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Hospital Competition and Financial Performance:

A Meta-Analytic Approach

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ABSTRACT

The relationship between competition and hospital financial performance has been investigated by many researchers for the last 20 years. Although considerable research has been devoted to understanding the relationship between competition and hospital financial performance, less attention has been paid to summarizing the mixed and sometimes conflicting findings of these studies and defining an overall effect of competition on hospital performance. This study is designed to evaluate the magnitude of the competition effect on hospital financial performance by using meta-analytic methods. As a measure of competition, we focused on the Herfindahl-Hirschman Index (HHI), the most frequently used measure of competition in the empirical literature. As financial performance indicators, we examined cost, profitability, and revenue ratios. In our final meta-analysis, we utilized 60 comparisons in 41 studies using random effect models. The results indicated overall effect size at positive 1% for profitability, at -1% for cost, and -3% for revenue, with only revenue being significant due to considerable heterogeneity across studies. The study findings suggest that hospitals located in less competitive markets (high HHI) experience higher profitability, lower cost, and lower revenue. Further advanced meta-analyses were also performed to understand underlying factors that led to high heterogeneity across studies.

Keywords: Financial Performance; Competition; Herfindahl-Hirschman Index (HHI); Hospital

Introduction

The study of competition between hospitals has become an essential aspect of financial performance research. When one considers recent legislation, quality initiatives, and pricing transparency trends that put U.S. hospitals under further financial pressures, it is expected that the attention on market competition among researchers and other healthcare stakeholders will continue to grow. A couple of recent systematic reviews identified market competition, measured by Herfindahl-Hirschman Index (HHI), as the one of the most frequently used independent variables (Ghiasi, Zengul, Ozaydin, Oner, & Breland, 2018; Oner, Zengul, Ozaydin, Pallotta, & Weech-Maldonado, 2016).

There have been mixed findings on the relationship between competition and financial performance in previous research. For example, one of the aforementioned systematic reviews found that out of 13 explored relationships between HHI and operating margin, 15% were significant and negative, 46% were non-significant, and 38% were significant and positive. These mixed findings may be due to differences in study designs, samples, and measurement approaches. For example, measures of HHI may vary based on the definition of hospital market, such as county, metropolitan statistical area, hospital service area, or hospital referral region (Baker, 2001; Wong, Zhan, & Mutter, 2005; Zwanziger, Melnick, & Mann, 1990). It also remains unclear how competition affects financial performance under different conditions. If competition affects financial performance, how much and in which direction, especially in regards to hospitals' profit, cost, and revenue, is also unclear.

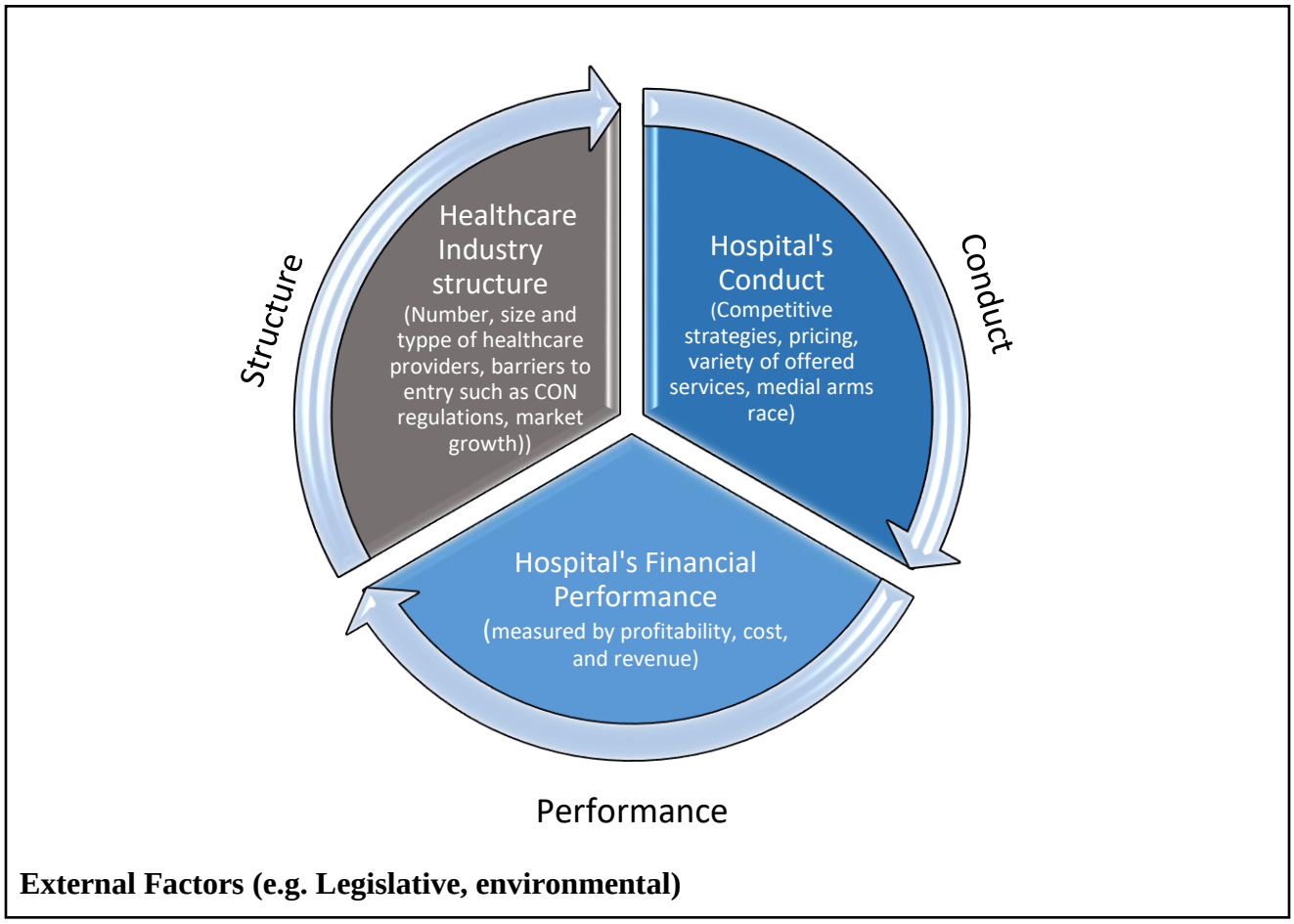
Meta-analysis is a useful technique for validating and summarizing findings of earlier studies by developing an overall effect size for a particular relationship (Borenstein et al., 2009). While systematic reviews rely on qualitative assessments of significant and non-significant relationships, meta-analysis provides a quantitative summary of the observed relationships from prior studies. This study uses meta-analytic methods to evaluate the magnitude of the effect of competition on hospital financial performance. Our primary aim in this paper is to provide insights into the relationship between hospital competition and financial performance (i.e., profit, cost, and revenue) by providing a quantitative synthesis of the empirical findings of earlier studies. Our secondary aim is to investigate the influence of potential study features on the overall effect size.

Conceptual Framework

The conceptual framework (Figure 1) of this study is based on the structure-conduct-performance (SCP) model that relies mainly on the pioneering work of Joe S. Bain (1962). In his work, Bain suggested that higher market concentration would be favorable to more moderate levels of competition, leading to high prices and better performance (or profits) (Sutton, 2001). Bain further explained high levels of concentration in markets with 'barriers to entry' (Sutton, 2001). According to the SCP model, the market structure refers to the playing field where organizations operate (Santerre & Neun, 2012). For the healthcare industry, this playing field is represented by the number, size, type, and distribution of providers, as well as the characteristics of patients. The structure also involves the barriers to entry, such as certificate of need (CON) regulations and information asymmetry between providers and patients (Santerre & Neun, 2012). Hospital's conduct is represented by various competitive and pricing strategies that hospitals engage in running the business. In our study, we selected competition, measured by HHI, as the primary independent variable due to two main reasons: 1) its high frequency of use in financial performance research; 2) it is the standard and preferred measurement method by various entities such as

Department of Justice and Federal Trade Commission (Baker, 2001). Hospital's financial performance is operationalized by the three most commonly used financial performance dimensions; profitability, cost, and revenue.

FIGURE 1
Conceptual Framework



Methods

Our primary method for this study is a meta-analysis, which is a technique used to synthesize a group of studies with similar aims into a single study. There must be a series of processes to get reliable results from a meta-analysis. Steps of a meta-analysis consist of defining the problem, searching literature, assessing inclusion/exclusion criteria, calculating the effect size, performing a basic and advanced meta-analysis and, finally reporting the findings (Field & Gillett, 2010; Rosethal, 1995; Borenstein et al., 2009).

At the initial step of the process, we determined the problem as 'what is the degree of relationship between competition and financial performance?'. The motivators that incited us to ask this

research question are the following: 1) Researches, especially in the USA, have been exploring the relationship between competition and financial performance for a long time. However, as of today, no study has provided information about the average effect of competition on hospital financial performance (Oner et al., 2016). Summarizing findings of earlier studies through average effect size is essential for researchers, administrators, and policymakers, since it would provide insights for interpretation of research results, strategic decision making, and economically sound allocation of scarce resources 2) It is also critical to find out if there are any study features affecting the effect size between competition and performance and if so, what the extent of their effect is.

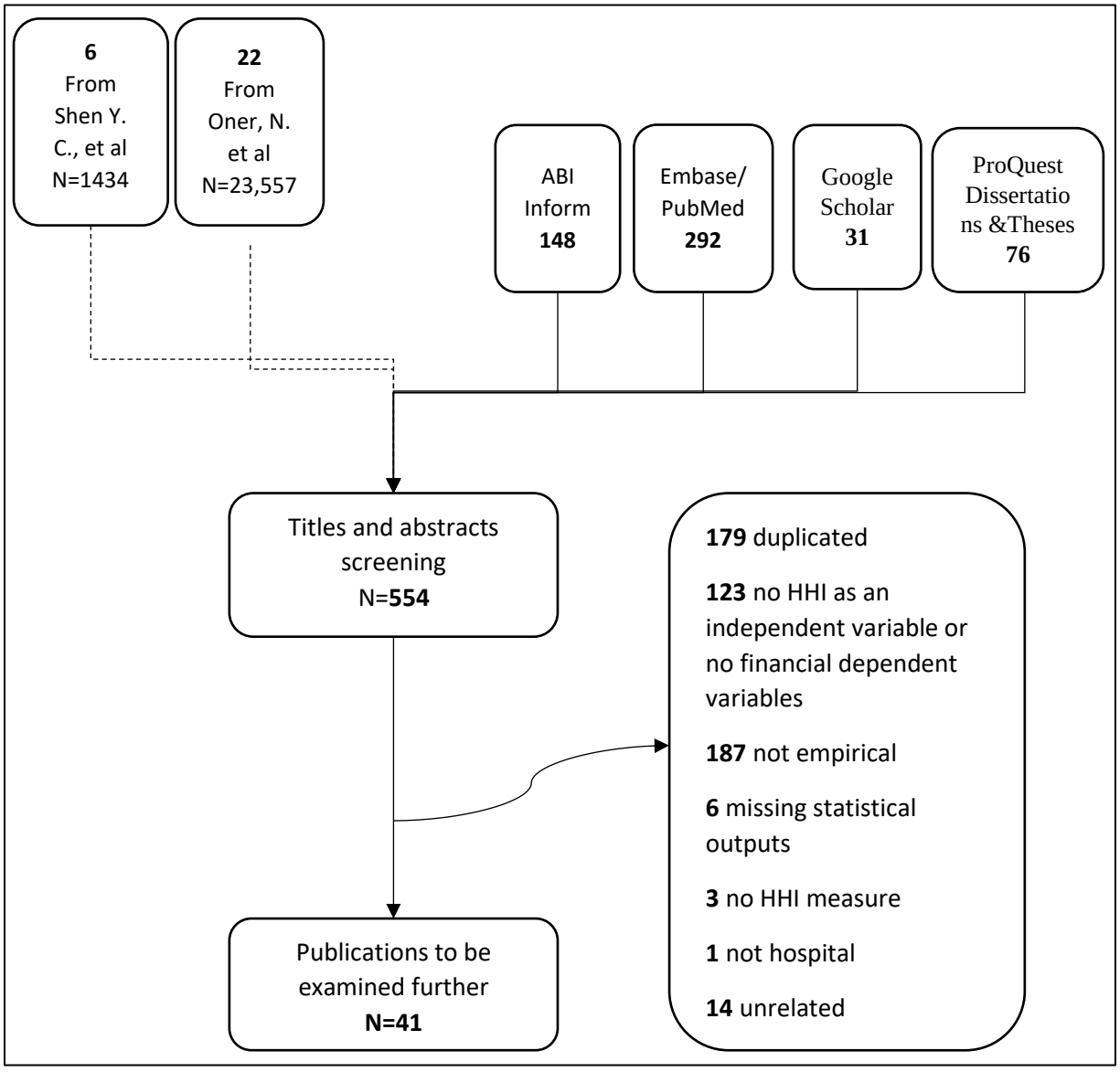
Literature Research and Inclusion and Exclusion Criteria

Figure 2 illustrates the search strategy. First, to gather the publications, we utilized findings of an existing systematic review (1996-2016) on hospital financial performance (Oner et al., 2016) and a meta-analytic review (1990-2004) on hospital ownership (Shen, Eggleston, Lau, & Schmid, 2007). Then to expand our search to not miss any potentially relevant publication, we determined the search terms (keywords) by using MeSH and EMTREE terms as well as gray literature. Boolean operators such as AND, OR were used as the principal operator for searching through EMBASE, PubMed, ABI inform, Google Scholar, and ProQuest Dissertations & Theses Global databases. No restriction criteria for publication type were used to reach all publications shown by search results. The search results include publications from 1996 through 2016.

Inclusion/exclusion criteria were defined to assess the publications with regards to suitability. We excluded publications that: 1) focused on hospital markets outside of the USA; 2) were published in a language other than English; 3) were not empirical; 4) did not include HHI as a competition measure, but used other competition measures such as numbers of competitors in a market; 5) did not include financial performance measures; 6) did not report (and we were unable to obtain from their authors) the statistical outputs (t values, p values or SE values), were unrelated or not at the hospital-level, and 7) were duplicates. We also prepared separate inclusion and exclusion forms for the financial outcome variables to allocate them into the three financial dimensions (profit, cost, and revenue) described in the conceptual framework (Figure 1).

We excluded the financial outcome variables that were either not suitable to the three financial dimensions or were measures of change of an underlying financial ratio. As a result of these steps, 41 studies remained for final analyses. For each of the 41 included studies, the following information was extracted into a pre-determined Microsoft Excel coding sheet: first author affiliation, study focus area, sample size, study year, data years, study design (cross-sectional versus longitudinal), sample level (e.g., national, multiple state, or single state), sample location (e.g., urban, rural), hospital ownership type (e.g., for-profit, not-for-profit, government, non-public); market share (based on admissions, number of beds etc.), market boundaries (e.g., county, HSA, MSA), and dependent variable (log-transformed versus not log-transformed). We also collected statistics such as beta coefficients and related t-statistics, p-values, and standard errors for every pair of HHI and financial outcome measures. We provided the details of the financial measures and dimensions included in this study in Appendix A.

FIGURE 2
Flow diagram of included studies



Meta-Analysis

Calculating Effect Size

Before calculating the effect size, it is necessary to determine which type of effect size will be calculated. Effect size can be defined as the level of variation between two groups (Coe, 2002) or the power of correlation between two variables. These methods can be classified as group or correlation designs. While group design methods consider variations among the groups, correlation design methods consider the power of correlation between variables (Durlak, 2009). This study explores the power of correlation between the level of competition (HHI) and financial performance measures (profit, cost, revenue). Correlation coefficients (r values) can be used to

measure the power and the direction of the two variables is measured (Rosethal,1991). Multiple regression analysis was the primary method in all studies examining this type of relation. However, regression analyses do not directly provide correlation coefficients. To address this limitation, we followed Shen's (2007) approach to calculate r values based on t statistics **(1)**.

$$r* = \sqrt{\frac{t^2}{t^2+d.f.}} \textbf{(1)}$$

t and *d.f.* (degree of freedom) values are needed for the above formula. However, t values were not directly reported in some studies. For these cases, $t = \frac{\beta}{SE}$ formula was used in studies where unstandardized beta coefficients (β) and Standard Error (*SE*) were provided. When these two values were not available in the published studies, then the authors of these studies were contacted to obtain those missing values. Unfortunately, these attempts were not satisfactory as only very few of those values were obtained. Therefore, the method used by Lipsey & Wilson (2001), which is based on calculating effect size by predicting t values from p values were utilized. Then, effect sizes were calculated using a web-based effect size calculator generated by Campbell Collaboration (Campbell Corporation, 2017). When the exact p-value is not provided in a study, the reported significance level thresholds, such as 0.1, 0.05, 0.01, or 0.001, were inserted into the calculator. We applied this approach since we were not able to obtain exact p-values from authors, despite multiple attempts. Beta coefficients' signs were considered as the direction of effect size. Hedges & Olkin (1985) revealed that the distribution of effect sizes tend to become more skewed as they move away from zero and suggested Fisher Transformation, which proximate the distribution to the Gauss Distribution. Therefore, we also applied fisher transformation **(2).**

$$Fisher(Z_{r^*}) = 0.5 * ln\left(\frac{1+r}{1-r}\right) \textbf{(2)}$$

After calculating effect sizes and performing Fisher transformations, 95% confidence intervals (CI) of standardized effect sizes were calculated. The following variance (V) **(3)** and confidence intervals (CIs) **(4)** formulas were used for these calculations (Borestein et al., 2009; Shen et al., 2005).

$$V(Z_{r^*}) = \frac{1}{n-3} \textbf{(3)}$$

$$CIs\ (Z_{r^*}) \pm 1.96 * \frac{1}{\sqrt{n-3}} \textbf{(4)}$$

It is likely for researchers to include more than one comparison of the investigated relationships. This non-reporting pattern is due to researchers wanting to compare the relationships at different times or with different dependent variables. However, it is expected that the data (i.e., relationships within reviewed studies) for meta-analysis should be independent of each other. This independence requirement might be a source of concern when more than one effect size is calculated in the same study. There are a few options available in this case: 1) Separate meta-analyses might be used for the assessment of each effect size. 2) the most suitable effect size would be selected. 3) a single effect size can be generated by combining those separate effect sizes (Cummings, 2012). As we mentioned earlier, we categorized study outcomes under three dimensions (i.e., revenue, cost, and profit). We combined the effect sizes that fall under one of these three dimensions from a particular study into one effect size. Such combining approach does not create bias since the magnitude of the effect sizes and CIs were very close. We refer the readers to more detailed discussions on effect

sizes and combination methods to several seminal publications in the meta-analytic field (Cummings, 2012, Borestein et al., 2009)

Basic Meta-Analysis

One of the crucial goals of meta-analysis studies is to determine an overall or combined effect that would summarize the impact of all included studies. A thorough calculation of targeted overall effect depends more on the weighting of included studies and proper information than taking effect sizes of all studies equally. Then, the question of how to determine the weight comes to mind. There have been two models so far, trying to answer this question: 1)fixed, and 2) random model analyses. While the fixed effects model assumes one proper effect size for all studies, the random effect model assumes that there might be more than one effect sizes that could be estimated. (Borestein et al., 2007, Cumming, 2014). This study used a random effect model since the populations of studies varied considerably, and the heterogeneity level was high among studies. As a random effect procedure DerSimonian–Laird (DL) estimator was used.

Advanced Meta-Analyses

One of the goals of our study was to determine the influence of pre-determined study features (i.e., market, study, sampling, and statistical) on the relationship between HHI and financial dimensions. For this reason, we performed separate meta-regressions for each financial dimensions. Meta-regressions investigate whether there is a difference between the effect sizes of the study features (Cumming, 2014) on the HHI-Financial Performance relationship. These study features are identified as the *scope of the study*, *authors' methodology classification*, *sample*, *design*, *sample level*, *sample location*, *hospital ownership*, *market share based on…*, *market boundaries*, and *functional form of the dependent variable* in this study. Due to their importance of advanced meta-analyses, we will explain each study feature in the following sections separately. More details are provided in Table 1 about the study features and their categories.

Scope of Study includes the focus areas that researchers utilized in their studies, such as environmental focus, external/internal organizational strategies, ownership factors, and performance factors. Environmental factors refer to non-competition, such as HMO penetration, per capita income in a county. External organizational strategies involve hospital system memberships, conversions, buyouts, and mergers and acquisitions. Internal Organizational Strategies include hospital downsizing, quality, staffing, planning, Board of Director's (BDO) structure, and effects on hospitals. Ownership factor refers to the effects types of ownership on hospitals. Lastly, performance factor A relates to general hospital performance, such as hospital cost minimizations, efficiency, and pay-for-performance.

Author's Methodology Classification aims to create a classification that represents structural and statistical information in the reviewed studies. We build our classification on Shen et al.'s (2007) meta-analytic study that focused on hospital ownership and financial performance. However, instead of having three categories, we improved Shen et al.'s 2007 classification by adding the most robust methodology category (i.e., Type-A studies). Our classification includes the following four categories: 1) Type-A studies are those that use panel data, market level (e.g., per capita income, population size), patient-level (e.g., case mix index, demographics) and hospital level (e.g., size, payer mix) variables. 2) Type-B studies use panel data and at least two levels from market, patient or hospital-level variables. 3) Type-C studies use either panel data variables or at least two level variables from the market, patient or hospital-level variables. 4) Type-D studies use

no panel data and only one level of variables from the market, patient or hospital-level variables. In our classification, as more levels are included the study becomes stronger. Therefore, Type A studies are the strongest since they included the most levels.

Study Samples refers to the focus of study samples according to their design, level, location, and ownership types. The sample design includes cross-sectional and longitudinal categories, whereas the sample level involves urban, rural, or non-limited categories. Sample locations are determined as national, multiple states, and a single state. Hospital ownership includes profit, not-for-profit, government.

Market Factors includes market share and market boundaries sub-groups. Market share sub-group classified based on various variables such as admissions, discharges, and inpatient/outpatient days that were used ultimately for the calculation of HHI. Moreover, the market boundary sub-group categorized into several geographical or legal boundaries such as county, health service area (HSA), metropolitan service area (MSA).

Statistical factors refer to the functional forms of dependent variables, whether the dependent variable is log-transformed or not. Studies utilized the log transformation to normalize the distribution of their study variables that tend to be skewed, such as revenue and cost data.

Before moving to the last step for advanced meta-analysis, we addressed the potential publication bias by utilizing a graphical method, funnel plots with/without trim and fill, and a statistical method, Linear Regression Method developed by Egger et al. (1997). For more discussions about these methods and pros and cons of alternative methods, we refer the reader to several valuable sources (Begg & Mazumdar, 1994; Borenstein, Hedges, Higgins, & Rothstein, 2010; Cumming, 2012; Duval & Tweedie, 2000a, b; Egger et al., 1997; Light & Pillemer, 1984; Rothstein, Sutton, & Borenstein, 2006).

As the last step, we performed outlier detection and sensitivity analyses to see the effect of each study on the overall (summary) effect size across financial dimensions. We used R Metafor package influence diagnostic method (Viechtbauer & Cheung, 2010) for outlier analyses, whereas the leave-one-out method (Viechtbauer, 2010) was used for sensitivity analyses.

Reporting

The Endnote program was used for the literature search phase. Meta-analyses were performed in R statistical software. There are a couple of meta-analysis packages in R software. In this study, the R Metafor package was used. This package can produce results for many meta-analytic models, such as a fixed model, random model, cumulative model, mixed models, multilevel model, multivariate model, and network model. There are a variety of suitable heterogeneity estimators for these models. Also, a great deal of meta-analytic plotting can be drawn with this package including forest plots, funnel plots, and radial plots, etc. (Viechtbauer, 2010). Random and mixed models were composed in this study based on each financial dimension. The plotting of these models consisted of forest plots and with trim fill or without trim fill funnel plots. The performed meta-analysis study is prepared based on the Meta-Analysis Reporting Standards (MARS) published by the American Psychological Association(MARS, 2008).

Results

Table 1 exhibits the descriptive statistics of the included studies by conceptual factors, study specifications, and financial dimensions. Studies that included financial dimensions of profitability, cost, and revenue were 19, 26, and 15, respectively. The majority of studies (31.7%) within the scope of study factors were classified under external organizational strategies. 43% of the studies were classified into Type-A, the most robust methodology category, followed by 26.7% of studies in the Type-B category. The majority of studies (53.3%) had a longitudinal design, were not limited to any sub-groups in regards to their sample level (63%), and their hospital ownership (53.3%), and were national (70%) according to their sample location. Most of the studies calculated market share by using discharges (21.7%), followed by inpatient/outpatient days (20%). Market boundaries were determined by utilizing mostly county (30%) followed by MSA (23%). Regarding the statistical factors, the majority of studies (51%) used log transformation on their dependent variables.

TABLE 1

Distributions of studies by conceptual factors, study specifications, and financial dimensions

Conceptual Factors	Study Specifications		Financial Dimensions			Total
			Profitability	Cost	Revenue	
Study Factors	Scope of study	Focus on Environmental Factors	4	6	3	21.7%
		Focus on External Organization Strategies	5	8	6	31.7%
		Focus on Internal Organization Strategies	6	1	0	11.7%
		Focus on Ownership	0	2	1	5.0%
		Focus on Performance	4	9	5	30.0%
	Authors' Methodology Classification	Type a	6	11	9	43.3%
		Type b	9	4	3	26.7%
		Type c	2	6	3	18.3%
		Type d	2	5	0	11.7%
Sampling Factors	Sample Design	Cross-sectional study	8	15	5	46.7%
		Longitudinal study	11	11	10	53.3%
	Sample Level	Rural area	2	2	1	8.3%
		Urban area	6	8	3	28.3%
		Not limited any sub-groups	11	16	11	63.3%
	Sample Location	National	14	20	8	70.0%
		Multi-States	1	2	2	8.3%
		California	0	1	2	5.0%

		Florida	3	1	1	8.3%
		Iowa	1	1	1	5.0%
		Pennsylvania	0	1	0	1.7%
		Texas	0	0	1	1.7%
	Hospital Ownership	For-Profit	1	3	4	13.3%
		Government	1	1	1	5.0%
		Not-for profit	4	2	1	11.7%
		Non-Government	3	4	3	16.7%
		Not limited any sub-groups	10	16	6	53.3%
Market Factors	Market Share Based on…	Admissions	2	5	2	15.0%
		Discharges	2	6	5	21.7%
		Number of Bed	3	3	3	15.0%
		Number of Hospital	0	2	0	3.3%
		Inpatient or outpatient days	6	4	2	20.0%
		Revenue	2	0	0	3.3%
		N/A	4	6	3	21.7%
	Market Boundaries	County	7	7	4	30.0%
		Hospital Service Area	1	2	2	8.3%
		Metropolitan Service Area	5	7	2	23.3%
		County /Metropolitan Service Area	3	4	3	16.7%
		ZIP Code	1	2	2	8.3%
		N/A	2	4	2	13.3%
Statistical Factors	Functional Form	Dependent variable is not logged transformed	16	9	4	48.3%
		Dependent variable is log transformed	3	17	11	51.7%
Number of Studies			19	26	15	

N/A.: Not applicable

Table 2 exhibits the studies that were included in this meta-analysis by the scope of studies, authors, financial dimensions, sample location, data year(s), and sample sizes or the number of observations. The highlighted six authors in Table 2 utilized all three financial dimensions, whereas the majority of the authors in included 28 studies utilized one financial dimension. There were substantial variations among studies in regards to their sample sizes or the number of observations.

TABLE 2

Studies Included in Meta-analyses

Scope of Studies	Author(s)	Financial Dimensions			Sample Loc.	Data Year (s)	N
		Profitability	Cost	Revenue			
Focus on Environmental Factors	**Clement et al 2001b**	1	1	1	NAT	1995	2386
	Conner et al. 1998		1	1	NAT	1986-1994	3684
	Douglas et al. 2003	1			NAT	1996-1998	824
	Henke et al. 2013		1		NAT	2008	742*
	Rivers et al. 1999		1		NAT	1991	837*
	Shen et al. 2004		1	1	NAT	1998	8628
	Thorpe et al. 2001	1	1		NAT	1991-1997	21000
	Young et al. 2002	1			FL	1990-1997	1017
Focus on External Organization Strategies	Carey a2003		1		NAT	1998	1209
	Clement et al 1997a	1	1	1	NAT	1994-1995	2482
	Kim et al 2012	1	1	1	MUL	2006-2009	121*
	Krishnatn et al. 2003			1	CA	1995-1996	113*
	Li et al 2009	1	1	1	IA	1998-2004	623*
	Mark 1999	1	1	1	NAT	1989-1992	30771
	Menke 1997		1		NAT	1990	1467*
	Tennyson et al. 2000	1			FL	1986-1992	332*
	Wedig et al. 1998		1		CA	1988	171*
	Wilcox-Gök et al. 2002		1	1	FL	1984-1987	573*
Focus on Internal Organization Strategies	Alexander et al. 2006a	1	1		NAT	1997-1997	1722
	Alexander et al. 2006b	1			NAT	1985-1994	950
	Chadwick et al. 2004	1			NAT	1991-1996	58*
	Collum et al. 2014	1			NAT	2011	517*

	Everhart et al. 2013	1			FL	2008	121
	Patidar et al. 2016	1			NAT	2006-2010	3150
Focus on Ownership	Ettner et al. 2001		1		NAT	1990	39532*
	Sloan et al. 2001			1	NAT	1982-1994	8403
	Song et al. 2013		1		NAT	2006	3317
Focus on Performance	Becker et al. 2002		1		NAT	1994	4705
	Carey et al. 2008		1		MUL	1998-2004	1018
	Carey 1997b		1		NAT	1987	1733*
	Clement 1997			1	CA	1985-1992	769*
	Garmon 2006			1	MUL	1999	65*
	Ginn et al. 2000	1			NAT	2000	1779
	Kim 2010	1			NAT	1998-2001	922*
	Kruse et al. 2012		1	1	NAT	2002-2005	260
	Lee et al. 2016			1	TX	2007-2010	1493*
	Pizzini 2006	1	1		NAT	1997-1998	277
	Potter 2001		1		NAT	1980-1994	4861*
	Rosko 2004		1		PA	1995-1998	714
	Schneider et al 2007	1	1	1	NAT	1997-2004	31302
	Younis et al. 2005		1		NAT	1991	1967*

* Average sample sizes for combined effect sizes
N: Sample size or number of observation
NAT: National, MUL: Multiple States, CA: California, FL: Florida, IO: Iowa PA: Pennsylvania, TX: Texas,

Basic meta-analysis results

The result of meta-analyses is provided in Table 3, which includes overall effect sizes for each financial performance dimensions by using random-effect models. It also exhibits I^2 (total heterogeneity/total variability) percentages and heterogeneity test (Q) results. Only revenue was found to be significant (negative) concerning the overall effect size. All models were significant in regards to their heterogeneity. Lastly, I^2 percentages, the percentage of the variation within each study (heterogeneity) to the total variation, were very high (greater than 83%) for all models. High heterogeneity across studies validates our approach of using the random-effects model in our meta-analyses.

TABLE 3
Overall random effect sizes of HHI by financial dimensions

	Profitability	Cost	Revenue
Overall Effect Size Estimation	0.006 (0.01)	-0.010(0.01)	-0.031(0.01) *
I^2 (total heterogeneity / total variability)	83.79%	85.32%	91.79%
Q (Test for Heterogeneity)	111.02***	170.35***	170.47***
Number of Studies	19	26	15

Values in parenthesis show calculated effect sizes' standard deviations
*** p<0.000, * p<0.05

Figure 3 exhibits the forest plots for the profitability dimension. The most striking finding is the aggregation of most of the effects sizes (i.e., black squares) along the vertical line, with the majority being on the positive side. The overall effect size (diamond) between HHI and Profitability was 1% located on the right of the vertical line at the bottom. However, the CI for the overall effect size was from -0.02 to 0.03. The largest CI belongs to the study performed by Chadwick, Hunter, and Walston (2004), which had the smallest sample size (n=58) and the weight (w=0.61%). The weight columns indicate the percentage contribution of a particular study on the average effect size. Studies with high sample sizes such as Mark (1999) and Schneider et al. (2007) had the highest weights with 9.40% and 9.41%, respectively. However, these two studies had opposite findings in regards to their effect size -0.01 and 0.01, respectively.

FIGURE 3
Forest plot of studies used profitability dimension

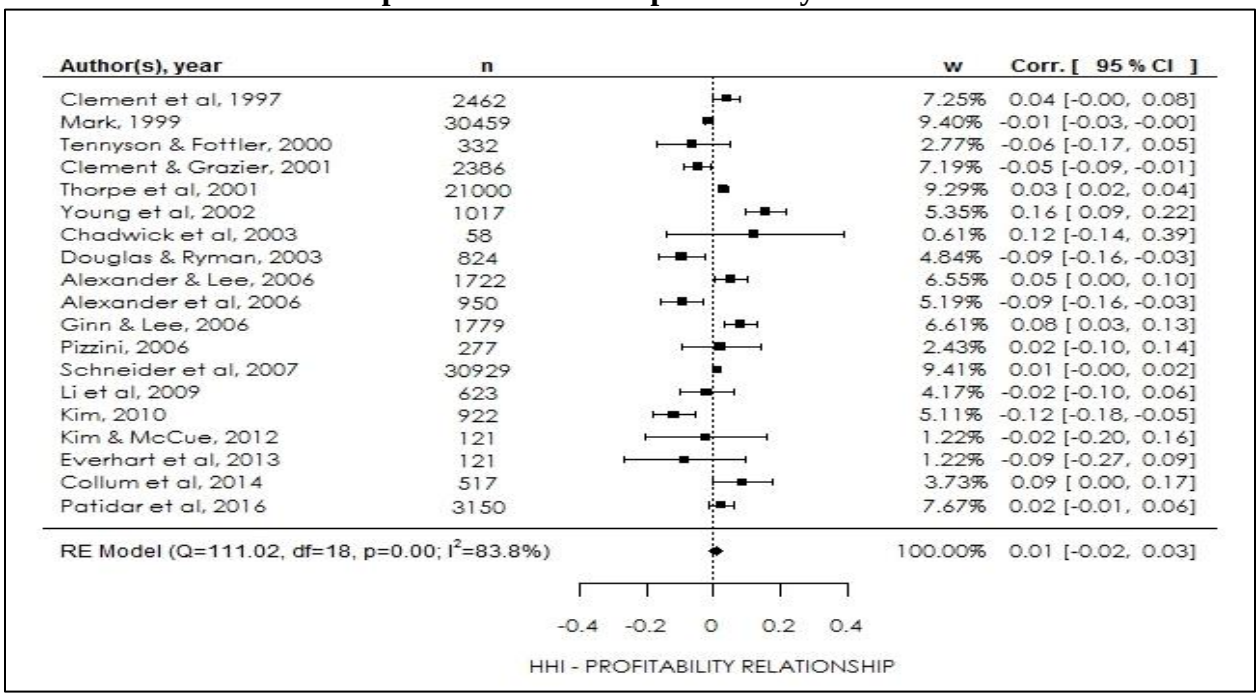


Figure 4 exhibits the forest plots for the cost dimension. The most notable finding is the aggregation of most of the effects sizes (i.e., black squares) along the vertical line, with the majority being on the negative side. The overall effect size (diamond) between HHI and Profitability was -1% located on the left of the vertical line at the bottom. However, the CI for the overall effect size was from -0.03 to 0.01. The largest CI belongs to the study performed by two studies: Wedig, Mahmud, Van Horn, and Morrisey (1998) and Kim and McCue (2012), both of which had the smallest sample sizes (n=171 and n=121) and the weights (w=0.93% and w=0.68). Studies with high sample sizes such as Mark (1999) and Schneider et al. (2007) had the highest weights (6.14%). Contrary to the profitability results, in the cost studies, these two studies had identical effect sizes (0.01) with the same (positive) directions. However, the overall effect size had a negative direction (-0.01).

FIGURE 4
Forest plot of studies used cost dimension

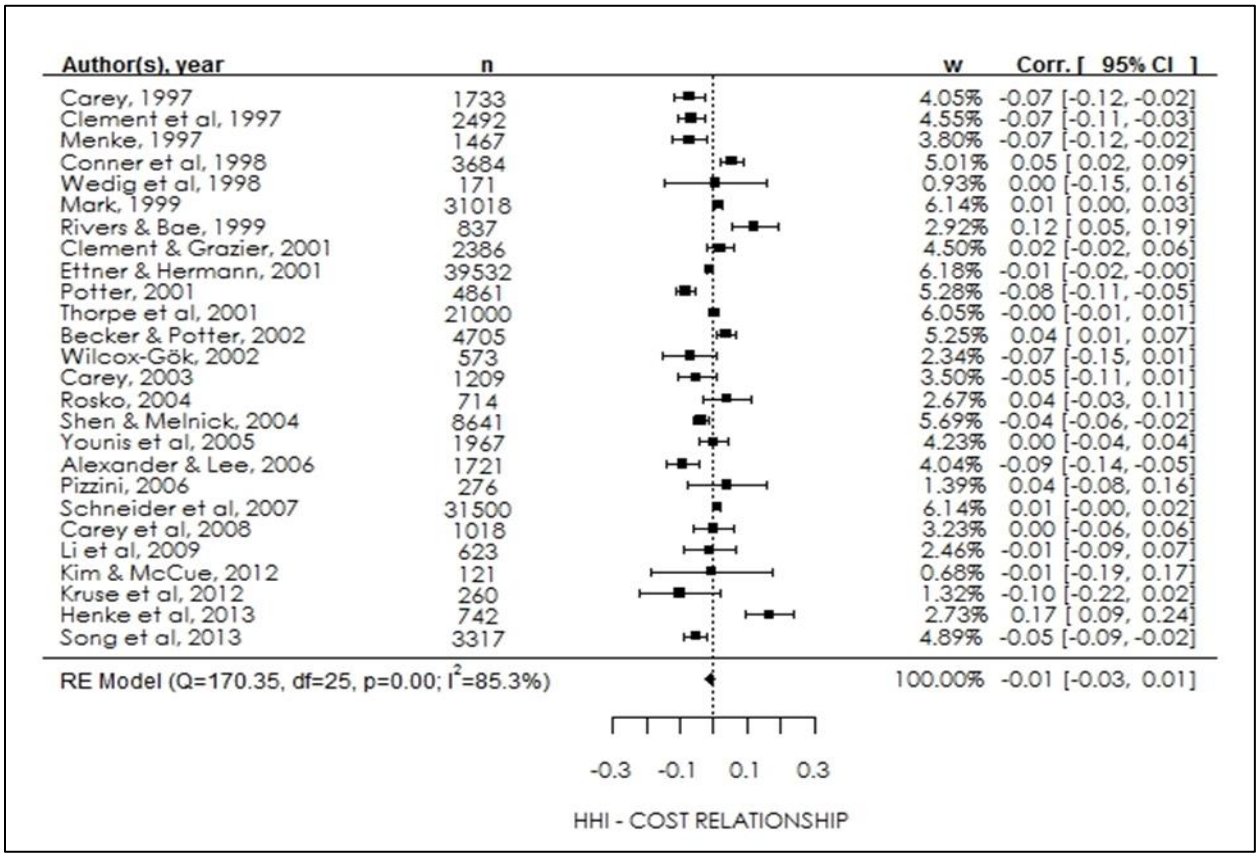
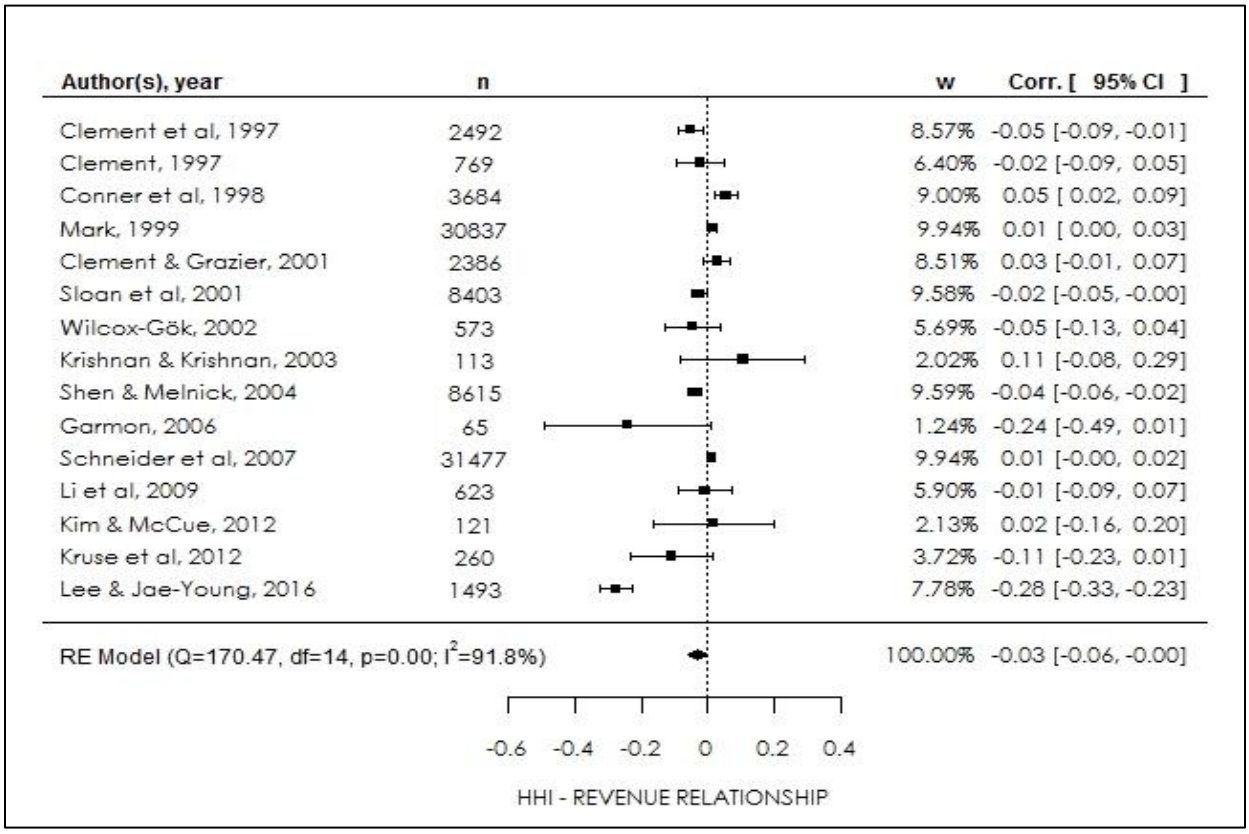


Figure 5 exhibits the forest plots for the revenue dimension. Again, the most important finding is the aggregation of most of the effects sizes (i.e., black squares) along the vertical line, with the majority being on the negative side. The overall effect size (diamond) between HHI and Profitability was -3% located on the left of the vertical line at the bottom. However, the CI for the overall effect size was on the negative side ranging from -0.06 to 0.00. The largest CI belongs to the study performed by two studies: Garmon (2006) and Lee and Jae-Young (2016). Both of them had the smallest sample sizes (n=65 and n=121) and the weights (w=1.24% and w=2.13%).

Similar to the profitability and cost, studies with high sample sizes such as Mark (1999) and Schneider et al. (2007) had the highest weights (9.94%). Similar to the cost results, in the revenue studies, these two studies had identical effect sizes (0.01) with the same (positive) directions. However, the overall effect size had a negative direction (-0.01).

FIGURE 5

Forest plot of studies used revenue dimension



Advanced meta-analysis results

Table 4 exhibits the study features that explained the differences among studies that investigated the effects of HHI on financial dimensions (profitability, cost, and revenue). We reported the meta-analysis results of profit studies in the first column. The first panel in Table 4 displays the meta-analysis results using study focus categories as independent variables. However, there were no significant findings in this first panel. In the profit column (first column), the majority of study features did not exhibit a significant effect on the relationship between HHI and profit except the panels dedicated to sample level and hospital ownership factors. The average effect size across all studies used urban area hospitals as the sample level (factor) was found to be 0.05 ($p<0.05$) lower than the reference category of not-limited-any-subgroups. In Table 5, all the effect sizes are reported concerning the average effect size of the reference groups (*italic and underlined*). The average effect size for each study feature subcategory can be calculated by adding the effect sizes to the average effect size reported in the reference category. For example, the average effect size for the not-limited-any-subgroups category within the hospital ownership category was

0.03($p<0.05$). This result means that there is a significant and positive association between HHI and profit when studies did not limit their sample to a particular ownership type. The average effect size of not-for-profit hospitals was found to be 0.08 ($p<0.02$) lower than the reference category of not-limited-to-subgroups. If one wants to calculate the average effect size for not-for-profit hospitals, it simply needs to add the average effect size in the reference category to the effect size in the not-for-profit category (0.03-0.08=-0.05). This result means that for not-for-profit hospitals, one unit increase in HHI (less competition) is associated with 0.05 decrease in profitability. The I^2 values at the bottom of the hospital ownership panel indicate that after controlling for hospital ownership, 79.78% of the variation in the standardized effects sizes are due to heterogeneity across studies.

TABLE 4

Meta-Regression Results for HHI studies by financial dimensions

Study Features	*Profitability*		*Cost*		*Revenue*	
	Est	*Se*	*Est*	*Se*	*Est*	*Se*
Scope of study						
Focus on Environmental Factors (Ref)	*0.01*	*0.03*	*0.04(*)*	*0.02*	*0.01*	*0.05*
Focus on External Organization Strategies	-0.02	0.04	-0.08(**)	0.03	-0.02	0.06
Focus on Internal Organization Strategies	0	0.04	-0.13(*)	0.05	-	-
Focus on Ownership	-	-	-0.07 (+)	0.04	-0.04	0.1
Focus on Performance	-0.01	0.04	-0.05 (*)	0.03	-0.12 (+)	0.07
I^2	83.57%		85.87%		78.45%	
Authors' Methodology Classification						
Type a (Ref)	*-0.02*	*0.02*	*-0.01*	*0.01*	*-0.01*	*0.02*
Type b	0.04	0.03	-0.02	0.02	0.01	0.03
Type c	0	0.06	0.03	0.02	-0.20(***)	0.04
Type d	0.02	0.04	-0.01	0.02	-	-
I^2	85.12%		86.46%		80.86%	
Study Design						
Cross-sectional study (Ref)	*0*	*0.02*	*-0.01*	*0.01*	*-0.01*	*0.03*
Longitudinal study	0.01	0.02	0	0.02	-0.03	0.04
I^2	84.66%		85.27%		89.08%	
Sample Level						
Not limited any sub-groups (Ref)	*0.03*	*0.02*	*-0.02(*)*	*0.01*	*-0.04(*)*	*0.02*
Rural area	-0.03	0.05	0.03	0.04	0.03	0.07
Urban area	-0.05(*)	0.03	0.03(+)	0.02	0.03	0.04
I^2	85.24%		86.48%		92.93%	
Sample Location						
National (Ref)	*0*	*0.01*	*-0.01*	*0.01*	*0*	*0.01*
Multi-States	-0.02	0.1	0.01	0.08	-0.07	0.08
California	-	-	0.01	0.05	0	0.04
Florida	0.06	0.04	-0.06	0.05	-0.04	0.05

Iowa	-0.02	0.05	0	0.05	0	0.05
Pennsylvania	-	-	0.05	0.05	-	-
Texas	-	-	-	-	-0.27(***)	0.04
I^2	85.14%		87.98%		83.09%	
Hospital Ownership						
Not limited any sub-groups (Ref)	*0.03(*)*	*0.02*	*0*	*0.01*	*-0.06(*)*	*0.03*
For-Profit	-0.06	0.1	-0.04	0.03	0.01	0.05
Government	-0.08 (+)	0.04	0.02	0.04	0.09	0.06
Not-for profit	-0.08 (**)	0.03	0	0.05	0.05	0.07
Non-Government	-0.02	0.04	-0.01	0.02	0.05	0.04
I^2	79.78%		85.92%		92.50%	
Market Share Type Based on						
Inpatient/outpatient days (Ref)	*-0.03*	*0.04*	*-0.03*	*0.03*	*-0.04*	*0.07*
Admissions	0.03	0.07	0.06	0.04	0.11	0.1
Discharges	0.02	0.08	0.03	0.04	-0.05	0.08
Number of Beds	0.07	0.07	0.01	0.05	0.01	0.09
Number of Hospitals	-	-	0.02	0.05	-	-
Revenue	0.07	0.07			-	-
I^2	86.27%		88.62%		83.09%	
Market Boundaries						
Metropolitan Service Area/County (Ref)	*0.01*	*0.04*	*-0.02*	*0.03*	*-0.02*	*0.05*
County	0.01	0.05	-0.01	0.03	-0.06	0.06
Hospital Service Area	0.11	0.15	-0.01	0.05	-0.01	0.09
Metropolitan Service Area	-0.04	0.05	0.04	0.03	0	0.07
ZIP Code	0.01	0.07	0	0.04	-0.07	0.08
I^2	87.12%		88.32%		94.41%	
Functional Form						
Dependent variable is not logged transformed (Ref)	*0.01*	*0.01*	*-0.02*	*0.01*	*-0.08(*)*	*0.03*
Dependent variable is log transformed	-0.04	0.03	0.02	0.02	0.07(+)	0.04
I^2	83.32%		84.66%		92.37%	

***p<0.001, ** p<0.01, *p<0.05, +p<0.10

Est: Effect size estimations, Se: Standard Error, Ref.: Reference Group, I^2: Residual heterogeneity / unaccounted variability

Regarding the cost dimension, only the scope of study and sample level study features had a significant impact on the relationship between HHI and cost. Within the scope of study panel under cost dimension, the coefficient on the reference group, .04, refers to the average effect size across all studies that focuses on environmental factors. Studies that are focusing on external/internal organizational strategies have an average effect size .08/.13 times smaller than studies whose focus is environmental factors, the reference category. Studies that are focusing on

ownership have an average effect size .07 times smaller than the reference category. However, this relationship was borderline significant ($p<0.1$) due to the relatively large SE.

Revenue which was the only financial performance dimension that exhibited significant and negative (-0.03) overall effect size in the basic-meta analysis (Figure 5) had also exhibited significant results in the advanced meta-analysis for most of the study features except three: *study design, market share based on…, and market boundaries*. Within the *scope of study* panel under revenue dimension (Table 4), the coefficient on the focus on performance group, -.12 indicates that the effect size for these studies 0.12 times smaller than studies whose focus is environmental factors, the reference category. However, this relationship was borderline significant ($p<0.1$) due to the relatively large SE. Revenue was the only financial dimension that exhibited significant results within the authors' methodology classification. The coefficient on the Type-C group, -.20 indicates that the average effect size for these studies was -0.21 which can be calculated by simply adding the average effect size of the reference category (-0.1). This finding means that there is a significant and negative association between HHI and revenue when studies are classified as Type-C. These studies are less robust than Type-B studies since they use either panel data variables or at least two level variables from the market, patient or hospital-level variables. The average effect size for the not-limited-any-subgroups category within sample level study features was -.04($p<0.05$). This finding suggests that there is a significant and negative association between HHI and revenue when studies did not limit their sample to a particular sample level, such as rural or urban. There is a significant and negative (-0.06, $p<0.05$) association between HHI and revenue when studies did not limit their sample to a particular ownership type. There is a significant and negative (-0.08, $p<0.05$) association between HHI and revenue when studies log-transformed their dependent variables. However, the association turns into positive and borderline significant (0.07, $p<0.1$) when studies did not log-transform their dependent variables, the revenue measures.

Publication bias and sensitivity analyses

As previously mentioned in the methods sections, we used Egger's Regression Method to investigate the publication bias statistically. As graphical analyses of publication bias, we utilized funnel plots with/without trim and fill. Figure 6.1 and 6.2 displays the funnel plots of profitability for the random-effects model without/with trim and fill. As can be observed from these two funnel plots, the dots that represent the included studies are symmetrically distributed on both sides of the vertical line. The white dot in figure 6.2 represents the article that we are possibly missing in our random-effects meta-analyses.

Similarly, Figures 7.1 and 7.2 exhibits the forest plots of the random-effect model without/with trim and fill for the cost. Figures 8.1 and 8.2 exhibits the forest plots of the random effect model without/with trim and fill for revenue. Again one can observe that the studies (black dots) in these four figures are symmetrically distributed on both sides of the black vertical line. There were no white dots (i.e., potentially missing articles) in these four figures. As a result of these analyses, we concluded that our study had no bias since no result had asymmetric distribution.

We also performed outlier analyses by utilizing the leave-one-out method and did not find any significant difference in I^2 variability. According to sensitivity analysis results, the majority of the overall effect size for profitability was positive and ranged from -0.002 and 0.013. All of the

overall effect sizes for cost were negative and ranged from -0.015 and -0.007. Similarly, all of the overall effect sizes for revenue were negative and ranged from -0.040 and -0.006.

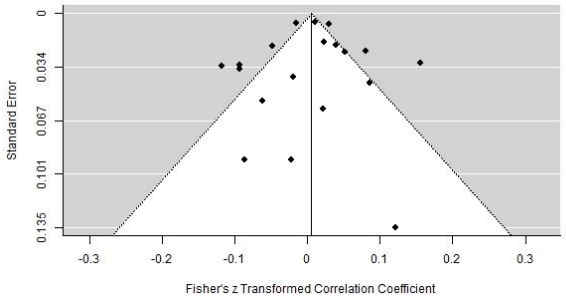


Figure 6.1 Funnel plot of studies used profitability measures (n=19)
Asymmetry test: z = -0.6054, p = 0.5449

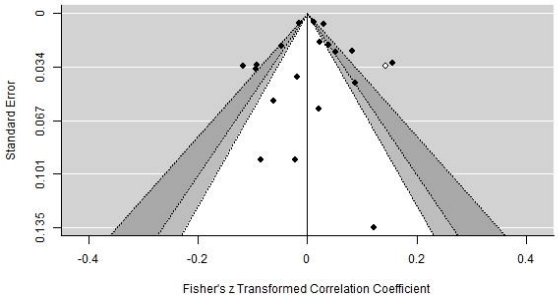


Figure 6.2 Funnel plot of studies used profitability measures with Trim Fill (n=19, n_p=1),White area= 90% CL Grey area= 95% CL,Dark gray area= 99%

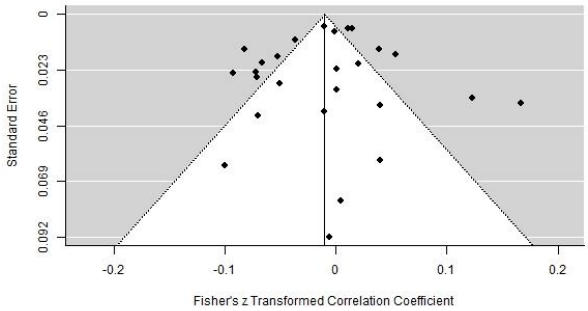


Figure 7.1 Funnel plot of studies used cost measures (n=15)
Asymmetry test: z = 0.3470, p = 0.7286

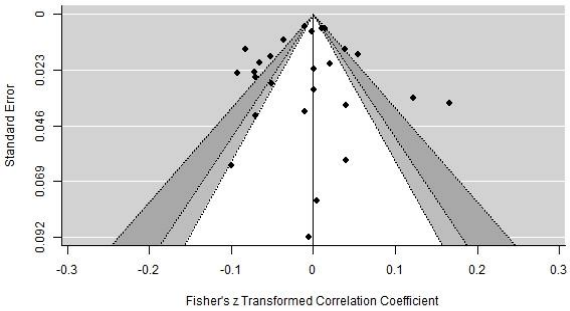


Figure 7.2 Funnel plot of studies used cost measures with Trim Fill (n=15, n_p=0), White area= 90% CL,Grey area= 95% CL,Dark gray area= 99%

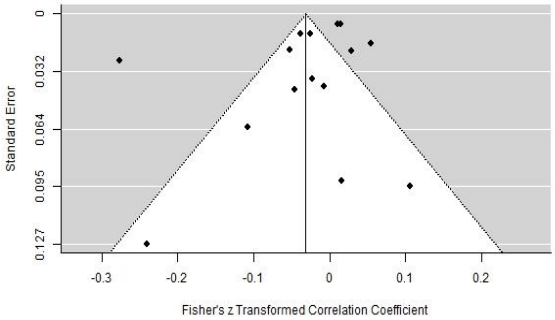


Figure 8.1 Funnel plot of studies used revenue measures (n=15)
Asymmetry test: z = -1.0860, p = 0.2775

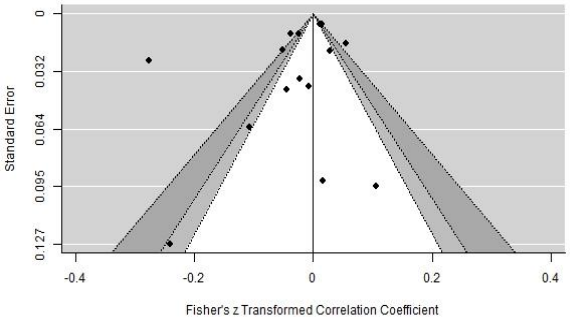


Figure 8.2 Funnel plot of studies used revenue measures with Trim Fill (n=15, n_p=0), White area= 90% CL,Grey area= 95% CL,Dark gray area= 99%

Discussion

This study aimed to determine the existence and magnitude of the effect size of HHI on hospitals' financial performance dimensions (profit, cost, revenue). To achieve this goal, a comprehensive and systematic literature search was performed to gather all potential studies investigating the relationship between HHI and Financial Performance. By utilizing a priori criteria, a study sample was established by excluding non-relevant studies. Then, the data from the included studies were utilized to perform meta-analysis along with appropriate sensitivity and outlier tests. The results were reported in tables, graphs, and figures.

There are several prominent findings of this study that necessitates further discussions. Firstly, the descriptive analyses revealed that the number of studies that focused on profitability, cost, and revenue was close to each other, with the cost being the highest number (59 relationships in 26 articles). The majority of these cost studies focused on cost minimization and cost-efficiency. Finding that the majority of studies is focusing only on one financial dimension call for the more diversified approach in analyzing financial performance.

Secondly, our results provided valuable insights regarding each financial performance dimensions, including profitability, cost, and revenue. Across all three financial dimensions, if someone explores individual study level findings and compares them with the findings of other studies, one can easily see that there is no agreement among studies in regards to the direction and effect sizes. This variation among studies confirms the need for a quantitative meta-analytic approach that provides tools to summarize these disparate and conflicting findings. Therefore, when one evaluates our results and the results of sensitivity analyses regarding the relationship between HHI and financial performance, one should pay attention to the direction and overall effect size of the particular relationship. In the following paragraphs, we will discuss our findings for all three financial dimensions separately.

Competition and Profit

When one evaluates the relationship between HHI and profitability at the individual study level, one can observe that the results are not evident in regards to the direction and the size of the relationship. However, the results and sensitivity analyses of studies have shown a positive 1% but non-significant overall effect size due to considerable heterogeneity across studies. This positive and small effect size may imply that an increase in HHI (refers to the reduction in competition and an increase in hospital market power) is associated with an increase in profitability. Further meta-regression analyses that intended to account for the heterogeneity across studies revealed several significant findings: 1) Studies that limited their sample to urban areas exhibited a significant and negative association between HHI and profitability. 2) Studies that did not limit their sample to a specific ownership type exhibited positive average effect size, hence, significant and positive association between HHI and profitability. In contrast, studies that limited their sample into not-for-profit and government hospitals have exhibited a negative effect size; therefore, the significant and negative association between HHI and profit.

These findings suggest that a decrease in competition (i.e., higher HHI) is associated with a decrease in profitability in urban hospitals, for not-for-profit and government hospitals. A potential explanation for this negative relationship would be the low per capita income of the patient population and the less generous insurance plans in the particular hospital market. One can expect that in such a market, there would be less competition since the market is not lucrative. Therefore,

fewer hospitals would be interested in entering into such an unprofitable market. The finding of the decrease in competition and an increase in profitability when studies did not limit their samples to specific ownership types is harder to explain, especially in the light of findings of specific hospital ownership types. In future studies that are exploring the relationship between HHI and profitability, we recommend sensitivity analyses on split samples of particular ownership types and the use of ownership types as control variable along with market measures such as per capita income and HMO penetration.

Competition and Cost

When the relationship between HHI and cost examined at the individual study level, the majority of the studies identified relationships on the negative side. However, significant numbers of them were also on the positive side. Moreover, the results and sensitivity analyses revealed that the overall effect size was negative and reached 1% level, but not significant due to considerable heterogeneity among studies. This negative and small effect size may suggest that an increase in HHI is associated with a decrease in cost. Further meta-regression analyses that were geared towards understanding the underlying factors of heterogeneity have revealed several prominent issues regarding the relationship between HHI and cost. 1) Except for the studies that were focused on environmental factors, all remaining studies (i.e., studies that focused on external/internal organizational strategies, on ownership, or performance) exhibited negative effect size; hence, the significant and negative association between HHI and cost. 2) Studies that did not limit their sample to either urban or rural hospitals had negative effect size; hence, the significant and negative association between HHI and cost. In contrast, studies that did limit their sample to urban hospitals had positive effect size; therefore, the significant and positive association between HHI and cost.

Our first finding of study focus can be considered as evidence for the importance of environmental measures in studies using HHI. Those environmentally-focused studies that were significantly different from other focus areas that used various environmental/market factors as control variables. This finding may explain the reduction in competition and increase in cost in environmentally-focused studies since they utilized other environmental/market control factors environmental factors such as HMO penetration, per capita income, unemployment rate, proportion of population over 65, physician per 1000 population, proportion of minority in MSA, proportion employed by large employers, proportion of MSA beds (Clement & Grazier, 2001; Connor, Feldman, & Dowd, 1998; Henke, Maeda, Marder, Friedman, & Wong, 2013; Rivers & Bae, 1999; Shen & Melnick, 2004; Thorpe, Seiber, & Florence, 2001; Young, Burgess, Desai, & Valley, 2002). The finding of the studies limiting their samples to urban hospitals having an association between low competition and higher costs also supports our finding of low competition and low profitability. Given that profitability is a function of revenue and cost, an increase in cost would cause low profitability if there were no increase in revenue.

Competition and Revenue

When the relationship between HHI and revenue examined at the individual study level, the majority of the studies identified relationships on the negative side; however, significant numbers of them were also on the positive side. Moreover, the results and sensitivity analyses revealed that the overall effect size was significant, negative, and reached 3% level. This negative effect size suggests that an increase in HHI (i.e., lower competition) is associated with a decrease in revenue. Further meta-regression analyses about the underlying factors of this relationship have revealed

that within the study features, all significant effect sizes were negative. These significant and negative effect sizes were observed in studies that 1) focused on performance, 2) classified under Type C methodologically, 3) not limited any sub-groups in regards to their sample level, 4) included Texas hospitals, 5) were not limited to any ownership categories, 6) had dependent variables that were not logged transformed.

Overall, among all financial dimensions, our finding of revenue is the most conclusive. Our finding suggests that a decrease in competition is associated with a decrease in revenue. This finding can be explained through some underlying reasons that would lead to low competition in a particular market. As the famous quote by Sister Irene Kraus from the Daughters of Charity National Health Care System "no margin, no mission" indicate the sustainability of healthcare services depends upon the positive margin that healthcare organizations experience. As a strategy to improve their revenue and profitability healthcare organizations seek opportunities to enter into more lucrative markets, therefore, stay away from less rewarding markets. Moreover, hospitals that are located in less lucrative markets in regards to the patient population, payer mix, volume, and profitability do not sustain their survival as well exemplified in the case of rural hospitals in the United States (Alexander & Succi, 1996; Kaufman et al., 2016; Probst, Samuels, Hussey, Berry, & Ricketts, 1999; Reif, DesHarnais, & Bernard, 1999; Warden & Probst, 2017). Therefore, hospitals that can survive would remain in less competitive areas and they seem to earn less revenue.

Conclusion

In summary, this meta-analytic review of the link between competition and financial performance has attempted to answer the question, "how competition affects the financial performance of hospitals?" Being the first meta-analytic review on this subject makes this study unique and important since it provides insights into various study features that may influence the relationship between competition and financial performance. The findings of this study can be utilized to improve studies that are investigating the relationship between competition and performance.

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Appendix 1: Included & Excluded Financial Outcome Measures for Meta-Analysis

Outcome Dimensions	Included Unique or Combined Outcomes	n	c	Excluded Outcomes	n	c
Profitability	Cash Flow Margin	7	11	Cash Flow Variability	1	1
	Operating Margin	5	8	Change in Operating Margin	1	2
	Return on Asset	1	1	Operating Income	1	2
	Total margin	4	4	Operating Profit	1	1
	Cash Flow Margin & Total Margin	1	2	Margin (Revenue-Cost)	1	1
	Operating Margin & Total Margin & Return on Asset	1	6			
	Sum	**19**	**32**	**Sum**	**5**	**7**
Revenue	Net Revenue Per Adjusted Patient Day from Private Payers	1	3	-	-	-
	Net Patient Revenue Per Adjusted Discharge	2	2			
	Revenue/Admission Change	1	1			
	Inpatient Net Revenue for Un-insurance Patient	1	4			
	Operating Revenue	4	5			
	Change in Net Revenue Per Patient	1	2			
	Revenue	1	1			
	Total Revenue &Gross Inpatient Revenue & Gross Outpatient Revenue	1	3			
	Revenue Per Case	1	1			
	Medicare Payment First 6 Month& Medicare Payment Less Index Admissions 6 Month	1	2			
	Average Net Revenue & Average Revenue	1	4			
	Sum	**15**	**28**	**Sum**	**0**	**0**
Cost	Cost	3	3	Cost Variability	1	1
	Expenses Per Bed	1	1	Change in Annual Operating Costs	1	1
	Expenditures	1	1	Inpatient Uncompensated Care Cost Change	1	4
	Total Cost	3	11		1	4

				Outpatient Uncompensated Care Cost Change		
	Operating Expenses Per Adjusted Discharge	2	2	Salary Expense Per Operating Expense	1	1
	Expense/Admission Change	1	1	Change in Operating Expense Per In-Patient	1	2
	Cost Per Discharge	1	2	Average Medicare Cost	1	1
	Operating Expenses & Salary Expense Per Operating Expense	1	2	Administrative Expense	1	1
	Operating Expenses	1	2			
	Operating Expenses Per Adjusted Admission	1	1			
	Total Expenses Per Adjusted Admission	1	4			
	Operational Expense Per Adjusted Admission	1	2			
	Uncompensated Care Adjusted Admission	3	3			
	Tax-Exempt Debt	1	2			
	Average Expenditure	1	2			
	Cost Per Adjusted Admission & Cost Per Adjusted Admission in >%5 Mortality Ratio	1	3			
	Sum	**23**	**28**	**Sum**	**8**	**15**

n: number of studies, c: number of comparisons within the studies