An Expanded Look into the Effects of Multi-Hospital Systems: Evidence on the Return to Quality Competition

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Abstract

Recent empirical studies have determined that hospitals increase their prices more rapidly when they belong to a hospital system. This study analyzes whether hospital systems are investing more in Diagnostic and Therapeutic Equipment valued in excess of $500,000, as well as what affect that investment may have on a hospital's market concentration.

When controlling for the hospital's size, type of control and determinants of investment, it was determined that hospitals belonging to a system were 11% more likely to invest in Diagnostic and Therapeutic Equipment in 2003, while investing 353% more. The differences between system member hospitals and non-system hospitals increased in 2006, with hospital system members being 21% more likely to invest while investing 1480% more. One explanation for these results could be that hospitals that belong to a hospital system have a better bargaining position and can thus increase their long term fixed costs with the anticipation of being able to recoup their expenditures.

Investment in Diagnostic and Therapeutic Equipment was found to be significant in increasing a hospital's HHI (concentration index) from 2003 to 2007. For a hospital with average market concentration, investing in the minimum amount increased their HHI by 3.7279%. When assuming that patients have some knowledge of the equipment and procedures available at a given hospital, the results would exemplify the presence of non-price competition between hospitals.

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Introduction

Between 1960 and 1990, the US averaged 12% annual growth in health care expenditures, with much of the long term cost growth during that time being attributed to the expansion and adoption of medical technologies and equipment [Newhouse 1992]. However, that annual growth subsided to a meager 5% for much of the 1990s. Many empirical studies credited the increased prevalence of managed care with the containment of growth. Some studies even touting its ability to contain long run cost growth through decreasing the adoption of expensive medical equipment i.e. MRI's and CAT Scans [Mas and Seinfeld 2008]. The contained growth was short lived and by 1999 health care expenditure growth returned to its torrid pace. Hospitals that belonged to regional and local hospital systems were increasing prices significantly more than non-system hospitals by 2003, a result that could be explained by the enhanced bargaining position of hospital systems [Melnick and Keeler 2006].

The erosion of managed care's bargaining position – and thus its ability to contain costs – may have farther reaching consequences than merely short run price increases. This study investigates whether hospital systems invest more heavily in the type of expensive Diagnostic and Therapeutic Equipment that was credited with the long term cost growth prior to the expansion of managed care and what effect that investment has on a hospital's concentration index when comparing two periods that are five years apart.

Literature Review

Currently, the majority of those who are neither uninsured nor insured through the Federal Government (Medicare and Medicaid) are insured by some sort of Managed Care Organization (MCO), whether it be through a PPO, POS, or HMO. Prior to the increased market share of MCOs, those who were privately insured were insured by companies that are referred to as fee-for-service coverage providers. A health insurance provider is referred to in this fashion when the insurer neither controls the network of hospitals and physicians a beneficiary can attend, nor the amount of care they will receive. With insurance companies playing a passive role in medical care decisions, physicians were the players who controlled demand. Fee-for-service insurance coverage insulates costs from patients and physicians which results in the demand for hospital services being determined by a hospital's quality of care, location, procedural complexity and amenities. This type of competition is commonly referred to as non-price competition. A common consequence of non-price competition was higher hospital prices in less concentrated markets (where there was a great deal of hospital competition) as a result of the "medical arms race". "Medical arms race" was a term coined for the strategic actions of hospitals where they would offer greater access to technologically complex services and equipment in order to stay competitive with local competitors that also offered those services [Zwanziger and Melnick 1996].

Non-price competition has been attributed with the rapid increases in medical technology and as a result, the cost of medical care rose dramatically as well. Joseph Newhouse (1992) attributed a bulk of the increase in medical care expenditures as the result of technological change. With every new piece of technologically complex equipment came the cost of knowledge, complimentary supplies and the expertise needed for adoption. These other factors were as much to blame for the cost increases as the fixed costs of the machines themselves [Spetz and Maiuro 2004].

Health care spending growth dropped dramatically between 1992 and 1999, averaging an annual growth rate of 5%, where it had previously averaged a 12% annual increase. The increased prevalence of managed care was credited with much of the reduction in cost growth [Levit 1998, Zwanziger and Melnick 1996]. Managed care differed from the traditional fee-for-service coverage by putting restrictions on patients' choice and utilization of services in an effort to contain costs. MCOs did this by making payments to physicians capitated, restricting the choice of products a beneficiary could receive to only a hospital in network, and creating the gatekeeper system in which a patient must have a referral to visit a specialist [Mas and Seinfeld 2008]. The price of reimbursement for a given procedure would be predetermined through the bargaining of the MCO and the hospital. Once managed care gained a significant market share, it would then have the market power to cut the price that it would pay for reimbursement.

The dynamic of competition between hospitals was changed from one being based on quality, to one dominated by cost control [Zwanziger and Melnick 1996]. As was previously stated, prior to managed care's increased market share, higher prices and costs were seen in the less concentrated markets. However after the expansion of managed care, a hospital within that same competitive market was now competing for the right to be in a network. This forced hospitals to lower and contain their costs as well as operate under a tight budget constraint. Once more, empirical studies have confirmed that during this period there was a positive correlation between price and market concentration [Danove (1997), Keeler, Melnick and Zwanziger (1999) and Brooks, Dor and Wong (1996)]. This positive correlation between price and market share meant that hospitals in more competitive areas had lower prices – and for possibly the first time – were price takers rather than price makers. These studies used this finding to conclude that managed care was creating price competition between these hospitals.

Managed care not only changed the structure of competition within the health care industry, it also changed the structure of hospitals. With hospitals now bound to keep their costs in line with rates of reimbursement in order to remain in network, they were no longer able to differentiate themselves by quality. Differentiation by quality was mainly accomplished through the adoption of new technologies and services. Therefore, it is plausible that an increase in the prevalence of managed care could decrease the rate and magnitude of the adoption of technology. For example, a high HMO market share was found to be associated with low availability of MRIs [Baker and Wheeler 1998]. That same study concluded that MCOs may have the ability to reduce the adoption of medical equipment and thus reduce health care costs. A recently published empirical study by Nuria Mas and Janice Seinfeld analyzed 13 different technologies and their adoption during the time that managed care plans became more widespread (1982-1995). They found three important results: managed care has a significant negative effect on hospital technology adoption for each of the 13 technologies; managed care has a long-term effect on health care savings through the decreased rate of adoption of new technologies; and managed care has a more significant negative effect for the adoption of less profitable technologies.

The modest growth in health care spending was short-lived, with spending resuming its furious growth after 1999. Empirical studies have focused on two explanations for the return to the rapid increases in health care spending: “The Managed Care Backlash” and the formation of regional and localized hospital systems. “The Managed Care Backlash” is the term used to describe the resultant two-tiered change in patient preference. First, there was reluctance by beneficiaries to be limited in their choice of health care. Secondly, there was the widespread opinion that MCOs, more specifically the more restrictive HMOs, were reducing the quality of healthcare. Dranove, Lindroth, White and Zwanziger tested how the relationship between market concentration and price sensitivity moved over time. They confirmed the results of previous studies that there was a positive relationship between price and market concentration between 1990 and 1995, which strengthened between 1995 and 2001. However, between 2001 and 2003 the relationship weakened substantially, which could indicate a significant reduction or total loss of MCOs’ ability to contain cost growth.

Hospitals began to merge and form multi-hospital systems in response to managed care’s ability to bargain down the prices for procedures. While there are numerous reasons for hospitals to consolidate some of which being efficiency, reputation, and economies of scale; the most frequently cited reason is a strengthening of hospitals' bargaining power with managed care plans [Melnick and Keeler 2006]. An MCO's capacity to limit prices is contingent upon its ability to move its beneficiaries to a different hospital. If a hospital system owns multiple hospitals in a geographical area, an MCO is unable to move its beneficiaries to a different hospital, and will therefore be unable to initiate price competition between hospitals [Town and Vistnes 2001]. The bargaining power appeared to be shifting away from MCOs to hospitals with some health plan providers reporting that they felt "forced" to pay the higher prices. With the presence of multi-hospital systems, it makes financial sense for managed care providers to pay a higher price and pass the increased cost onto beneficiaries through premiums rather than drop the hospital from its network.

Glenn Melnick and Emmet Keeler examined whether hospitals that belonged to a multi-hospital system were able to increase their prices faster than non-system hospitals. Previous research showed a link between rising prices in hospitals that had either merged or formed hospital systems with competitors. Melnick and Keeler broadened the scope of the analysis to examine whether regionalized multi-hospital systems have the same effect on prices. Their results indicate that hospitals which belonged to a multi-hospital system were able to increase their prices more rapidly than a non-system hospital. When hospital systems were divided into large systems and small systems, the difference in rate of increase in prices was respectively, 34% and 17%, as compared to non-system hospitals in 2003.

Theory

This study's main concern was to combine the findings of Melnick and Keeler (2006) and Mas and Seinfeld (2008) in order investigate whether hospitals that belong to a system reduce managed care's ability to restrain the adoption of expensive medical equipment. There has not been an investigation into hospital investment during the time period where hospital systems began to take effect. The main explanatory variable is a hospital belonging to multi-hospital system, while controling for determinants of investment. This study uses the control variables that Calem and Rizzo (1995) used when explaining the investment of hospitals. While their study used rate of accumulation of total fixed assets $[(TFA_t - TFA_{t-1}) / TFA_{t-1}]$ as their dependent variable, their independent variables will explain investment in this studies dependent variable as well.

Given that this study uses variables specified in the Calem and Rizzo (1995) empirical study, it would be logical to modify the dependent variable and use the rate of accumulation of equipment $[(Equipment_t - Equipment_{t-1}) / Equipment_{t-1}]$. However, using an aggregated Equipment measure does not illustrate the actual investment since $Equipment_t = Equipment_{t-1} + AddedEquipment -$ RetiredEquipment. The type of equipment added is an essential component of this study which would not be captured with the aggregated equipment measure. The character and use of equipment is important to specify because it is the adoption of expensive and technologically complex equipment that leads to long run cost growth. Therefore, the empirical analysis examines the relationship between the investment in Therapeutic or Diagnostic Equipment valued at an amount equal to or greater than $500,000, while controlling for various determinants of investment, the type of hospital control and the hospitals size.

Data

The empirical analysis utilized the publicly available data from the Office of Statewide Health Planning and Development (OSHPD) of the State of California. This detailed data set is available online and has been used in numerous empirical studies of hospitals (Dranove and Zwanziger, 2007, Melnick and Keeler, 2005, Krishnan, 2001, Dranove and Shanley, 1995). Hospital data was only used from California because there are numerous regulatory differences between states in the adoption of medical technology (Esposto 2008), and in order to control for this, it is best to use hospital data from one state.

The study used OSPHD's Selected Financial, Utilization, and Patient Discharge Data from 2002-2007. Hospitals that did not report in one year of the study were excluded because the validity of results are contingent upon a given hospital's accuracy in reporting. Kaiser Permanente hospitals were eliminated when integrating the data with the Selected Financial Data set because they do not report any financial data to the State of California. Only hospitals described as providing General Acute Care were included, since hospitals of other types are neither comparable nor numerous. Also, hospitals that were newly formed or had their licenses suspended or closed were excluded because their investment in Therapeutic or Diagnostic Equipment greater than $500,000 would bias this study. A hospital that had their license either suspended or closed would not invest in expensive Diagnostic or Therapeutic Equipment, since it is unlikely they would receive a return on investment. Newly formed hospitals may either invest more heavily in Diagnostic and Therapeutic Equipment or not at all, since they may or may not possess all of the necessary amenities.

The creation of an ownership variable follows the work of previous empirical studies by characterizing hospitals as either non-profit, for-profit, or government (city/county and district hospitals). It was also important to control for teaching hospitals as well since their investment in diagnostic and therapeutic equipment would be different than that of non-teaching hospitals.

Dependent Variable

The dependent variable, investment in Diagnostic or Therapeutic Equipment valued at an amount greater than $500,000, has not been previously used in an empirical study. The variable is discontinuous from $0 to $500,000 and is continuous after that value, which results in a great degree of variation in the distribution. In order to capture the effect, the study conducted two regressions: a probit to test the likelihood of investment, and a normal regression to test what affects the magnitude of investment. For the probit analysis a value of 1 was assigned if a hospital invested in at least one Diagnostic or Therapeutic Equipment valued in excess of $500,000. In the Ordinary Least Squares Regression, the values of the equipment for a given hospital were summed for that year. As stated above, the variable was discontinuous from $0 to $500,000: in order to bring in the variance of the distribution, the specification takes the natural log of the hospital's summed value.

Independent Variables

The main explanatory variable was a hospital's membership in a hospital system. Only those hospitals that had other system members within the state of California were included. Hospitals that belonged to a national system but had no other members in that state, do not have the bargaining advantage with the Managed Care Organizations that regional and localized hospital systems possess. By reviewing the Parent Name section of each year's Utilization Report, it was possible to determine the hospitals that were in a national system with no other state or local members. This method of hospital system determination was prompted by the findings of Dranove (1995), which found that hospitals that belonged to non-localized or non-regional national hospital systems were being released to become independent entities. While Melnick and Keeler separate hospital systems into small and large systems, this study only identifies whether a hospital is a member of a hospital system or not. This was done because during the period of the study, Tenet, the largest hospital system in California, went from forty to nineteen hospitals. The hospitals that left Tenet broke into smaller hospital systems that were localized; therefore, they can still be considered hospital systems.

The type of hospital control (For-Profit, Not-For-Profit and Government) may also affect investment in the dependent variable. Not-For-Profit hospitals would be expected to be positively related to investment since they are subject to a distribution constraint where any profits must be reinvested in the hospital or distributed to the community through charitable care. For-Profit hospitals are expected to be negatively related to investment in the dependent variable, because they must distribute profits to shareholders and stakeholders. The coefficient for Government controlled hospitals could be either positive or negative due to the counterbalancing incentives they face. Given that the dependent variable is an indicator of investment, determining whether there is a difference between Not-For-Profit and For-Profit hospitals would be an interesting finding, since empirical evidence is inconclusive on a difference in price between the two types of control [Melnick and Keeler 2006].

A control variable identifying whether a hospital is a teaching hospital is used, because their investment in Therapeutic and Diagnostic Equipment may be different than that of a non-teaching hospital. The impact of this variable is predicted to be positive and significant, since Melnick and Keeler (2006) found that being a teaching hospital had a significant positive effect on prices. The last explanatory variable is a measure for profitability, the ratio of net income to Net Patient Revenue. Net Patient Revenue is used because OSPHD specifies that it is a more comparable measure than Gross Patient Revenue. Additionally, Net Patient Revenue indicates the actual amount collected from patients and third party payers. It is expected to be positively correlated with investment in the dependent variable. Also, the size of the hospital could dictate whether a hospital invests in Diagnostic or Therapeutic Equipment greater than $500,000. In order to control for that variable, the number of available beds was included.

Calem and Rizzo (1995) used two variables to control for expected marginal product on capital, EMEXRATIO and FTERATIO. EMEXRATIO (employee expenses to total fixed assets) controls for the labor to capital ratio, while FTERATIO (the number of full-time equivalent employees per bed) controls for a hospital's utilization measure. EMEXRATIO was found to be positive and significant in Calem and Rizzo (1995). However, FTERATIO was not significant in all of their regressions. The ratio of a hospital's Accumulated Depreciation to Total Fixed Assets (AccTFA) was created in order to control for the usable life of a hospital's Equipment. Ideally, the measure used would have been Accumulated Depreciation of Equipment to Total Equipment; however, this information was not available. The coefficient for this should be positive since it is logical to assume that if a hospital has older Equipment (and hence a higher amount of Accumulated Depreciation in relation to Total Fixed Assets) they would invest more than a comparable hospital with newer Equipment. Following the method of Calem and Rizzo (1995), the investment ratios were lagged one year. Therefore, it is assumed that hospital investment is a function of the previous year's profitability, labor to capital ratio and utilization.

Results

Tables 1 through 3 report the summary statistics, , OLS with Robust Standard Errors, Weighted Least Squares Regression, Probit analysis and Probit marginal effects analysis for the investment in Diagnostic and Therapeutic Equipment valued in excess of $500,000 by multi-hospital systems while controlling for a hospital's profitability, utilization, labor to capital ratio, hospital size, control type and the ratio of accumulated depreciation to total fixed assets. All of the regressions were heteroskedastic, therefore the method of weighted least squares and robust standard errors were used. When interpreting the data, the coefficients from the regressions using robust standard error were used.

For 2003 and 2006, hospitals belonging to multi-hospital systems invested significantly more than non-system hospitals. Regressions were conducted for 2004 and 2005 and were found to be not significant; however, there is reason to believe that this was due to the changes enacted by the OSPHD in Financial Data reporting date for 2003-2004. As stated above, the investment controls were lagged for ‘t-1’ in order to capture the realistic assumption that investment in time ‘t’ is a function of the events in ‘t-1’. But in the 2003 and 2004’s Financial Reports, there were numerous hospitals that made multiple reports of varying lengths of time. Some reports were for less than a less than a year, while others were greater than a year. With investment and profitability control variables dependent upon the accuracy and validity of the Financial Data, there is good reason to reject the 2004 and 2005 findings.

For 2003, hospitals belonging to a system were 11% more likely to invest in at least one piece of Therapeutic and Diagnostic Equipment valued at or above $500,000 and spent 353% = [exp(1.509627)-1] more than non-system hospitals. The difference between hospital system members and non-system members became greater in 2006 with hospital systems members 21% more likely to invest, while spending 1480%=[exp(2.760089)-1] more. Although the profit margin was determined to be a significant determinant in 2003, it was not significant in 2006. The size of the hospital (determined by the number of available beds) and FTERATIO (the ratio of full time equivalent workers to the number of beds) both had a significant positive effect in 2003 and 2006.

Surprisingly, the percent of accumulated depreciation to total fixed assets and EMEXRATIO (labor to capital ratio) were not significant in either year. Teaching hospitals were negatively significant in 2003 and insignificant in 2006. Upon creating a correlation matrix, it was evident that teaching hospitals were significantly correlated with the number of beds. Therefore, the number of beds regressor may be picking up the significance of being a teaching hospital. It was also determined that the type of ownership of the hospital was insignificant in determining investment in Diagnostic or Therapeutic Equipment valued in excess of $500,000.

Discussion of Results

For the years 2003 and 2006, hospital systems invested significantly more in Diagnostic and Therapeutic Equipment valued at an amount greater than $500,000 when controlling for various determinants of investment, size of the hospital, and type of control. This finding is consistent with the results of Melnick and Keeler (2005) who found that hospital systems were able to raise their prices substantially more than comparable non-system hospitals. These results speak to the bargaining position that hospital systems possess when they negotiate with MCOs. In an environment of Managed Care, hospitals' budgets are constrained by the expected revenue from the predetermined bargained price for their procedures. Therefore, an individual hospital will not invest in equipment if it does not believe it will receive more revenues to make the purchase profitable or even affordable. This logic was a motivating factor in Mas and Seinfeld's empirical study on the effect of managed care on the adoption of technology from 1982-1995. Their results demonstrated the restrictive affect managed care had on the rate of adoption of medical technologies. But while they conclude that managed care leads to the containment of long term medical cost growth, this study's results may indicate that this is not the case.

Mas and Seinfeld's empirical study only investigates the time period from 1982-1995. Their conclusions were based on findings prior to the restructuring of hospitals into regional and localized hospital systems in an effort to increase their bargaining position vis-à-vis MCOs. Suppose there are two comparable hospitals, one belonging to a system, the other not. The hospital belonging to a system possesses the bargaining position which will better enable them to extract a higher price than the comparable non-system hospital for similar procedures. That same hospital system member can now invest in a new expensive piece of Therapeutic or Diagnostic Equipment since it has the ability to bargain a higher price in the future to recoup its higher cost, while the non-system hospital does not have this ability.

But why would a hospital within a system use its bargaining power to invest in expensive equipment while it could simply provide the same mix of services and quality as the comparable non-system hospital – and enjoy higher profit margin? This question was the motivation for the study into the effect of investment in Therapeutic and Diagnostic Equipment valued at or above $500,000 from 2003 to 2006 on the change in a hospital's concentration index. In order to capture its affect, the study controls for the hospitals' index level in 2003 and the artificial variations that increase or decrease a hospitals index due to the way in which it is calculated.

Market Concentration Study

Most of the recently published hospital level empirical studies use a control for competition called HHI. The formulation of this variable stems from the 1990 article by entitled "Measures of Hospital Market Structure: a Review of the Alternatives and a Proposed Approach". In the article, three RAND Corporation Economists (Zwanziger, Melnick, and Mann) introduce a proposed alternative to measuring hospital market concentration and conduct a sensitivity analysis. When the article was written, MCOs were changing the nature of hospital competition from one determined by quality of service to one based on price. MCOs would be unlikely to negotiate a lower price with a given hospital if that hospital had sufficient market power. Antitrust divisions were beginning to investigate hospital market power, but were without a viable measure.

There are two methods to measure industry market power: one is focused on price, and the other on shipment. When price is the method used, market areas are defined as where prices move together. This type of analysis is does not work in the context of hospitals, because the price actually charged to a

MCO is based on its secret discount factor. The shipment method within the context of hospitals involves identifying the geographic location where a hospital's discharges originate. Prior to this article, geographic areas were defined by metropolitan statistical areas (MSAs). This methodology creates discontinuity in markets as well as overestimating the market concentration of rural hospitals while underestimating the concentration within cities. When calculating the market concentration of hospitals in Los Angeles, the use of MSA boundaries will assume that all hospitals are competing with one another. However, in reality, a community hospital on the north side of the city is in competition with only those hospitals within a close proximity [Zwanziger, Melnick and Mann 1990].

Zwanziger, Melnick, and Mann proposed a method that utilizes the readily available Zip Code Area and Hospital Level Discharge Data provided by the OSPHD. The method used in measuring the competitive intensity in a market is a Hirschman-Herfindahl index (HHI) = $\sum s_i^2$ "where s_i is the share of total discharges and the summation runs over all hospitals in the market" [Melnick and Keeler 2006]. The values have a range between 0 (very competitive market) and 1 (monopolistic competition). HHI has an advantage over other methods since it takes into account the distribution of market shares, as well as the number of competitors in a market. The method of calculating a hospital's HHI has been slightly modified since the original article to account for the creation and expansion of hospital systems.

The method described in Burgess (2005) was used to compute and create the hospital level HHI because it gave the most detailed account of the steps involved in calculating HHI. One must first identify all hospitals in a given hospital system, separate them from the rest of the discharge data, and then sum their discharges across each zip code to create a new hospital system discharge total for each zip code. This is done in order to capture the effect that hospital systems have, since hospitals in a given system bargain with MCOs jointly. Once this procedure is done for every hospital system, all of the remaining hospitals are combined with the newly formed system's aggregated discharge data. Each entry is divided by the total number of discharges in that zip code area, that term is squared and all terms are summed across that specific zip code. This forms the zip code level HHI.

When creating the hospital level HHI, all hospitals are considered individuals. The proportion of discharges from a zip code for a hospital is calculated by dividing the number of discharges the hospital has at that zip code by their total number of discharges. A hospital's HHI is calculated by multiplying the zip code level HHI by the hospitals proportion of discharges from that zip code to its total discharges and each new term is summed across all the zip codes a hospital services. Therefore, a hospital's Hirschman-Herfindahl index (HHI) = $\sum s_i^2$ is the weighted sum of its zip code specific HHI values.

Although this method of calculation is used as a control for market concentration for numerous hospital level empirical studies (Melnick and Keeler 2005), the construction of the variable could be viewed as a measurement of a hospital's success in competing, especially if values are compared over time. As previously stated, the zip code level HHI is contingent upon not only how many competitors are in the market but their individual market shares. Therefore, unless one was to micro-analyze the roughly 1.2 million data points, it is impossible to determine whether a hospital has a high HHI due to few competitors, or whether they are merely successful in competing. Also, the factors that change a hospital's market concentration over time may give a better indication of anti-competitive behavior.

Motivation and Methodology

When viewing the variable of hospital HHI as a success in competition, as well as degree of market concentration, it is prudent to investigate and identify the factors that increase a hospital's concentration and thus makes them successful. In particular, does the summed investment in Diagnostic or Therapeutic Equipment between 2003 and 2006 significantly affect the difference in a hospital's HHI when comparing 2003 and 2007? It is useful to compare two periods that are five years apart because a hospital may gain patients due to the addition of newer and better equipment yet such a move could subsequently result in the hospital being dropped by MCOs due to its lack of cost control. To answer this question, it was necessary to control for the hospital's HHI in 2003 as well as various factors related to the method of calculating HHI that artificially inflate or deflate a hospital's HHI. These factors pertain entirely to calculating a hospital HHI when using the hospital system method.

The creation of the artificial inflating and deflating HHI controls were created because between 2003 and 2007, the Tenet hospital system divested and shrunk from forty to nineteen hospitals. Since a specific zip code area's HHI is calculated with system member hospitals treated as a single hospital, if a hospital system has more than one local competitor in a given zip code, the zip code level HHI will decrease because of the calculation methodology and not because of a hospital losing its individual share. Suppose that a zip code sends its patients to five different hospitals: A, B, C, D, and E. The market shares are divided between the hospitals in the following proportion .4, .3, .2, .05, and .05 respectively. Now suppose that hospitals A and C belong to the same hospital system; the zip code level HHI for year t_o would be .5. During the next year, the hospital system that A and C belong decides to divest hospital C but the market shares of that zip code remain unchanged. Therefore, the zip code level HHI for year t_1 would be .34. Since a hospital's HHI is the weighted sum of its zip code specific HHIs, the hospitals that are competitors in that zip code will have a decreased hospital level HHI even though there was no change in the market shares.

To control for this, every hospital that belonged to a particular hospital system was grouped together and placed in separate files for 2003 and 2007. The discharge data was then coded to identify whether a hospital was competitive in a given zip code. The definition of being a competitor in a zip code was drawn from Keeler and Melnick (2005) where they state that a competitor is a hospital that draws at least 3% of the zip code area's discharges. Subsequently, a determination was made as to whether the same hospitals belonged to a system in 2003 and 2007. Those hospitals that were lost were then examined to determine whether they had any local competitors in a zip code area that contained a significant amount of discharges in relation to the total number of discharges in the system. If it was determined that a hospital lost a system member that was a local competitor, both of those hospitals were binarily coded to capture the artificial loss in HHI. The same process was performed to determine whether a hospital entered a system, whether a hospital left a system, or if a hospital switched systems.

Dependent Variable

The dependent variable, the difference between a hospital's HHI in 2007 minus its HHI in 2003, was constructed by first calculating the HHIs for all hospitals for 2003 and 2007. This was done using the Zip Code Area and Hospital Level Discharge Data provided by the OSPHD. There were numerous hospitals that were not observed in both periods, which meant that a hospital had closed, opened or changed its name. Hospitals were matched with their OSPHD ID number for the given year with the Financial and Utilization data sets. Hospitals that were not matched by names were thus matched by their OSPHD ID number. Only hospitals that were remaining from the initial cleaning of the Therapeutic or Diagnostic Equipment with a value in excess of $500,000 were used. From that group of hospitals, only those that had HHIs calculated for 2003 and 2007 were used.

Independent Variables

The main explanatory variable, the natural log of the summed amount of investment in Diagnostic and Therapeutic Equipment in excess of $500,000 from 2003 to 2006, could be positively or negatively related to the change in a hospital's HHI. If hospitals are able to engage in non-price competition, investing in Diagnostic or Therapeutic Equipment should be positive. However, if that investment leads to a hospital being dropped from one or multiple MCOs due to its lack of cost control, the coefficient would be negative. Thus, a two tail test would be the appropriate test for the main explanatory variable. The variable, HHI in 2003, has the possibility to be either positive or negative as well. However, given that the average HHI decreased from 2003 to 2007, it is expected to be negative. Change in Licensed Beds, the difference between the number of licensed beds in 2007 and 2003, should be positively significant since increasing the size of a hospital should result in more discharges and thus a larger market share.

The controls, LostaLocalSystemMember and LeftaSystem, are expected to be negative and significant since they both artificially lower the HHI of the hospitals involved. While the study does control for hospitals that enter a hospital system and change hospital systems during the period studied, they are expected to be insignificant. This is due to the fact that there was not a significant number of new hospital systems created from 2003 to 2007. Also, a hospital changing from one system to another may lose and / or gain local system members which would negate any significant changes.

Results

Tables 4 and 5 present the summary statistics and the regression results for the assessment of the determinants of change for a hospital's market concentration index HHI. When controlling for the previous period's HHI (2003) as well as the various artificial inflators and deflators of HHI, adding Therapeutic or Diagnostic Equipment valued at an amount exceeding $500,000 was a significant determinant in the change in a hospital's HHI from 2003 to 2007. For instance, if two comparable hospitals had equal HHIs in 2003, one that invested in the minimum amount ($500,000) and number (one piece of equipment) and the other did not, the investing hospital's HHI would increase by .010498. For the average hospital, this would relate to a 3.7279% increase in market share from 2003 to 2007. However, the average dollar amount added, given a hospital did add Diagnostic or Therapeutic

Equipment greater than $500,000 was $4,339,666. Therefore, if one hospital invested in the average amount given they invested; it would increase their HHI by .01222 or 4.34%. The effect is more significant for those hospitals that are in more competitive markets since more competitive markets are associated with lower levels of HHI.

Discussion of Results

There has not been an investigation into the factors that affect the concentration index of hospitals, so further investigation is needed. However, the main explanatory variable – the sum of Therapeutic or Diagnostic Equipment with a value equal to or greater than $500,000 – had a significant impact on the concentration index of hospitals. When used in the context of an explanatory variable for a hospital's concentration index, this result could indicate that hospitals are competing for patients based on quality of care rather than competing between each other through price containment for managed care contracts.

Further evidence of non-price or quality competition may be the decrease in the average market concentration from 2003 to 2007. At first glance, the decrease in average HHI from 2003 to 2007 may appear to indicate that there is more competition between hospitals. However, the method of calculating HHI does not adequately account for a shift of discharges from one zip code to hospitals that are further away. A hospital's loss of patients from one zip code (that comprises a large amount of their discharges) decreases that hospital's HHI disproportionately to the increase in HHI for the hospital that gains the discharges. This is because the zip code level HHI will decrease by a greater magnitude than the increase in percentage of discharges for that hospital.

There are two hypotheses for why patients care about the technologically sophisticated equipment of a hospital: option demand and the stimulation of demand. Option demand is the idea that patients believe they have a higher than actual probability of needing the services provided by the high tech hospital. Hospitals may attempt to increase their market share by investing in technologically sophisticated equipment and advertising its availability in an effort to appear to be "state-of-the-art" technologically [Hodgkin 1996]. Hodgkin (1996) found that hospital choice for cardiac patients was strongly correlated with the changing availability of cardiac catheterization, but not correlated with patients who were not in need of cardiac care. When reviewing the descriptions of the equipment adopted by the various hospitals, it is apparent that the majority of equipment added was CAT Scans, MRIs and other types of multi-DRG equipment. A new technologically complex CAT Scan or Open MRI may be marginally better than a less complex version. However, if its purchase signals quality of care, a risk-adverse individual may opt for the hospital offering the newer, technologically complex equipment – even if they are not given access to it.

Concluding Remarks and Future Research

Since this is the first study into the causes of changes in HHI, there are numerous avenues that future research could investigate in order to create a more encompassing model. Future study into the causes of changes in HHI should include a measure that includes changes in hospital mortality rates, since it was found to have a significant effect on hospital choice prior to the expansion of managed care [Luft, Garnick and Mark 1990]. This type of measure was not available through the data set used in this study; therefore, more research would be needed to find an appropriate measure. Another future study could group specific types of equipment together based on the number of DRGs that a given piece of Diagnostic or Therapeutic Equipment serves. This specification stems from the findings of Hodgkin (1996), whose results tend to confirm option demand, but only for those patients needing a specific procedure. However, hospitals could exploit option demand by investing in technologically complex equipment that is used for multiple DRGs. For example, CAT Scans and MRIs are used more frequently than a Da Vinci Robotic Surgical System, so investment in technologically complex CAT Scans and MRIs may have a stronger affect on the change in HHI than a Da Vinci. With this study only examining one of the two factors that have been attributed to the recent growth in hospital prices, another future analysis could conduct a panel study to investigate the effect that the "Managed Care Backlash" had on investment.

This empirical study provides significant evidence that hospital systems are investing more heavily in expensive Diagnostic or Therapeutic Equipment than non-system hospitals, and the difference between the two is increasing. Hospital systems were 11% more likely to invest in 2003 while being 21% more likely in 2006. The significant positive effect that investment in Diagnostic or Therapeutic Equipment has on a hospital's HHI is an important finding in hospital competition and non-price competition. If hospital systems are indeed using this investment in expensive Therapeutic or Diagnostic Equipment to increase their market share, action may be needed to prevent hospital systems from gaining monopoly power.

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Tables of Results

Table 1

Summary Statistics for Variables in Tables 2 and 3

Year	SumEquip	ProfMarg	FTERatio	EMEXratio	LicBeds	AccumDep	NFP	Gov	FP	Teaching
2003	$484,117	.0441924	4.196479	1.1187	211.811	.502985	***.520979***	***.2202797***	***.2587***	***.0769231***
	($1,183794)	(.132597)	(1.845455)	(1.845455)	(169.85)	(.1901544)				
2006	$761,695	.049188	4.486251	1.268	218.0507	.5265837	***.5253623***	***.22463***	***.25001***	***.0797101***
	(1,735,150)	(.1068347)	(2.072288)	(2.55963)	(165.477)	(.1852459)				

Note: Bold and Italicized numbers indicate percentage of hospitals for binary variables

Table 2

Regression Results for natural log of the sum of Diagnostic and Therapeutic Equipment valued in excess of $500,000

Eq.	C	HosSys	ProfMa	AccTFA	FTE	EMEX	Teach	BedAv	NFP	Gov	R^2 Adj R^2	F
1	-6.199	1.298	6.998	3.24	0.867	0.041	-3.96	0.017	-0.851	-0.048	0.2490	9.14``
	(3.65)*	(2.52)+	(2.09)+	(1.78)	(3.26)*	(0.71)	(2.35)^	(6.23)~	(1.19)	(0.05)		
2	-3.559	1.510	2.404	2.16	0.764	-0.026	-3.65	0.010	-0.483	-0.291	0.1554	7.05``
	(2.80)*	(1.98)+	(0.99)	(1.28)	(3.25)*	(0.83)	(1.76)	(2.85)~	(0.55)	(0.27)		
3	-5.371	3.526	6.01	-1.914	0.764	0.174	-2.49	0.017	1.42	3.98	0.2984	11.45``
	(4.29)*	(5.28)~	(1.82)	(1.24)	(4.49)*	(1.41)	(0.74)	(4.65)~	(2.37)+	(3.94)*		
4	-3.081	2.760	7.736	-0.951	0.568	-0.003	-0.169	0.013	1.47	1.022	0.2620	22.90``
	(2.43)^	(3.58)~	(1.97)+	(.47)	(2.84)*	(5.00)*	(0.09)	(4.75)~	(1.50)	(0.86)		

Notes: *significant at 1% level, two-tailed test for t-statistics
^significant at 5% level, two-tailed test for t-statistics
~significant at 1% level, one-tailed test for t-statistics
+significant at 5% level, one-tailed test for t-statistics
``significant at 1% level, one-tailed test for f-statistics

Equation 1: 2003 Results Corrected for Heteroskedacity with Weighted Least Squares (# of Obs.=286)
Equation 2: 2003 Results Corrected for Heteroskedacity with Robust Standard Errors (# of Obs.=286)
Equation 3: 2006 Results Corrected for Heteroskedacity with Weighted Least Squares (# of Obs.=276)
Equation 4: 2006 Results Corrected for Heteroskedacity with Robust Standard Errors (# of Obs.=276)

Table 3

Probit Results for Adding at least one Diagnostic or Therapeutic Equipment valued in Excess of $500,000

Eq.	C	HosSys	ProfMa	AccTFA	FTE	EMEX	Teach	BedAv	NFP	Gov	PseudoR^2	Wald Chi^2
1	-2.344	***0.109***	0.778	0.694	0.190	-0.334	***-0.136***	0.002	***-0.061***	***-0.041***	0.1604	34.55``
	(4.33)*	(2.19)+	(0.91)	(1.21)	(3.28)*	(1.39)	(1.79)	(2.99)~	(0.98)	(0.54)		
2	-2.213	***0.208***	1.887	-0.382	0.125	-0.0340	***-0.031***	0.003	***0.088***	***0.691***	0.2226	59.79``
	(5.01)*	(3.57)~	(2.62)~	(0.68)	(2.62)*	(0.69)	(0.27)	(4.48)~	(1.17)	(0.65)		

Notes: *significant at 1% level, two-tailed test for t-statistics
^significant at 5% level, two-tailed test for t-statistics
~significant at 1% level, one-tailed test for t-statistics
+significant at 5% level, one-tailed test for t-statistics
``significant at 1% level, one-tailed test for f-statistics

Equation 1: 2003 Probit Results with Robust Standard Errors

Equation 2: 2006 Probit Results with Robust Standard Errors

Note: Coefficients that are Bold and Italicized indicate that they report Marginal Effects therefore; coefficients report the Probability of a Likely Occurrence for Binary Variables.

Table 4

Summary Statistics for HHI Study

ChangeHHI	HHI03	HHI07	SumEq03-06	ChangeBeds	LostSysMem	LeftSys	EnterSys	ChangSys
-0.005783	0.2816046	0.2758216	$2625421	3.836299	***0.096085***	***0.0427046***	***0.0284698***	***.0320285***
(0.043878)	(0.1200144)	(0.1101233)	($5150289)	(31.54987)				

Note: Bold and Italicized numbers indicate percentage of hospitals for binary variables

Table 5

Regression Results for Change in HHI from 2003 to 2007 with Robust Standard Errors

C	LnSum	LstSys	LeftSys	EntSys	ChngSys	ChgBed	HHI03	R^2	F
0.0286	0.00888	-0.0106	-0.0088	0.029	-0.0118	-0.00002	-0.14655	.2044	4.95``
(3.90)*	(2.38)^	(1.76)	(0.23)	(1.33)	(0.44)	(0.38)	(4.53)*		

Notes: *significant at 1% level, two-tailed test for t-statistics
^significant at 5% level, two-tailed test for t-statistics
~significant at 1% level, one-tailed test for t-statistics
+significant at 5% level, one-tailed test for t-statistics
``significant at 1% level, one-tailed test for f-statistics