hospitals' competitive service strategy. Our later empirical analysis and general model in Web Appendix A show that our findings generalize beyond duopolies.

Second, the average PSMS prices increase with greater PSMS breadth (M_i) as our pediatric care example illustrates because hospitals add more complex services rather than simpler services, which increase Medicare and healthcare network reimbursement rates. For example, a hospital with a level 1 trauma center may add a new level 3 trauma center; a hospital with basic nursery rooms (average $1,195 per day) may add advanced neonatal rooms (average $8,935 per day); a hospital with basic burn care may add an Advanced Burn Life Support (ABLS); a hospital performing heart transplants (average $1.4 million per patient) may likely offer less expensive transplants. However, the converse is unlikely. Adding expensive PSMS dramatically increases the average PSMS prices even when existing PSMS prices remain unchanged; note, as shown in our examples, increasing PSMS breadth is neither strictly horizontal nor strictly vertical. In addition, large healthcare networks find greater breadth attractive because they have patients with different medical conditions and patients unsure of their exact medical conditions. Consequently, greater PSMS breadth increases healthcare network payments, and it also increases Medicare reimbursement rates.

Third, as rival hospitals are more attractive (larger $M_{\sim i}$), maintaining output levels requires lower prices. For example, it is difficult to negotiate high healthcare network prices when similar hospitals offer many PSMS. Prices decline more when hospital substitutability is higher (i.e., the market is more competitive). Beyond output, competition also occurs on service breadth.

Fourth, service breadth differs from quality (Propper, Burgess, and Green 2004). Beyond obvious differences in empirical measures for service breadth (e.g., number of services) and care quality (e.g., mortality rates), conceptual differences exist. Higher quality raises prices because buyers will pay more, but demand may decrease. In contrast, adding PSMS increases the number of patients because cannibalization is minimal given limited substitutability. Liver transplants do not compete with heart transplants. Patients seldom upgrade from 1st degree burn-care to ABLS. Our equilibrium outcomes capture the positive relationships of PSMS breadth with both price and demand.

Table 6 provides some empirical observations consistent with our model. We find that hospitals with greater PSMS breadth have less popular, more expensive services and a higher case mix index (CMI). CMI is a standard measure of a hospital's disease severity (i.e., the complexity and costs of a hospital's average medical procedures). CMI also reflects expected reimbursement rates because Medicare, Medicaid, and many third-party payers (e.g., Blue Cross) adopt case-mix reimbursement systems (Steinwald and Dummit 1989). We see that, when hospitals expand PSMS breadth, they add more advanced, expensive PSMS (e.g., critical neonatal care, ABLS, heart transplants) having higher CMI, expected reimbursement rates, and average payments while attracting new patients.

[Insert Table 6 about here]

Fifth, our profit function captures enormous investments required for adding PSMS. For example, Mercyhealth's new level III neonatal intensive care unit (NICU) and pediatric trauma center cost $.5 billion (McCallum 2018). A 16-bed level III tertiary NICU is $37.8 million ($2.4 million per bed).

Sixth, our model is aggregate. Hospital markets are complex and not patient-driven (see Dranove, Shanley, and White 1993). Table 7 shows that households' out-of-pocket payments are small, 2.9% in 2016, rapidly declining from 20.6% in 1960. Hospitals often negotiate with healthcare networks having patients with many different medical conditions. Hence, service breadth becomes important. Many other agents can influence hospital prices and demand including employer healthcare plans, health insurance companies, health maintenance organizations, pharmaceutical firms, government agencies, regulators, etc. Although important, modeling all these agents is beyond the scope of our analyses and awaits future research.

[Insert Table 7 about here]

Objective Functions: For-profit vs. Nonprofit

For-profits seek profits for their stakeholders. However, nonprofits have no well-defined residual claimant, making their objective ill-defined (Pope 1989; Sloan 2000). Past studies assume different nonprofit objectives that predict different outcomes (e.g., Hoerger 1991; White 2013). Fortunately, different predictions allow empirical testing (e.g., Harrison and Lybecker 2005; Horwitz and Nichols 2009). Some studies suggest nonprofits maximize profits, claiming nonprofit status to avoid taxation (Sloan and Vraciu 1983; Weisbrod 1998; Hirth 1999; David 2009). However, Deneffe and Masson (2002) and Chang and Jacobson (2011) empirically show that pure profit-seeking is unlikely. Some studies suggest altruism or maximization of social welfare (Lien 2002). Deneffe and Masson (2002) and Chang and Jacobson (2011) also show that pure altruism is unlikely. Albeit less popular, other nonprofit objectives include maximizing prestige - a combination of output and quality (Rosenman, Li, and Friesner 2000) and maximizing privileged employee rewards (Pauly and Redisch 1973).

We model nonprofit hospitals as seeking a combination of profits and output for three reasons.

First, that objective is consistent with empirical observations (Zwanziger, Melnick, and Bamezai 2000; Deneffe and Masson 2002; Dranove, Garthwaite, and Ody 2017) including our data. Note that most healthcare researchers use that objective (Dranove 1988; Philipson and Posner 2009; Gaynor, Ho, and Town 2015; Gowrisankaran, Nevo, and Town 2015).

Second, nonprofit compensation contracts reward executives on both output (patient growth) and profits (e.g., Kramer and Santerre 2010; Hancock 2013; Reiter et al. 2009). Nonprofits seek output because they should produce community benefits such as uncompensated care (Baumol and Bowen 1965; Rose-Ackerman 1987; Gaynor and Vogt 2003; Lakdawalla and Philipson 2006; Horwitz and Nichols 2009). Nonprofits also seek profits because, given that outside nonprofit income sources are often limited or purpose restricted, they need profits to provide necessary cash flow for operating hospitals. Moreover, profits make tax-free bonds attractive for nonprofit investment, and these bonds allow nonprofit growth and long-term viability (Adelino, Lewellen, and Sundaram 2015).

Third, although a nonprofit objective is sometimes subject to a zero-profit constraint (Newhouse 1970; Sloan et al. 1990), that constraint conflicts with our observations in Table 1 and later empirical analysis; note, recent research seldom uses the zero-profit constraint.

Based on these reasons, we model for-profits as maximizing profits and nonprofits as maximizing a weighted sum of profits and output. Thus, hospital i's objective function (Π_i) is given by

$$\Pi_i = \pi_i + \beta_i(q_i^B + q_i^P), \text{ for } i = 1, 2, \tag{3}$$

where $\pi_i = \pi_i^B + \pi_i^P$ is hospital i's total profits from Equation 2. In Equation 3, $\beta_i \geq 0$ captures hospital i's weight on output. For nonprofits, $\beta_i = \beta > 0$, and for for-profits, $\beta_i = 0$. Web Appendix D provides a model for social welfare maximizing nonprofits and its implications.

Equilibrium Outcomes

Adding PSMS requires expertise, facilities, and hardware (e.g., life-support, diagnostic, treatment and therapeutic devices) like R&D investments. Thus, we adopt the conventional approach of a two-stage competitive R&D game (e.g., Kamien, Muller, and Zang 1992). In stage 1, the forward-looking hospitals determine how much they invest in PSMS breadth (M_i). In stage 2, having observed the investment levels, the hospitals determine output quantity for basic services and PSMS (q_i^B, q_i^P). For example, hospitals build wards and set output after completion. Prices are at the level corresponding to that output given the specified service breadth; see Equation 1.

The hospitals find the optimal decisions to maximize their objectives in Equation 3. Solving this game by backward induction, we derive the unique subgame-perfect Nash equilibrium:

$$\begin{aligned} &M_i^* = [K\tilde{\alpha}_P + \{2(2-\theta_P)k - 1\}\beta_i - \{\theta_P(2-\theta_P)k + 1\}\beta_{\sim i}]/[kK(4-\theta_P^{\,2})], \\ &q_i^{P*} = (2-\theta_P)kM_i^*,\ q_i^{B*} = [(2-\theta_B)\tilde{\alpha}_B + 2\beta_i - \theta_B\beta_{\sim i}]/(4-\theta_B^{\,2}), \end{aligned} \tag{4}$$

where M_i^* and q_i^{j*} are equilibrium PSMS breadth and output for $j = B, P$; $K = (2 - \theta_P)^2 k - 2 > 0$. Substituting Equation 4 into Equations 1 and 2, we obtain equilibrium prices (p_i^{j*}) and profits (π_i^{j*}):

$$(5) \qquad \begin{aligned} & p_i^{j*} = q_i^{j*} - \beta_i + c_j, \\ & \pi_i^{B*} = (q_i^{B*} - \beta_i) q_i^{B*},\ \pi_i^{P*} = k(K+1)(M_i^*)^2 - \beta_i q_i^{P*},\ \text{for } i = 1, 2,\ j = B, P. \end{aligned}$$

Let $m_i^{j*} = q_i^{j*}/(q_1^{j*} + q_2^{j*})$, i.e., hospital i's market share for $j = B, P$, and Δ denote the between-hospital difference operator for any equilibrium outcomes (e.g., $\Delta M^* = M_2^* - M_1^*$, $\Delta q^{B*} = q_2^{B*} - q_1^{B*}$).

Note that, in a mixed market, we assume $\beta < \tilde{\alpha}_P K/[\theta_P(2 - \theta_P)k + 1]$ and $\theta_j \tilde{\alpha}_j < \beta < \tilde{\alpha}_j$ for $j = B, P$, i.e., nonprofits weigh output sufficiently to clearly distinguishable them from for-profits, yet nonprofits do not weigh output so much that nonprofits could drive for-profits from the market, excluding the degenerate cases of $M_i^* \le 0$ or $q_i^{j*} \le 0$ for for-profits from Equation 4.

Comparing Different Market Structures: Mixed vs. Pure Markets

This section compares hospital behavior in mixed markets where nonprofits compete with for-profits to pure markets where like-hospitals compete. In theory, pure markets can consist of only for-profits. However, many pure markets consist of only nonprofits due to state regulations.

From Equations 4 and 5, Lemma 1 follows. All proofs are in the appendix.

Lemma 1: All hospital types provide more PSMS and output having higher prices and profits when competing with for-profits than when competing with nonprofits.

Lemma 1 proves that hospitals are worse off competing with nonprofits than competing with for-profits, consistent with Table 4. In our model, the willingness of nonprofits to sacrifice some profits for output causes them to more aggressively respond to the competitor's actions than for-profits. For example, let $\delta_1 < 0$ denote a price cut by hospital 1. For-profit hospital 2 responds with price cut

$\delta_2^{FP} = \delta_1/2$. However, when hospital 2 is nonprofit, its price cut becomes $\delta_2^{NP} = (\delta_1 - \beta_2)/2 < \delta_2^{FP} < 0$, making investment in PSMS less attractive. Thus, any hospital types competing with nonprofits provide less PSMS obtaining lower output (or market share), prices, and profits than competing with for-profits that are less responsive to price decreases given their profit-maximizing objective.

Competition Between Nonprofit and For-profit Hospitals

Basic services. We compared different market types. Now, we compare the equilibrium outcomes of for-profits ($\beta_1 = 0$) and nonprofits ($\beta_2 = \beta > 0$) in the same mixed market. Lemma 2 reveals hospitals' output decisions for basic services in mixed markets.

> **Lemma 2:** (Basic Services-Output) In mixed markets, nonprofit hospitals produce greater basic service output than for-profit hospitals; $q_2^{B*} > q_1^{B*}$. Greater competition increases the output difference, $\partial(\Delta q^{B*})/\,\partial\theta_B > 0$, but $\partial q_2^{B*}/\,\partial\theta_B$ is not necessarily positive.

Lemma 2 looks simpler than it is. The effect of competitive intensity (θ_B) on hospitals' output decisions is complex in mixed markets. The intuition depends on the nonprofits' ability to poach patients from for-profits. A very small θ_B protects for-profits from nonprofits' patient poaching because each hospital is a monopolist with little influence over the other. As θ_B grows, the hospitals can poach each other's patients, so the competition decreases equilibrium output quantities for both nonprofits and for-profits. As θ_B grows still larger, only nonprofits find poaching more beneficial because small sacrifices in profits yield large gains in output. Hence, the nonprofits' output changes non-monotonically with θ_B. However, as Lemma 2 reveals, the difference in output is monotonically increasing in θ_B because, facing greater competition, for-profits always cede share to nonprofits. In sum, when competition intensifies, the difference between nonprofit and for-profit hospitals' output (e.g., number of patients) increases because nonprofit hospitals can easily increase their share over for-profit hospitals. However, the number of nonprofit patients does not necessarily increase because competition decreases the profitability of adding patients.

Lemma 3 shows equilibrium prices and profits for basic services given the equilibrium output.

Lemma 3: (Basic Services-Average Prices and Profits) For-profit hospitals have higher average basic service prices and profits than nonprofit hospitals; $p_1^{B*} > p_2^{B*}$ and $\pi_1^{B*} > \pi_2^{B*}$.

For basic services, given the nonprofit output-orientation, for-profits produce less output but have higher average prices, obtaining greater profits than nonprofits. For PSMS, in contrast, we will show that nonprofits can achieve both higher prices and profits. Service mix is the key.

PSMS (premium specialty medical services). We found that output-seeking nonprofits provide greater basic service output with lower average basic service prices and profits than for-profits. Now, we show how PSMS allow nonprofits to achieve larger profits with both greater output and higher average prices than for-profits. Different for-profit and nonprofit objectives cause them to adopt different strategies.

Proposition 1 shows nonprofits and for-profits' differences in PSMS investment and output.

Proposition 1: (PSMS-Investment and Output) Compared with for-profit hospitals, nonprofit hospitals invest more in PSMS, have greater output, and achieve greater market share; $M_2^* > M_1^*$; $q_2^{P*} > q_1^{P*}$; $m_2^{P*} > m_1^{P*}$. Greater competition increases those differences; $\partial(\Delta M^*)/\,\partial\theta_P > 0$; $\partial(\Delta q^{P*})/\,\partial\theta_P > 0$; $\partial(\Delta m^{P*})/\,\partial\theta_P > 0$. Lower PSMS costs also increase them; $\partial(\Delta M^*)/\,\partial k < 0$; $\partial(\Delta q^{P*})/\,\partial k < 0$; $\partial(\Delta m^{P*})/\,\partial k < 0$.

Proposition 1 is consistent with the greater nonprofit PSMS and output statistics in Table 3. The next section provides an empirical analysis that replicates the differences (main effects) and shows the competition effects on those differences (interaction effects) while controlling for other factors.

Proposition 1 shows that, at equilibrium, output-seeking nonprofits make greater investments in PSMS and produce greater output. As competition intensifies, foreseeing lower PSMS prices, for-profits invest less in PSMS (i.e., have fewer PSMS) and produce less output. However, nonprofits respond with larger PSMS investment because nonprofits can easily poach PSMS patients from for-profits. Thus, greater competition increases the differences in PSMS breadth and output (nonprofit vs. for-profit). In contrast, the difference in PSMS breadth decreases when the costs of investing in PSMS increase because the cost increases affect nonprofits more severely given their larger incentive to invest in PSMS. Less investment reduces nonprofits' output and their competitive advantage.

Given the investment and output decisions, Proposition 2 provides equilibrium PSMS prices.

Proposition 2: (PSMS-Average Prices) Given sufficient competition, nonprofit hospitals have higher average PSMS prices than for-profit hospitals; otherwise, for-profits have higher average PSMS prices; $p_2^{P*} > p_1^{P*}$ if and only if $\theta_P > (3 - \sqrt{1 + 8/k})/2$. Greater competition increases the price gap; $\partial(\Delta p^{P*})/\,\partial\theta_P > 0$. Lower PSMS costs also increase it; $\partial(\Delta p^{P*})/\,\partial k < 0$.

As noted earlier, we later measure the competitive intensity, θ_P, by hospital substitutability. To understand Proposition 2, consider the case with no competition. The hospitals would maximize their own objectives by investing in PSMS. Given their PSMS, profit-seeking for-profits would provide less PSMS output having higher average prices for better profits than nonprofits that also seek output. As the competition intensifies, for-profits invest less in PSMS while nonprofits invest more in PSMS because competitive output-oriented nonprofits can easily poach for-profit patients. The nonprofits' larger PSMS investment causes them to have higher average prices, and the price difference further increases with greater competition.

When PSMS investment costs increase, the nonprofits' poaching strategy becomes more costly, effectively lessening competition. Therefore, the price gap decreases. However, when technological advances decrease the costs of existing PSMS (Pucci et al. 2017), nonprofits focusing on growth add more PSMS than for-profits, increasing the price gap, consistent with Table 2 and our previous PET example. Of course, healthcare costs can still increase as new costly PSMS emerge.

Corollary 1 shows the effects of increased investment costs on PSMS prices may be surprising.

Corollary 1: As the costs of investing in PSMS increase, the for-profit's average PSMS price increases, but the nonprofit's average PSMS price decreases; $\partial p_1^{P*} / \partial k > 0$ and $\partial p_2^{P*} / \partial k < 0$.

Higher PSMS costs reduce nonprofits' incentive to poach patients by adding PSMS, decreasing competition. Thus, for-profits return to high monopolistic prices while nonprofits do the opposite. Recall, for basic services, for-profits have higher prices than nonprofits. See Table 8.

[Insert Table 8 about here]

Last, Proposition 3 shows when nonprofits have greater PSMS profits than for-profits.

Proposition 3:(PSMS-Profits) Nonprofit hospitals attain greater profits than for-profit hospitals for PSMS, $\pi_2^{P*} > \pi_1^{P*}$, if and only if the cost of investing in PSMS is sufficiently small, $k < (1-\theta_P)(2\tilde{\alpha}_P + \beta)/[(2-\theta_P)^2(\beta - \theta_P\tilde{\alpha}_P)]$.

If nonprofits behave like for-profits (i.e., $\beta < \theta_P\tilde{\alpha}_P$), the less nonprofit weight on output can result in nonprofits' greater PSMS profits (see the appendix). Interestingly, even with larger weight (i.e., $\beta > \theta_P\tilde{\alpha}_P$), Proposition 3 shows that nonprofits can attain greater profits than for-profits when technological advances reduce the costs of PSMS. With greater PSMS opportunities, output-seeking nonprofits invest even more in PSMS than for-profits, achieving higher relative output and average prices (see Propositions 1-2). This implies that technological advances may allow greater expansion of healthcare service mix from nonprofits rather than for-profits.

In brief, nonprofits dominate PSMS markets, which allows them to have both greater output and higher average prices than for-profits. Greater competition further increases the differences in output and price. Hence, the profit difference is larger in a highly competitive market than in a monopolistic market. Corollary 2 follows.

Corollary 2: The PSMS profit difference between nonprofit and for-profit hospitals is larger in a competitive market ($\theta_P \to 1$) than in a monopolistic market ($\theta_P \to 0$).

Propositions 1-3 explain our empirical observations (Tables 1-4). On average, nonprofit hospitals have more clinical departments and services (PSMS), produce greater output, have higher average prices, and obtain larger profits than for-profit hospitals. The next section provides new empirical analyses consistent with our analytical results.

Empirical Analysis

Our prior analysis explains how nonprofit hospitals differ from for-profit hospitals and suggests some nonobvious interaction effects. (1) Nonprofits invest more in PSMS and provide more output of both basic services and PSMS. (2) The nonprofits' aggressive investment allows them to obtain higher average prices and profits because it deters PSMS investment by forward-looking for-profits. (3) Greater competition increases the differences between nonprofit and for-profit hospitals. This section shows our U.S. hospital data are consistent with our analytical results while providing several new empirical findings.

Data

Our integrated database includes data from the American Hospital Directory (AHD), the Centers for Medicare & Medicaid Services, American Hospital Association, American Health Information Management Association, Centers for Disease Control and Prevention, National Center for Health Statistics, U.S. Census Bureau (American Community Survey, Decennial Census, and Population Estimates Program), the Kaiser State Health Facts, American Health Care Association, and Kantar Media. We use 2016 hospital-specific data sets from the AHD including 2,438 U.S. hospitals (1,677 nonprofits and 761 for-profits) from 1,000 counties in 35 states. We define the market by county.

We have 11 focal variables. First, we have two measures of PSMS breadth: the number of clinical departments (e.g., cardiovascular, neurosurgery, oncology, organ transplant, radiology, etc.) and the number of clinical services from all departments. For example, a cardiovascular department might have cardiac Cath lab, rehabilitation, surgery, stenting, coronary interventions, etc. Second, we have 6 output measures: the number of Medicare certified beds, emergency-room treatments (admitted plus non-admitted), surgeries (inpatients plus outpatients), patient days, discharges, and outpatient visits. Third, we include the average prices and profits computed from the AHD. Last, we include CMI that measures the average service complexity and costs reflecting expected reimbursement rates (e.g., Steinwald and Dummit 1989); Medicare, Medicaid, and many third-party payers use case-mix reimbursement systems. Note, greater PSMS breadth leads to higher CMI (Table 6). Let Y_{ij} denote hospital i's variable j for $j = 1, \ldots, 11$. See Table 9.

[Insert Table 9 about here]

Note that (1) we do not use posted prices because indigents may pay less. We use actual payments and imputed prices (i.e., revenue/output), so charitable actions decrease nonprofit prices, i.e., work against our theory. (2) We calculate profits by using standard accounting income adjusted for capital expenditures by subtracting accumulated depreciation. (3) We do all profit comparisons before tax, i.e., nonprofits do not enjoy a tax advantage in our calculations. Hence, our price and profit measures are tightly linked to our analytical model.

We treat the hospital status (for-profit vs. nonprofit) as exogenous in part because founder intent depends on exogenous factors. See our Spectrum Health Butterworth Hospital example. Founders' intent is the primary determinant of initial hospital status. For founders seeking profit or control, only for-profits are appropriate because legal restrictions prohibit nonprofits from distributing profits or other benefits to stakeholders. Founders cannot recover assets accumulated by nonprofits or retain control after founding nonprofits. Note that nonprofit finances are open to the public for inspection allowing public scrutiny. Many nonprofits grew from religious foundations; others often grew from philanthropic bequests for altruistic reasons. In addition, most hospitals were founded decades before current service mix decisions. It is unlikely that founders anticipated neoteric marketing strategy in PSMS breadth, output, and advertising, lessening any simultaneity bias.

Our empirical analyses benefit from natural exogenous variations in the market mix caused by some state laws effectively prohibiting for-profit entry. For example, Connecticut allows state vetoes of any nonprofit hospital sale to a for-profit entity. Illinois has severely limited the operations of the for-profits by micromanaging these hospitals, prohibiting new branches, and stopping the expansion of outpatient facilities. Vermont and many other states have Certificate-of-Need (CON) laws. CON laws are meant to contain costs, but they can prevent competition by inhibiting entry. These different state laws induce ample exogenous, heterogeneous variations in the market mix (hospital type and competitive intensity) across states and regions within the state. We exploit the exogenous variations to (1) compare the markets with different compositions of nonprofit and for-profit hospitals and (2) study how the competitive intensity affects the differences between nonprofits and for-profits.

We have 44 supply-side and demand-side control variables, denoted $\mathbf{X}_i$. Our supply-side controls include three specialty hospital classes defined by law (e.g., the Affordable Care Act) and regulatory agencies. The three classes are Low Volume Hospital (LVH_i), Sole Community Hospital (SCH_i), and Rural Referral Center (RRC_i), where $LVH_i = 1$ if hospital i is more than 15 road miles from another hospital with less than 1,600 discharges; $SCH_i = 1$ if hospital i is located more than 35 miles from other like-hospitals and meets other geographic conditions; $RRC_i = 1$ if hospital i is a high-volume hospital in a rural area and satisfies certain criteria on hospital facilities; otherwise, zero (for more information, see www.ecfr.gov). We also control for university and church-owned hospitals which can possibly have different marketing strategies. For the demand-side controls, we use 2016 market demographics defined by the U.S. Census Bureau including population, poverty, median income and the numbers of births and deaths. We also control for state fixed effects.

Empirical Results: Duopoly Cases

We provide an empirical analysis comparing mixed and pure duopoly markets, consistent with our competitive analytical duopoly model, before checking generality in more complex settings. Our duopoly model suggests that, given different objectives, nonprofits provide more PSMS and output obtaining higher average prices and profits in mixed markets competing with for-profits while for-profits provide more PSMS and output obtaining higher average prices and profits in pure markets competing with like for-profits (Lemma 1); see Table 4 for PSMS breadth. To check the consistency of those model results with our data, using only duopoly markets, we regress our measures of output, price, expected reimbursement rates, and profits on the competitor type (FR_i), the inverse PSMS breadth ($\text{No. Services}_i^{-1}$), and their interaction. See Equation 6.

(6) $$Y_{ij} = \phi_{0j} + \phi_{1j} FR_i + \phi_{2j} \text{No.Services}_i^{-1} + \phi_{3j} FR_i \times \text{No.Services}_i^{-1} + \varphi_{ij}, \text{ for } i \in \text{Duopoly},$$

where $\mathrm{FR_i}$ is an indicator that equals 1 if hospital i competes with a for-profit rival (FR) and zero otherwise; $\mathrm{No.Services_i}$ is hospital i's number of clinical services (PSMS breadth); $\mathrm{Duopoly} = \{\mathrm{i} \mid$ hospital i is in a duopoly market$\}$; $\varphi_{ij} \sim \mathrm{NID}(0, \sigma^2_{\varphi_j})$. From Lemma 1, we expect $\mathrm{FR_i}$ has positive effects. Moreover, in Equations 4 and 5, the positive relationships of PSMS breadth with output and price suggest that $\mathrm{No.Services_i}$ has positive effects on the hospital output, average prices, expected reimbursement rates, and profits. We also expect higher $\mathrm{No.Services_i}$ increases the positive effects of $\mathrm{FR_i}$ because having more PSMS increases the hospitals' competitive advantage.

Note, our data include 160 duopoly markets. Most of the pure markets are nonprofit (56.1%) due to the Hill-Burton Act (White 1982) and some state regulations exogenously inhibiting for-profits' entry. Mixed markets comprise 32.4%, and the remaining 11.5% are pure for-profit markets.

Table 10 shows the estimation results. The positive coefficients of $\mathrm{FR_i}$ indicate that, regardless of the ownership, hospitals have higher output, average prices, CMI (expected reimbursement rates), and profits competing with for-profits than competing with nonprofits, consistent with Lemma 1. In the next section, we show that these results can generalize beyond duopoly markets. Moreover, as hypothesized, the negative coefficients of $\mathrm{No.Services_i^{-1}}$ show that greater PSMS breadth leads to higher output, average prices, expected reimbursement rates, and profits. Last, the coefficients of $\mathrm{FR_i} \times \mathrm{No.Services_i^{-1}}$ are negative and significant. This indicates as hypothesized that given greater PSMS breadth, hospitals are even better off competing with a for-profit rival.

[Insert Table 10 about here]

Empirical Results: General Cases

This section explores the generality of our findings beyond duopoly markets. We show that, in general cases, competition has similar effects on the behavior of nonprofits and for-profits.

Our analytical model defines competitive intensity as hospital substitutability, so we measure the market-level competitive intensity using the market-level differentiation. See Equation 7.

(7) $$\mathrm{DIF_i} = \left[\frac{\sum_{i_1, i_2 \in \mathrm{County_i}} \sum_{s \in \mathrm{Service_i}} \delta_{i_1 s} \delta_{i_2 s}}{\sum_{i_1, i_2 \in \mathrm{County_i}} \sum_{s \in \mathrm{Service_i}} 1} \right]^{-1},$$

where $\mathrm{Services_i} = \{\mathrm{s}$ | service s is offered in hospital i's market, $\forall \mathrm{s}\}$; $\mathrm{County_i} = \{\mathrm{l}$ | hospitals l and i are located in the same market, $\forall \mathrm{l}\}$; $\delta_{\mathrm{is}} = 1$ if hospital i has service s, and zero otherwise.

A larger $\mathrm{DIF_i}$ indicates that fewer services are offered by two or more hospitals, i.e., high market-level differentiation. Conversely, a smaller $\mathrm{DIF_i}$ indicates low market-level differentiation. Hence, $\mathrm{DIF_i}$ captures the market-level differentiation, which is inversely related to the competitive intensity in our theory. Although a hospital's selection of services affects $\mathrm{DIF_i}$, there is no natural relationship between $\mathrm{DIF_i}$ and PSMS breadth. For example, when a hospital adds a service, $\mathrm{DIF_i}$ decreases if other hospitals offer the same service and increases otherwise. Service selection rather than PSMS breadth determines $\mathrm{DIF_i}$. Therefore, we expect no endogeneity problems from reverse causality. In addition, Web Appendix E shows our empirical results hold for a different measure of competition, i.e., the Herfindahl index.

Market share analysis. We found nonprofits in duopoly markets gain from competing with for-profits over nonprofits. To generalize beyond duopolies, we consider the proportion of for-profits in hospital i's market, denoted $\mathrm{Profit(\%)_i}$. Nonprofits face more for-profit rivals (for-profit-like competition) as $\mathrm{Profit(\%)_i}$ increases and more nonprofit rivals (nonprofit-like competition) as it decreases. Then, we hypothesize that, with higher $\mathrm{Profit(\%)_i}$, nonprofits will seek a greater share of PSMS and output, and that effect increases as competition increases. To check that hypothesis, we regress the logarithm of nonprofit market share (Cooper 1993) on $\mathrm{Profit}(\%)_i$, DIF_i, and their interaction. See Equation 8.

(8) $$\log \mathrm{Y}(\%)_{ij} = \alpha_{0j} + \alpha_{1j}\mathrm{Profit}(\%)_i + \alpha_{2j}\mathrm{DIF}_i + \alpha_{3j}\mathrm{Profit}(\%)_i \times \mathrm{DIF}_i + \mathbf{a}_{1j}\mathbf{X}_i + \varepsilon_{ij},$$

where $\mathrm{Y}(\%)_{ij} = \mathrm{Y}_{ij} / \sum_{i \in \mathrm{County}_i} \mathrm{Y}_{ij}$ and $\varepsilon_{ij} \sim \mathrm{NID}(0, \sigma^2_{\varepsilon_j})$ for $j = 1, \ldots, 8$.

Table 11 shows the estimation results. The coefficients of $\mathrm{Profit}(\%)_i$ are all significant, positive. Hence, consistent with Lemma 1, competing in more for-profit-like markets, nonprofits have greater shares of both PSMS and output. The negative coefficients of $\mathrm{Profit}(\%)_i \times \mathrm{DIF}_i$ indicate that those positive effects increase with greater competition, consistent with Lemma 2 and Proposition 1 (note that DIF_i is inversely related to the competitive intensity).

[Insert Table 11 about here]

PSMS breadth, output, price, and profit analyses. Now, we show that our mixed duopoly results can generalize. Generalizing the findings of Propositions 1-3 and Corollary 2, we hypothesize that, on average, nonprofits have greater PSMS breadth than for-profits across different markets, and greater competition increases their differences in PSMS breadth, output, average price, and profits. Note that our oligopoly model in Web Appendix A provides some theoretical support for these generalizations. To check our hypothesis for general cases, using all markets in our data, we regress our measures of PSMS breadth, output, price, and profits on the nonprofit status, DIF_i, and their interaction. See Equation 9.

(9) $$\mathrm{Y}_{ij} = \beta_{0j} + \beta_{1j}\mathrm{Nonprofit}_i + \beta_{2j}\mathrm{DIF}_i + \beta_{3j}\mathrm{Nonprofit}_i \times \mathrm{DIF}_i + \mathbf{a}_{2j}\mathbf{X}_i + \eta_{ij},$$

where $\mathrm{Nonprofit}_i$ is an indicator which equals 1 if hospital i is nonprofit and zero otherwise; $\eta_{ij} \sim \mathrm{NID}(0, \sigma^2_{\eta_j})$ for $j = 1, \ldots, 10$.

Table 12 shows the estimation results. The coefficients of $\mathrm{Nonprofit}_i$ are all significant, positive. Thus, on average, nonprofits provide more PSMS, produce more output, and obtain greater profits with higher average prices than for-profits. The significant, negative coefficients of $\mathrm{Nonprofit_i} \times \mathrm{DIF_i}$ show that those differences increase as competition intensifies ($\mathrm{DIF_i}$ decreases). These results are consistent with our hypothesis. Our findings seem to generalize beyond duopolies.

[Insert Table 12 about here]

Hospital Advertising

Advertising can be local or national (Sridhar et al. 2016). Nonprofit hospitals with more PSMS require a larger geographic footprint. Hence, nonprofits would focus more on national advertising, which can appeal to distant patients who seek PSMS, than for-profits. In contrast, for-profits would focus more on local advertising than nonprofits because for-profits rely more on basic services than nonprofits, and locals prefer local care for basic services; i.e., for-profits might obtain greater return through local advertising than nonprofits.

To check this prediction, we employ 2014 Kantar Media advertising spending data for 190 private hospitals. We classify outdoor advertising (e.g., transit displays) as local and other advertising (e.g., national TV commercials), targeting broader markets, as national. We regress the ratio of the national advertising expenditure to the total media expenditure ($\mathrm{N_i}$) on the nonprofit indicator ($\mathrm{Nonprofit_i}$). See Equation 10.

(10) $$\mathrm{N_i} = \gamma_0 + \gamma_1 \mathrm{Nonprofit_i} + a\mathbf{W}_i + \zeta_i,$$

where $\mathbf{W}_\mathrm{i}$ includes the control variables in $\mathbf{X}_\mathrm{i}$ except, given fewer observations, state fixed effects, and $\zeta_i \sim \mathrm{NID}(0, \sigma_\zeta^2)$. We find that the coefficient of $\mathrm{Nonprofit_i}$ is positive and significant ($\gamma_1 = .28$, $t = 4.44$). Therefore, nonprofits allocate a larger percent of their advertising expenditure on national advertising than for-profits; i.e., for-profits allocate more on local advertising than nonprofits. As we hypothesized, the nonprofit PSMS focus favors national advertising while the for-profit basic service focus favors local advertising.

Conclusions

Our analytical model and empirical analyses of several large healthcare databases explain how nonprofit hospitals achieve higher average prices and profits than for-profit hospitals while providing new findings on hospital competition. The key is the service mix. We find nonprofit hospitals have a broader service mix than for-profit hospitals. Greater breadth also implies higher average prices (i.e., payments, reimbursements) because hospitals expand their existing services (e.g., add level III trauma or burn centers to level II centers) or add higher-priced advanced PSMS (e.g., neurosurgery, pediatric trauma, neonatal intensive care, oncology, epilepsy, tomography, critical intensive care) allowing more complex medical procedures. Given limited substitutability of additional PSMS (e.g., liver transplants do not substitute for heart transplants), a broader mix also increases output (e.g., treatments, surgeries, procedures) with minimal cannibalism.

For basic services, we find nonprofits provide greater output, having lower prices and profits than for-profits. However, we show the nonprofits' willingness to sacrifice profits for output leads them to invest more in PSMS than for-profits. Larger PSMS investment allows nonprofits to achieve larger profits with both higher average prices and greater output than for-profits, where greater nonprofit investment deters for-profit investment.

Our competitive service mix model helps explain interesting empirical observations on nonprofit profitability and the effect of competition on service mix (e.g., Horwitz and Nichols 2009). Without competition, for-profits would offer PSMS at higher average prices than nonprofits having greater profits. With greater competition, output-valuing nonprofits find poaching more beneficial, so for-profits cannot retain high-priced PSMS, decreasing investment in PSMS. With less for-profit PSMS investment, nonprofits invest more, obtaining higher PSMS prices and profits than for-profits. Thus, intensifying competition leads to greater differences between nonprofits and for-profits in PSMS breadth, output, price, and profits. Moreover, given the nonprofits' aggressive investment in PSMS, both hospital types have a broader service mix competing with for-profits than nonprofits.

Our model can also explain why the differences between nonprofits and for-profits are increasing (see Table 2). As technological advances decrease existing PSMS costs, output-seeking nonprofits invest more aggressively in PSMS than for-profits, increasing their gaps in output and price. Perhaps, nonprofits contribute more to expanding the healthcare service mix. Of course, new emerging PSMS can increase healthcare costs.

In addition, our findings suggest nonprofit and for-profit hospitals have different communication strategies. With greater PSMS breadth, nonprofits focus more on national advertising than for-profits because national advertising reaches distant markets needed to support PSMS. In contrast, for-profits with fewer PSMS may focus more on local advertising than nonprofits because the local community usually prefers local hospitals for basic services.

Although we model hospital markets, our findings may apply elsewhere. We expect our findings are more relevant for revenue-based nonprofits (e.g., credit unions, TIAA-CREF, YMCA, museums, universities, and private schools) that enjoy substantial profits rather than donation-based nonprofits (e.g., labor unions, churches, charities, political organizations, and volunteer services). For example, if museums have similar objective functions to those of hospitals; nonprofit museums might have more premium exhibitions than for-profit museums. Similarly, if private schools and hospitals have similar objectives, nonprofit schools might invest more in new advanced facilities (e.g., physics labs, supercomputer centers, etc.) than for-profit schools. However, before generalizing, we should check whether our model assumptions hold or not (e.g., objective functions, Cournot competition, etc.).

Finally, our study has limitations. First, our analysis is aggregate. Modeling patients, healthcare networks, and PSMS selection will help us better understand hospitals' marketing decisions. Second, inferring causality from non-experimental data is precarious. Our empirical analysis is no exception. Third, our advertising results are preliminary, so replication with better data is essential.

Implications

We provide some useful implications on hospital management and public policy. First, managing nonprofits may require more expertise and more highly compensated staff given additional PSMS complexity in operations, marketing, advertising, and financing. In fact, more expertise may explain controversially large nonprofit hospitals' executive salaries beyond popular explanations involving irresponsible boards of directors and cronyism.

Second, beyond community benefits, e.g., serving under-insured and impoverished communities, the nonprofit tax relief may create access to more services. Thus, grants might focus on nonprofits for reasons other than treatment of indigents. Moreover, allowing for-profit entry may be useful not for lower prices but for increased availability of nonprofit PSMS.

Last, nonprofits with greater PSMS breadth might require local labor with greater skills. It may affect nonprofits' locational choice, their alliances with local institutions, and perhaps, gentrification of their immediate geographic area.

Future Research

Our new findings would gain from additional validation and consideration of many other factors. However, given these caveats, the following list offers several recommendations from our findings at least worthy of future inquiry for investors, patients, physicians, hospital suppliers, philanthropists, insurance companies, Medicare, policy makers, and regulators.

- Hospital vendors offering cutting-edge medical devices and pharmaceutical firms launching innovative drugs might focus on nonprofits.

- PSMS expansion potentially facilitates donations given direct opportunities for naming rights and associated benefits. Hence, nonprofits might favor tangible growth (e.g., buildings) over intellectual capital growth.
- Insurers should consider that more competitive markets might require greater reimbursements for nonprofit medical services.
- Reaching larger geographic target markets may explain nonprofit hospital advertising beyond popular explanations that advertising is wasteful and self-serving (Moser and Freeman 2014).
- Although patients often visit hospitals for specific procedures, they might benefit from having broader nonprofit PSMS given possible unexpected diagnoses or complications.
- Having more PSMS can create a competitive advantage because PSMS staff can perform non-PSMS functions when necessary, but the reverse is seldom true.

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Tables

Table 1. The Most Profitable Hospitals Are Nonprofit

Profit Rank	Hospitals (%)		Profits (%)	
	Nonprofit	For-profit	Nonprofit	For-profit
10	70.0	30.0	72.7	27.3
20	65.0	35.0	67.7	32.3
30	63.3	36.7	65.3	34.7
40	62.5	37.5	64.2	35.8
50	58.0	42.0	60.8	39.2
60	58.3	41.7	60.8	39.2
70	60.0	40.0	61.6	38.4
80	63.8	36.2	63.8	36.2
90	64.4	35.6	64.2	35.8

Note:
Hospitals (%) = Percent of hospitals within rank (e.g., top 10, top 20).
Profits (%) = Percent of total profits within rank (e.g., top 10, top 20).
Raw data are available from Gerard F. Anderson, director of the Center for Hospital Finance and Management at the Johns Hopkins Bloomberg School of Public Health.
In our data, on average, nonprofits have 28.7% greater accounting profits than for-profits.

Table 2. Price Differences Are Increasing (Nonprofit vs. For-profit)

Year	Nonprofit ($)	For-profit ($)	Difference (%)
1999	1,139	999	14.0
2000	1,181	1,057	11.7
2001	1,255	1,121	12.0
2002	1,329	1,181	12.5
2003	1,425	1,238	15.1
2004	1,501	1,362	10.2
2005	1,585	1,413	12.2
2006	1,637	1,580	3.6
2007	1,776	1,536	15.6
2008	1,876	1,556	20.6
2009	1,957	1,574	24.3
2010	2,025	1,629	24.3
2011	2,088	1,628	28.3
2012	2,214	1,747	26.7
2013	2,289	1,791	27.8
2014	2,346	1,798	30.5
2015	2,413	1,831	31.8

Note: we report the average cost per inpatient day across 50 states. Raw data are available from Becker's Hospital Review reports published in different years. Difference (%) is calculated by Nonprofit costs − For-profit costs as percent of For-profit costs.

Table 3. Nonprofits Have Greater PSMS Mix, Output, and Revenue

Variables	Nonprofit	For-profit	Difference (%)
PSMS (Premium Specialty Medical Services)			
Number of Clinical Services	22.9	15.8	45.1
Number of Clinical Departments	9.5	7.4	28.2
Output			
Number of Emergency Treatments (Admitted)	7,847.7	4,720.5	66.2
Number of Emergency Treatments (Not Admitted)	21,375.6	13,112.4	63.0
Number of Surgeries (Inpatient)	3,325.9	1,733.6	91.9
Number of Surgeries (Outpatient)	7,294.3	3,941.1	85.1
Number of Patient Days	51,942.7	28,039.3	85.2
Number of Outpatient Visits	87,572.8	26,606.6	229.1
Revenue			
Total Patient Revenue ($)	1,057,397,054	684,754,205	54.0

Note: our data include 1,677 nonprofit hospitals and 761 for-profit hospitals.

Table 4. Duopoly Markets: Hospitals Provide more PSMS Competing with For-profits

Analysis by Hospital Type[a]	Nonprofit	For-Profit	*p*-value[b]
Number of Clinical Services	24.5	17.2	.000
Number of Clinical Departments	9.8	8.0	.000
Average Payment ($)	10,718.8	9,573.0	.000
Number of Patient Days	37,266.0	22,178.3	.000
Number of Outpatient Visits	79,939.4	28,859.8	.000
Number of Employees	1,141.5	463.2	.000
Number of Discharges	8,404.2	5,135.6	.000
Number of Patient Days/Number of Discharges	4.39	3.89	.002
Number of Employees/Number of Discharges	.19	.12	.003
Analysis by Market Type[c] with Nonprofits	**Mixed Market[d]**	**Pure Market[e]**	***p*-value**
Number of Clinical Services	28.8	24.0	.005
Number of Clinical Departments	10.5	9.9	.021
Analysis by Market Type with For-profits	**Mixed Market**	**Pure Market**	***p*-value**
Number of Clinical Services	19.4	23.4	.032
Number of Clinical Departments	8.5	9.8	.021

Note: [a] the analysis only includes hospitals with at least 2 reported services; [b] we report *p*-values for the differences between the two statistics in the second and third columns; [c] the analysis only includes duopoly markets with populations of at least 100K; 56.3% are pure markets with nonprofits, 13.0% are pure markets with for-profits, and 30.7% are mixed markets; [d] mixed markets include nonprofit and for-profit hospitals; [e] pure markets include the same type of hospitals.

Table 5. Notation

Variables	Descriptions
β_i	Hospital i's propensity to produce more output for $i = 1, 2$;
	$\beta_i = \beta > 0$ when hospital i is nonprofit; $\beta_i = 0$ when hospital i is for-profit
c_B, c_P	Marginal costs for basic services and PSMS, respectively
π_i^B, π_i^P	Hospital i's profits from basic services and PSMS, respectively; $\pi_i = \pi_i^B + \pi_i^P$ for $i = 1, 2$
Π_i	Hospital i's objective function for $i = 1, 2$
M_i	Hospital i's PSMS breadth, or the resulting average price premium for $i = 1, 2$
q_i^B, q_i^P	Hospital i's output quantity of basic services and PSMS, respectively, for $i = 1, 2$
p_i^B, p_i^P	Hospital i's average price (payment) for basic services and PSMS, respectively, for $i = 1, 2$
α_B, α_P	Market reservation prices for basic services and PSMS, respectively
θ_M	Competitive intensity reflecting the effect of rivals' PSMS breadth on own prices
θ_B	Competitive intensity reflecting the effect of rivals' basic service output on own prices
θ_P	Competitive intensity reflecting the effect of rivals' PSMS output on own prices
k	Fixed costs for unit investment (parameter of the quadratic cost function)

Table 6. Hospitals Add More Advanced Expensive PSMS

PSMS Breadth (No. Services)	Percent Hospitals (%)	Average Hospital Service Popularity (%)	Correlation Between PSMS Breadth and Hospital Service Popularity (%)	Average Payment per Patient ($)	Average Case Mix Index
Over 40	.9	43.5	−72.1	20,996.00	2.45
31-40	17.1	52.8	−81.1	11,627.44	1.73
21-30	36.7	59.4	−68.8	10,510.55	1.59
1-20	45.3	65.9	3.9	9,471.96	1.40

Note:
Percent Hospitals = percent of hospitals in the specified range of PSMS breadth.
A service's popularity = percent of hospitals with the service.
Hospital Service Popularity = average service popularity across a hospital's services.
Average Hospital Service popularity = average Hospital Service Popularity across hospitals within the specified range.
Correlation Between PSMS Breadth and Hospital Service Popularity is calculated for each range.
Average Payment per Patient and Average Case Mix Index are calculated using hospitals in duopoly markets.

Table 7. Patients Pay Less Out-of-Pocket

Year	Total Expenditures ($MM)	Funding Source: Patient Out-of-Pocket (%)	Private Health Insurance (%)	Government (%)	Other Private (%)
1960	8,985	20.6	35.6	42.6	1.2
1970	27,168	9.0	32.5	55.3	3.2
1980	100,517	5.4	36.6	53.0	5.0
1990	250,439	4.5	38.5	52.9	4.1
2000	415,531	3.2	33.9	57.6	5.2
2010	822,301	3.4	36.6	54.9	5.2
2011	851,850	3.4	37.2	54.3	5.1
2012	902,539	3.5	37.5	53.1	5.8
2013	937,645	3.6	37.3	53.1	6.0
2014	978,174	3.4	37.4	53.3	5.9
2015	1,034,502	3.0	38.7	52.9	5.3
2016	1,092,794	2.9	39.7	52.0	5.4

Note: raw data are available from Centers for Medicare & Medicaid Services (www.cms.gov).

Table 8. Analytical Findings in Mixed Markets: Nonprofit vs. For-profit

	PSMS Price	PSMS Output	PSMS Breadth
Differences	Nonprofit > For-profit for intense competition	Nonprofit > For-profit	Nonprofit > For-profit
Derivatives of the differences with respect to			
Competition (θ_P)	Price gap increases	Output gap increases	PSMS breadth gap increases
Investment cost (k)	Price gap decreases	Output gap decreases	PSMS breadth gap decreases
Hospital reactions to increasing competition[a]			
For-profit	Decrease	Decrease	Decrease
Nonprofit	U-shape	U-shape	Increase
Hospital reactions to increasing investment costs			
For-profit	Increase	Increase	Decrease/Inverted U-shape
Nonprofit	Decrease	Decrease	Decrease

Note: see the appendix for proofs. [a]: We consider $\beta \geq \tilde{\alpha}_P/2$; nonprofits and for-profits have sufficiently different objectives so that they behave differently as competition intensifies.

Table 9. Focal Variables

j	Variables	j	Variables
PSMS Breadth			
1	Clinical Departments	2	Clinical Services (No. Services)
Output			
3	Medicare Certified Beds	4	Emergency Treatments
5	Surgeries (inpatient and outpatient)	6	Patient Days
7	Discharges	8	Outpatient Visits
Price and Profit			
9	log (Price)	10	log (Profit)
Procedure Complexity & Expected Reimbursement Rate			
11	CMI (case mix index)		

Note: 1-8 are the total numbers of corresponding hospital outcomes. We obtain Price and Profit by calculating total hospital revenue/total discharges and total patient revenue − total operating expense, respectively, where the hospital revenue and cost data are available at www.ahd.com. We take the logarithm of Price and Profit. CMI is a standard measure of procedure complexity and costs reflecting expected reimbursement rates.

poly Market Analysis: Hospitals Are Better Off Competing with For-profits Than Competing with Nonprofits

	Output								
	Certified Bed (000')	Emergency Treatment (00000')	Surgery (0000')	Patient Day (00000')	Discharge (0000')	Outpatient Visit (00000')	log Price	CMI (Case Mix Index)	log Profit
	.21**	.24**	.84**	.34**	.79**	.74**	9.27**	1.60**	−1.00**
	(.01)	(.01)	(.05)	(.03)	(.05)	(.01)	(.02)	(.02)	(.08)
	.12**	.14**	.42**	.30**	.58**	.22	.15**	.23**	1.36**
FR)	(.03)	(.03)	(.13)	(.07)	(.13)	(.14)	(.05)	(.05)	(.20)
	−.36**	−.49**	−1.72**	−.60*	−1.58**	−1.54**	−.49**	−.65**	−5.18**
	(.10)	(.10)	(.46)	(.23)	(.45)	(.47)	(.16)	(.18)	(.69)
	−1.99**	−2.12**	−7.88**	−4.46**	−8.93**	−5.78**	−3.89**	−4.56**	−21.3**
es $^{-1}$	(.41)	(.41)	(1.90)	(.97)	(1.88)	(1.96)	(.67)	(.73)	(2.87)
rvations	320	320	320	320	320	320	320	320	320
	.13	.17	.11	.10	.12	.07	.15	.17	.31

rs are in parentheses. *, ** denote significant value at 5% level and 1% level (two-sided). We use ordinary least squares (OLS) for estimation.

onprofit Hospitals Obtain Greater Market Share (%) in Markets with Higher Proportion of For-profits (%)

	PSMS		Output					
	Clinical Department	Clinical Service	Certified Bed	Emergency Treatment	Surgery	Patient Day	Discharge	Outpatient Visit
	−1.21**	−1.25**	−1.40**	−1.61*	−1.56**	−1.59**	−1.52**	−1.62*
	(.19)	(.22)	(.24)	(.68)	(.56)	(.31)	(.30)	(.65)
	.77**	.93**	1.19**	2.51**	2.12**	1.65**	1.67**	2.42**
	(.24)	(.27)	(.30)	(.85)	(.71)	(.38)	(.37)	(.81)
	.15**	.16**	.17**	.20**	.21**	.19**	.19**	.22**
	(.01)	(.01)	(.01)	(.04)	(.03)	(.02)	(.02)	(.03)
	−4.51**	−4.57**	−4.79**	−9.45**	−7.85**	−5.57**	−5.82**	−8.41**
)	(.47)	(.54)	(.59)	(1.70)	(1.41)	(.77)	(.74)	(1.61)
ions	1677	1677	1677	1677	1677	1677	1677	1677
	.60	.53	.51	.17	.21	.40	.41	.19

re in parentheses. *, ** denote significant value at 5% level and 1% level (two-sided). All regression models include 44 control variables: 5 indicators
s, church hospitals, low volume hospitals, sole community hospitals, and rural referral centers), 5 county demographic variables, and 34 state fixed
or estimation.

ble 12. Greater Competition Increases the Differences Between Nonprofit and For-profit Hospitals

	PSMS		Output							
	Clinical Department	Clinical Service	Certified Bed (00’)	Emergency Treatment (0000’)	Surgery (0000’)	Patient Day (0000’)	Discharge (000’)	Outpatient Visit (0000’)	log Price	log Profit
	7.61**	17.4**	2.26**	1.64**	.98**	3.16**	6.13**	4.06*	15.5**	−1.64**
	(.53)	(1.77)	(.42)	(.43)	(.20)	(1.01)	(1.90)	(1.95)	(.15)	(.20)
	1.91**	7.69**	1.22**	1.68**	.63**	3.25**	6.61**	6.61**	.21**	.53**
	(.16)	(.52)	(.12)	(.13)	(.06)	(.29)	(.56)	(.57)	(.04)	(.06)
	3.11**	9.87**	1.16**	1.89**	.48*	2.57**	5.85**	7.10**	.21	1.17**
	(.48)	(1.60)	(.38)	(.39)	(.18)	(.91)	(1.72)	(1.77)	(.14)	(.19)
	−1.90**	−7.96**	−1.88**	−2.03**	−.81**	−4.40**	−9.00**	−7.35**	−.61**	−1.20**
	(.48)	(1.58)	(.37)	(.39)	(.18)	(.90)	(1.69)	(1.74)	(.13)	(.18)
ns	2438	2438	2438	2438	2438	2438	2438	2438	2438	2279
	.22	.27	.22	.19	.17	.21	.23	.16	.29	.41

in parentheses. *, ** denote significant value at 5% level and 1% level (two-sided). DIF is expressed in hundreds. All regression models include 44 control
or university hospitals, church hospitals, low volume hospitals, sole community hospitals, and rural referral centers), 5 county demographic variables, and
e costs (i.e., profits) data are not available for 159 hospitals. We use OLS for estimation.

Appendix. Proofs

Proof of Lemma 1. From Equations 4 and 5, the proof is straightforward for PSMS breadth, output and prices. We only need to prove that $\pi_i^{j*}(\beta_{\sim i} = 0) > \pi_i^{j*}(\beta_{\sim i} > 0)$. For $\beta_1 = 0$, $\pi_1^{B*}(\beta_2 = 0) = [q_1^{B*}(\beta_2 = 0)]^2 > [q_1^{B*}(\beta_2 = \beta)]^2 = \pi_1^{B*}(\beta_2 = \beta)$ and $\pi_1^{P*}(\beta_2 = 0)/\pi_1^{P*}(\beta_2 = \beta) = [q_1^{P*}(\beta_2 = 0)/q_1^{P*}(\beta_2 = \beta)]^2 > 1$. For $\beta_2 = \beta$, $\pi_2^{B*}(\beta_1 = 0) - \pi_2^{B*}(\beta_1 = \beta) = [2(2-\theta_B)\tilde{\alpha}_B - (1-\theta_B)\theta_B \beta]\theta_B\beta/(4-\theta_B^2)^2 > 0$ because $2(2-\theta_B)\tilde{\alpha}_B - (1-\theta_B)\theta_B\beta > 2(2-\theta_B)\tilde{\alpha}_B - (1-\theta_B)\theta_B\tilde{\alpha}_B = [\theta_B^2 + 3(1-\theta_B) + 1]\tilde{\alpha}_B > 0$. Last, we have $\pi_2^{P*}(\beta_1 = 0) - \pi_2^{P*}(\beta_1 = \beta) = [2(2-\theta_P)K(K+1)\tilde{\alpha}_P - \{\theta_P(1-\theta_P)K^2 + 2(1-\theta_P^2)K - (2+\theta_P)\}\beta](\theta_P K + 2 + \theta_P)\beta/[K^2(K+2)(4-\theta_P^2)^2] > 0$ since $2(2-\theta_P)K(K+1)\tilde{\alpha}_P - [\theta_P(1-\theta_P)K^2 + 2(1-\theta_P^2)K - (2+\theta_P)]\beta > [\{\theta_P^2 + 3(1-\theta_P) + 1\}K^2 + 2(\theta_P^2 - \theta_P + 1)K]\tilde{\alpha}_P > 0$. Q.E.D.

Proofs of Lemmas 2 and 3. Proofs follow from Equations 4 and 5. Q.E.D.

Proofs of Propositions 1-3. From Equation 4, we have $\Delta M^* = \beta/K > 0$; $\Delta q^{P*} = (2-\theta_P)k\Delta M^* > 0$; $\Delta m^{P*} = (2+\theta_P)\Delta q^{P*}/(2\tilde{\alpha}_P + \beta) > 0$. Then, the proof of Proposition 1 is trivial. Similarly, the differences in prices and profits are:

(11) $$\Delta p^{P*} = \Delta q^{P*} - \beta,\ \Delta\pi^{P*} = \left(\frac{[\theta_p(2-\theta_p)^2 k + 2(1-\theta_p)]\tilde{\alpha}_p - (K+1+\theta_p)\beta}{(4-\theta_p{}^2)K}\right)\beta.$$

From Equation 11, $p_2^{P*} > p_1^{P*}$ if and only if $(2-\theta_P)^2 - (2-\theta_P) - 2/k < 0$, or equivalently, $\theta_P > (3-\sqrt{1+8/k})/2$ for $0 < \theta_P \leq 1$. Next, it is trivial to show $\partial(\Delta p^{P*})/\partial\theta_P > 0$ and $\partial(\Delta p^{P*})/\partial k < 0$. Last, $\pi_2^{P*} > \pi_1^{P*}$ if and only if $k(2-\theta_P)^2(\theta_P\tilde{\alpha}_P - \beta) + (1-\theta_P)(2\tilde{\alpha}_P + \beta) > 0$. Then, for $\beta < \theta_P\tilde{\alpha}_P$, $\pi_2^{P*} > \pi_1^{P*}$. For $\beta > \theta_P\tilde{\alpha}_P$, $\pi_2^{P*} > \pi_1^{P*}$ if and only if $k < (1-\theta_P)(2\tilde{\alpha}_P + \beta)/[(2-\theta_P)^2(\beta - \theta_P\tilde{\alpha}_P)]$. Q.E.D.

Proof of Corollary 1. From Equation 5, $\partial p_1^{P*}/\partial k = -\partial p_2^{P*}/\partial k = (2-\theta_P)\beta/K^2 > 0$. Q.E.D.

Proof of Corollary 2. From Equation 11, $\lim_{\theta_P \to 1} \Delta\pi^{P*} = \beta k(\tilde{\alpha}_P - \beta)/[3(k-2)] \geq 0$; $\lim_{\theta_P \to 0} \Delta\pi^{P*} = \beta[2\tilde{\alpha}_P - (4k-1)\beta]/[8(2k-1)]$. The difference in the profit difference is

(12) $$\lim_{\theta_P \to 1} \Delta\pi^{P*} - \lim_{\theta_P \to 0} \Delta\pi^{P*} = \beta \frac{2(8k^2 - 7k + 6)\tilde{\alpha}_P - (4k^2 + 19k - 6)\beta}{24(2k-1)(k-2)}.$$

From Equation 12, $\lim_{\theta_P \to 1} \Delta\pi^{P*} > \lim_{\theta_P \to 0} \Delta\pi^{P*}$ because $2(8k^2 - 7k + 6)\tilde{\alpha}_P - (4k^2 + 19k - 6)\beta > 2(8k^2 - 7k + 6)\tilde{\alpha}_P - (4k^2 + 19k - 6)\tilde{\alpha}_P = 3(k-2)(4k-3)\tilde{\alpha}_P > 0$ for $k > 2$. Q.E.D.

Proof of Table 8. We have shown the differences and derivatives of the differences in Table 8. Next, the hospitals' output and price reactions to higher PSMS costs are $\partial q_1^{P*}/\partial k = -\partial q_2^{P*}/\partial k = \partial p_1^{P*}/\partial k > 0$ (see the proof of Corollary 1). For hospitals' investment reactions, we derive

(13) $$\frac{\partial M_1^*}{\partial k} = -\frac{[(2-\theta_P)\tilde{\alpha}_P - \theta_P\beta]K^2 - 2(2+\theta_P)\beta(K+1)}{(2-\theta_P)^2(2+\theta_P)(kK)^2},$$
$$\frac{\partial M_2^*}{\partial k} = -\frac{[(2-\theta_P)\tilde{\alpha}_P + 2\beta]K^2 + 2(2+\theta_P)\beta(K+1)}{(2-\theta_P)^2(2+\theta_P)(kK)^2} < 0.$$

From Equation 13, $\frac{\partial M_1^*}{\partial k} < 0$ if and only if $k > \frac{(2-\theta_P)(2\tilde{\alpha}_P+\beta)+\sqrt{(4-\theta_P^2)(2\tilde{\alpha}_P+\beta)\beta}}{(2-\theta_P)^2[(2-\theta_P)\tilde{\alpha}_P-\theta_P\beta]}$. Note $\lim_{\theta_P \to 0, k \to 2} \frac{\partial M_1^*}{\partial k} = -[7(\tilde{\alpha}_P - \beta) + 11\tilde{\alpha}_P]/288 < 0$, so given a sufficiently small θ_P, $\partial M_1^*/\partial k < 0$ for $k > 2$; i.e., in a monopolistic market, M_1^* decreases with k. Finally, we show the hospitals' reactions to increasing competition. Differentiating M_i^* with respect to θ_P for $i = 1, 2$, we obtain

(14) $$\frac{\partial M_1^*}{\partial \theta_P} = \frac{2\theta_P\tilde{\alpha}_P}{k[(2-\theta_P)(2+\theta_P)]^2} - \frac{2(2-\theta_P)(2+\theta_P+\theta_P^2)\beta}{k[(2-\theta_P)^2(2+\theta_P)]^2} - \frac{4(2-\theta_P)(K+1)\beta}{k[(2-\theta_P)^2K]^2},$$
$$\frac{\partial M_2^*}{\partial \theta_P} = \frac{2\theta_P\tilde{\alpha}_P}{k[(2-\theta_P)(2+\theta_P)]^2} + \frac{2(2-\theta_P)(2+3\theta_P)\beta}{k[(2-\theta_P)^2(2+\theta_P)]^2} + \frac{4(2-\theta_P)(K+1)\beta}{k[(2-\theta_P)^2K]^2} > 0.$$

From Equation 14, $\partial M_1^*/\partial\theta_P < 0$ since $2\theta_P(2-\theta_P)\tilde{\alpha}_P - 2(2+\theta_P+\theta_P^2)\beta \leq 2\theta_P(2-\theta_P)\tilde{\alpha}_P - (2+\theta_P+\theta_P^2)\tilde{\alpha}_P = -[(2-\theta_P)(1-\theta_P) + 2\theta_P^2]\tilde{\alpha}_P < 0$. Then, $\partial q_1^{P*}/\partial\theta_P = -kM_1^* + (2-\theta_P)k(\partial M_1^*/\partial\theta_P) < 0$; $\partial q_2^{P*}/\partial\theta_P = -kM_2^* + (2-\theta_P)k(\partial M_2^*/\partial\theta_P)$. Note that $\lim_{\theta_P \to 0} \partial q_2^{P*}/\partial\theta_P = -[2\tilde{\alpha}_P(2k-1)^2 - \beta(6k-1)]/[8(2k-1)^2] < -[2\tilde{\alpha}_P(2k-1)^2 - \tilde{\alpha}_P(6k-1)]/[8(2k-1)^2] = -\tilde{\alpha}_P(8k^2 - 14k + 3)/[8(2k-1)^2] < 0$; $\lim_{\theta_P \to 1} \partial q_2^{P*}/\partial\theta_P = (4\beta - \tilde{\alpha}_P)/9 + (3k-2)\beta/(k-2)^2 > 0$. Therefore, q_2^{P*} decreases for small θ_P and increases for large θ_P. We have the same price reactions ($\because \partial p_i^{P*}/\partial\theta_P = \partial q_i^{P*}/\partial\theta_P$). Q.E.D.