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The Moderating Effect of Hospital Teaching Status on the Relationship between Financial Ratios and Hospital Efficiency

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Abstract

This study examines how hospital financial characteristics relate to operational efficiency and whether these relationships differ by teaching status. Using 2020 U.S. hospital data, efficiency is measured via Data Envelopment Analysis and hospitals are classified as technically efficient or inefficient. Logistic regression is then employed to assess how financial ratios influence the likelihood of efficiency. The results show that asset utilization, working capital management, and profitability are positively associated with efficiency, while capital structure effects vary by teaching status, highlighting the importance of organizational context in hospital performance evaluation.

Keywords: Financial ratios, hospital efficiency, hospital finance, hospital financial ratios, hospital performance.

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1. Introduction

Hospitals operate under increasing financial and operational pressure due to rising healthcare costs, capital intensity, workforce shortages, and regulatory constraints. These pressures have heightened interest among researchers and policymakers in understanding how efficiently hospitals transform financial and physical resources into healthcare services [1,2]. As a result, hospital efficiency has become a central theme in health economics and healthcare management research.

A substantial body of literature has examined hospital efficiency using frontier-based methods, particularly Data Envelopment Analysis (DEA). DEA has been widely applied because hospitals are multi-input, multi-output organizations for which prices are often unavailable or distorted by regulation [3,4]. Empirical studies consistently document substantial variation in efficiency across hospitals, even within similar institutional and regulatory environments [5,6]. These findings suggest that differences in managerial practices, resource allocation, and financial structure may play important roles in shaping hospital efficiency.

Parallel to the efficiency literature, a large body of research in hospital finance documents considerable heterogeneity in hospitals' financial performance. Studies examining profitability, liquidity, capital structure, and debt management show that financial outcomes differ widely across hospitals and are influenced by ownership, reimbursement mechanisms, and organizational mission [7–9]. Importantly, financial performance and operational efficiency, while related, are conceptually distinct. Efficiency reflects relative resource utilization, whereas financial outcomes are shaped by accounting rules, payment systems, and strategic financing decisions [10,5].

Prior research suggests that improvements in operational efficiency are often associated with stronger financial performance, as efficient hospitals are better positioned to control costs and sustain operations [5,9]. However, this relationship is not uniform across hospital types. In nonprofit and mission-driven hospitals, efficiency gains do not always translate into higher profitability due to service-mix decisions and regulatory constraints [9]. These findings indicate that the efficiency–financial performance relationship is contingent on institutional context.

Teaching hospitals provide a particularly important case of organizational heterogeneity. In addition to patient care, teaching hospitals support medical education and research, which fundamentally alters their production processes and cost structures. Empirical evidence shows that teaching intensity is associated with higher resource utilization and greater capital and labor costs, often making teaching hospitals appear less efficient under conventional efficiency metrics [11]. At the same time, teaching hospitals operate in distinct financial environments, relying on diversified revenue streams such as graduate medical education payments and research funding [12,13].

Several studies emphasize that teaching status conditions managerial behavior, strategic priorities, and financial performance. Langabeer et al. show that high-performing teaching hospitals rely heavily on strategic positioning and scale rather than pure cost minimization [14], while Innis et al. find that teaching status influences how hospitals adopt evidence-based practices [15]. These findings suggest that financial ratios may convey different efficiency implications in teaching and non-teaching hospitals. Nevertheless, most empirical studies either compare teaching and non-teaching hospitals descriptively or include teaching status as a control variable, rather than explicitly modeling it as a moderating mechanism.

Another limitation of the existing literature concerns empirical strategy. Many studies regress continuous DEA efficiency scores directly on financial variables, implicitly assuming linear and marginal relationships. However, DEA efficiency scores are relative measures that identify whether hospitals operate on or below a best-practice frontier [3,2]. From this perspective, efficiency may be better conceptualized as an operational state—distinguishing hospitals that operate on or near the frontier from those that do not—rather than as a continuously varying outcome.

This study addresses these gaps by integrating hospital efficiency measurement, financial ratio analysis, and organizational context within a unified empirical framework. Using nationally representative data from the 2020 American Hospital Association Annual Survey, hospital efficiency is first measured using DEA. Hospitals are then classified as technically efficient or inefficient based on their proximity to the efficiency frontier. Logistic regression is subsequently employed to examine how financial characteristics influence the probability of operating efficiently, while explicitly accounting for hospital teaching status as a moderating factor.

Guided by the financial ratio framework developed by Zeller and Stanko [8], this study examines seven dimensions of hospital financial performance: profitability, liquidity, fixed asset efficiency, capital structure, debt coverage, working capital efficiency, and fixed asset age. By combining DEA-based efficiency classification with probability modeling, the study extends prior research and provides a more nuanced understanding of how financial structure and organizational mission shape hospital efficiency.

This study contributes to literature in three ways. First, it conceptualizes hospital efficiency as an operational state rather than a marginal outcome, supporting a two-stage DEA–logistic regression framework. Second, it advances prior research by explicitly modeling teaching status as a moderating mechanism. Third, it provides recent, nationally representative evidence on the financial drivers of hospital efficiency in the United States. These contributions offer new insights for researchers, hospital administrators, and policymakers concerned with efficiency in complex healthcare organizations.

The remainder of the paper is organized as follows. First, the relevant literature is reviewed. Next, the data and methodology are described. The empirical results are then presented, followed by a discussion of the findings, and conclusion.

2. Literature review

2.1 Theoretical Foundations: Hospital Efficiency, Financial Performance, and Teaching Status

Hospital efficiency has long been a central concern in healthcare economics due to the sector's capital-intensive nature, regulatory constraints, and increasing pressure to deliver high-quality care at sustainable cost levels. Hospitals operate as multi-input, multi-output organizations that transform labor, capital, and operating expenditures into patient services. From an economic perspective, efficiency reflects the extent to which hospitals minimize waste while maintaining service output and quality [1].

A substantial body of literature suggests that hospital efficiency and financial performance are closely related, though not identical concepts. Improvements in operational efficiency are often associated with stronger financial outcomes because efficient hospitals are better positioned to control costs, utilize resources effectively, and sustain operations. Buchner et al. show that changes in hospital efficiency frequently precede changes in profitability, indicating that operational performance can serve as an early signal of financial health [5]. Similarly, Langabeer et al. find that hospitals with higher operational efficiency and stronger market positioning tend to achieve superior financial performance [14].

However, the relationship between efficiency and financial performance is not uniformly linear. In nonprofit hospital settings, financial outcomes may be constrained by service-mix decisions and mission-driven objectives that limit the translation of efficiency gains into higher margins. Rosko et al. demonstrate that efficiency improvements in U.S. nonprofit hospitals do not always result in increased profitability due to the pursuit of social objectives and the provision of less profitable services [9]. In addition, reimbursement mechanisms can weaken the observed link between technical efficiency and financial health. Borden shows that diagnosis-related group (DRG) payment systems may penalize hospitals treating higher-acuity patients, thereby decoupling efficiency measures from financial outcomes [10].

Together, these studies indicate that while efficiency is a necessary condition for strong financial performance, it is not sufficient on its own. Institutional characteristics and financial structures play a critical role in shaping how efficiency translates into economic outcomes.

The literature demonstrates that hospital efficiency is closely linked to financial performance across multiple dimensions, while also highlighting substantial heterogeneity across hospital types. DEA provides a robust framework for measuring efficiency, but financial outcomes depend on how efficiency interacts with organizational mission, financial structure, and institutional context. Teaching hospitals, due to their unique objectives and cost structures, may experience systematically different efficiency–financial performance relationships than non-teaching hospitals.

Despite extensive research on hospital efficiency and financial ratios, few studies explicitly examine hospital teaching status as a moderating mechanism that alters the relationship between financial indicators and efficiency outcomes. By integrating DEA-based efficiency measurement with financial ratio analysis and modeling teaching status as a moderator, this study addresses an important gap in the literature and contributes to a more nuanced understanding of hospital efficiency in heterogeneous organizational settings.

2.2 Measuring Hospital Efficiency: Data Envelopment Analysis

Measuring hospital efficiency requires an analytical framework capable of handling multiple, non-commensurate inputs and outputs. Data Envelopment Analysis (DEA), introduced by Charnes et al., has become one of the most widely used methods for evaluating hospital efficiency for this reason [3]. DEA is a non-parametric, frontier-based approach that evaluates each hospital's performance relative to best-practice peers rather than sample averages.

The original Charnes–Cooper–Rhodes (CCR) model assumes constant returns to scale, while the Banker–Charnes–Cooper (BCC) model allows for variable returns to scale and separates pure technical efficiency from scale efficiency [4]. This distinction is particularly important in hospital settings, where size, service scope, and patient complexity vary substantially across institutions. As noted by Ozcan, DEA is well suited for healthcare applications because it avoids restrictive assumptions regarding production functions and prices [2].

DEA has been widely applied to assess how hospitals utilize inputs such as beds, labor, and operating expenses to produce outputs including inpatient admissions and outpatient visits [6]. More recent studies increasingly integrate DEA efficiency scores with financial indicators to examine how operational efficiency relates to economic performance [16,17]. This integrated approach provides a more comprehensive assessment of hospital performance than efficiency or financial analysis alone.

Consistent with prior hospital efficiency research, efficiency in this study is conceptualized not merely as a continuous performance metric but as a qualitative operational state—distinguishing hospitals operating on or near the efficiency frontier from those operating substantially below it. This perspective supports an empirical approach that examines the likelihood of a hospital being classified as technically efficient rather than marginal changes in efficiency scores. Accordingly, this study adopts a two-stage framework in which DEA is used to identify efficient and inefficient hospitals, followed by logistic regression to assess how financial characteristics and teaching status influence the probability of efficiency.

2.3 Financial Ratios and Hospital Efficiency

Financial ratio analysis provides a structured way to examine how hospitals manage profitability, liquidity, capital investment, and financial risk. Zeller and Stanko develop a comprehensive framework that classifies hospital financial ratios into seven dimensions: profitability, liquidity, fixed asset efficiency, capital structure, debt coverage, working capital efficiency, and fixed asset age [8]. This framework has been widely adopted in subsequent hospital finance research and serves as the basis for the present study's hypotheses.

2.3.1 Profitability and Hospital Efficiency

Profitability reflects a hospital's ability to generate financial surplus from its asset base and operations. Prior research generally finds that profitability measures such as return on assets and operating margins are positively associated with hospital efficiency, as efficient hospitals are better able to control costs and utilize resources effectively [5,9]. However, some studies report mixed findings, particularly in nonprofit settings where profitability may be constrained by mission-driven objectives [14].

Hypothesis 1: Profitability is positively related to hospital efficiency.

2.3.2 Liquidity and Hospital Efficiency

Liquidity reflects a hospital's ability to meet short-term obligations and sustain operations without financial distress. Studies consistently identify liquidity indicators such as days cash on hand and current ratios as important determinants of hospital performance, particularly in maintaining operational stability [18]. Hospitals with stronger liquidity positions are better equipped to manage day-to-day operations and absorb financial shocks.

Hypothesis 2: Liquidity is positively related to hospital efficiency.

2.3.3 Fixed Asset Efficiency and Hospital Efficiency

Fixed asset efficiency captures how effectively hospitals utilize capital-intensive resources such as buildings and equipment. Prior studies show that hospitals with higher asset turnover ratios tend to achieve superior efficiency and productivity outcomes [16,19]. Effective asset utilization enables hospitals to spread fixed costs across a larger volume of services.

Hypothesis 3: Fixed asset efficiency is positively related to hospital efficiency.

2.3.4 Capital Structure and Hospital Efficiency

Capital structure reflects how hospitals finance operations and long-term investments through debt and equity. Empirical evidence suggests that capital structure decisions influence hospital efficiency, though the relationship varies by ownership and institutional context [20,21]. Teaching and nonprofit hospitals often face financing constraints that affect their ability to optimize leverage.

Hypothesis 4: Capital structure is significantly related to hospital efficiency.

2.3.5 Debt Coverage and Hospital Efficiency

Debt coverage measures a hospital's capacity to service debt obligations using operating earnings. Prior research generally finds that stronger debt coverage is associated with improved financial stability and efficiency [21,22]. Hospitals with adequate debt servicing capacity face lower financial risk and greater operational flexibility.

Hypothesis 5: Debt coverage is positively related to hospital efficiency.

2.3.6 Working Capital Efficiency and Hospital Efficiency

Working capital efficiency reflects how effectively hospitals manage short-term assets and liabilities. Studies spanning multiple decades show that effective management of receivables, payables, and short-term liquidity is positively associated with hospital efficiency and financial sustainability [23,24].

Hypothesis 6: Working capital efficiency is positively related to hospital efficiency.

2.3.7 Fixed Asset Age and Hospital Efficiency

Fixed asset age reflects the condition and technological currency of hospital infrastructure. Older assets are often associated with higher maintenance costs and lower productivity, which can constrain efficiency. Prior studies generally find a negative relationship between asset age and hospital efficiency, though the magnitude may vary by hospital type and location [7,25].

Hypothesis 7: Fixed asset age is negatively related to hospital efficiency.

3. Methodology

3.1 Conceptual Model

This study examines the relationship between hospital financial characteristics and hospital efficiency, with hospital teaching status serving as a moderating factor. Figure 1 shows the conceptual framework. The framework builds on prior hospital finance and efficiency literature, particularly the financial ratio framework developed by Zeller and Stanko [8], which categorizes hospital financial performance into profitability, liquidity, fixed asset efficiency, capital structure, debt coverage, working capital efficiency, and fixed asset age.

Hospital efficiency is measured using Data Envelopment Analysis (DEA), which allows for the evaluation of relative efficiency among hospitals operating under similar production environments. Financial ratios are then used to explain variation in efficiency outcomes across hospitals, while teaching status is incorporated to capture organizational heterogeneity arising from differences in mission, cost structure, and financing environments.

Consistent with the theoretical framework, hospital efficiency in this study is conceptualized not as a marginal performance outcome but as a qualitative operational state. Hospitals operating on or near the efficiency frontier are viewed as structurally different from those operating substantially below it. Accordingly, this study adopts a two-stage analytical framework in which Data Envelopment Analysis (DEA) is first used to identify technically efficient and inefficient hospitals, followed by probability modeling to examine how financial characteristics and teaching status influence the likelihood of technical efficiency.

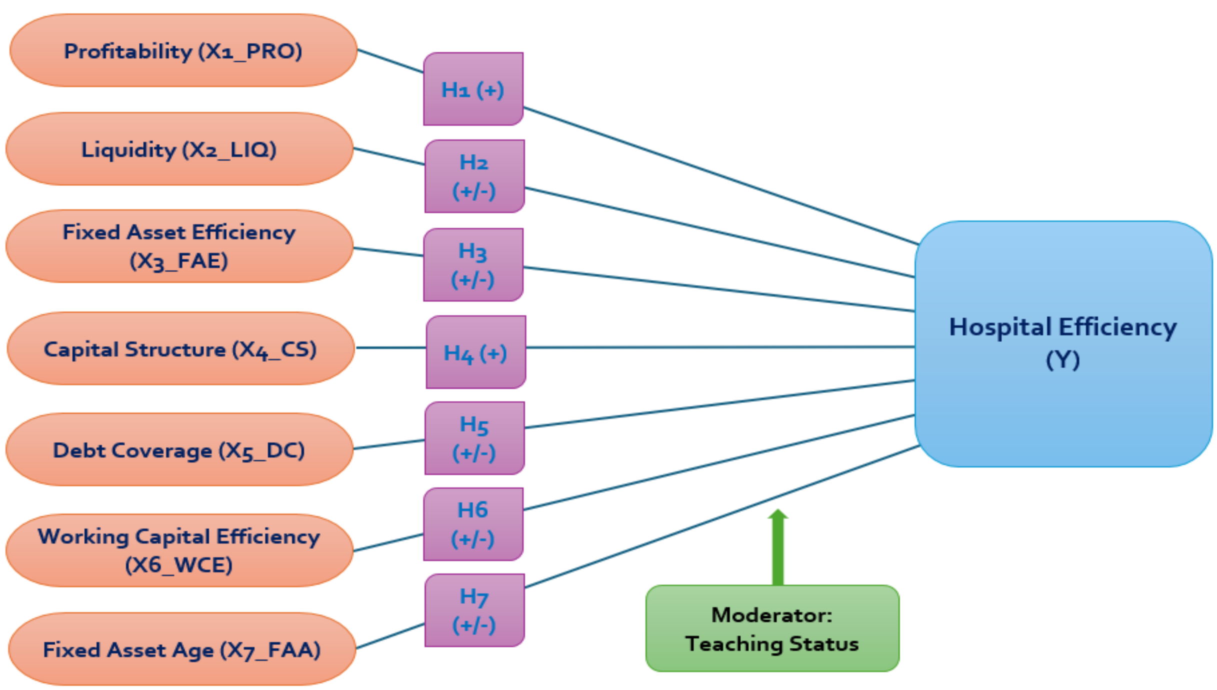

Figure 1: Conceptual Framework

3.2 Dependent Variable: Hospital Efficiency

Hospital efficiency is measured using Data Envelopment Analysis (DEA), a non-parametric frontier-based methodology grounded in the efficiency framework of Farrell [1] and later extended by Charnes et al. [3] and Banker et al. [4]. DEA is particularly suitable for hospital analysis because it accommodates multiple inputs and outputs without requiring price information or restrictive functional form assumptions.

In DEA, each hospital is treated as a decision-making unit (DMU). Efficiency is measured by comparing each DMU to an efficiency frontier constructed from the best-performing hospitals in the sample. Hospitals operating on the frontier are considered technically efficient, while those below the frontier are considered inefficient.
To explore the mathematical property of DEA, let E_0 be an efficiency score for the base DMU 0 then,

$$\text{Maximize } E_0 = \frac{\{\sum_{r=1}^{R} u_{r0} y_{r0}\}}{\{\sum_{i-1}^{I} v_{i0} x_{i0}\}} \tag{1}$$

subject to

$$\frac{\{\sum_{r=1}^{R} u_{r0} y_{r0}\}}{\{\sum_{i-1}^{I} v_{i0} x_{i0}\}} \leq 1 \; for\ all\ k \tag{2}$$

$$u_{r0}, v_{i0} \geq \delta \text{ for all r, i,} \tag{3}$$

where:
y_{rk}: the observed quantity of output r generated by unit $k = 1, 2, \ldots, N$,
x_{ik}: the observed quantity of input i consumed by unit $k = 1, 2, \ldots, N$,
u_{r0}: the weight to be computed given to output r by the base unit *0*,
v_{i0}: the weight to be computed given to input i by the base unit *0*,
d: a small positive number.

This study employs three DEA models to evaluate hospital efficiency: the Charnes–Cooper–Rhodes input-oriented model (CCR), the Banker–Charnes–Cooper model (BCC), and a slack-based measure (SBM). The CCR model assumes constant returns to scale, while the BCC model allows for variable returns to scale. The SBM model is used to assess non-radial inefficiencies.
Although multiple DEA models are estimated to compare efficiency under different assumptions, the CCR model is used to construct the efficiency classification variable employed in the subsequent logistic regression analysis. The CCR model was selected for reasons. First, it provides the most conservative efficiency boundary under constant returns to scale, ensuring that hospitals classified as efficient represent genuinely high-performing units rather than those benefiting from favorable scale conditions. In addition, CCR efficiency scores are the most widely used benchmark in the hospital efficiency literature, facilitating comparability with prior work.
The summary statistics across models will be provided in the results section. To further assess the robustness of the main findings to the choice of DEA model, logistic regression analyses using the BCC and SBM efficiency classifications as alternative dependent variables are reported in the Robustness Check subsection of the Results.
Although multiple DEA models are estimated to compare efficiency under different assumptions, the CCR model is used to construct the efficiency classification variable employed in the subsequent logistic regression analysis. DEA efficiency scores derived from the CCR model are used to construct the dependent variable for regression analysis. Following prior hospital efficiency research, efficiency is operationalized as a binary classification rather than a continuous score.
This quartile-based classification approach serves two important purposes. First, it sharpens the distinction between operationally efficient and inefficient hospitals by focusing on clear performance extremes, consistent with the conceptualization of efficiency as a qualitative operational state rather than a marginal outcome. Second, this approach follows established practice in hospital efficiency research and provides adequate sample sizes in both groups (N = 763 in each) for robust logistic regression analysis while maintaining statistical power [6, 19].
The resulting binary dependent variable takes a value of 1 for technically efficient hospitals and 0 for technically inefficient hospitals.

3.3 Independent Variables: Financial Characteristics

The independent variables in this study consist of seven groups of hospital financial ratios derived from audited financial statements, consistent with the framework developed by Zeller and Stanko [8]. These financial characteristics are used to capture distinct dimensions of hospital financial structure and performance that are theorized to influence operational efficiency. Collectively, the variables represent profitability, liquidity, fixed asset efficiency, capital structure, debt coverage, working capital efficiency, and fixed asset age.

Profitability variables reflect a hospital's ability to generate financial surplus from its operations and asset base and are measured using ratios such as return on assets, operating margin, and return on equity. Liquidity variables capture a hospital's capacity to meet short-term financial obligations and maintain operational continuity, commonly measured using indicators such as days cash on hand and current ratios. Fixed asset efficiency variables assess how effectively hospitals utilize capital-intensive resources, including buildings and medical equipment, and are measured using fixed asset turnover and total asset turnover ratios.

Capital structure variables describe how hospitals finance their operations and long-term investments through combinations of debt and equity, captured through ratios such as long-term debt to equity and equity financing measures. Debt coverage variables reflect a hospital's ability to service its debt obligations using operating earnings and are measured using indicators such as debt service coverage and times interest earned. Working capital efficiency variables evaluate the management of short-term assets and liabilities, including current asset turnover and current ratios, which are critical for sustaining daily operations. Finally, fixed asset age variables reflect the condition and technological currency of hospital infrastructure and are measured using ratios such as average age of plant and depreciation rates.

Each group of financial variables corresponds directly to the developed hypotheses. The variables are included in the regression models to examine how different dimensions of hospital financial structure and performance are associated with the likelihood of operating on or near the efficiency frontier.

3.4 Control Variable: Hospital Teaching Status

Hospital teaching status is included as a control variable and is derived from the American Hospital Association (AHA) Annual Survey. Teaching status is coded as a binary variable, where teaching hospitals are assigned a value of 1 and non-teaching hospitals are assigned a value of 0.

Teaching status is modeled as a moderating control variable rather than as a primary predictor because the focus of this study is not on efficiency differences attributable solely to teaching status, but on whether financial characteristics operate differently across teaching and non-teaching hospitals.

Table 1: summarizes how all variables are operationalized

Variable	Item	Description	References
Hospital Efficiency (Y1)	**Inputs:**		Ozcan (2014) *, Kohl et al. (2019)
	BDTOT	Number of beds	
	FTE	Number of full-time employees	
	OEXPTOT	Total operating expense	
	Outputs:		Ozcan (2014) *, Kohl et al. (2019)
	CMAAD	Case mix-adjusted admissions (CMAAD= CMI x ADMTOT)	
	VTOT	Number of outpatients	
	Y1_DEA	1 = Hospitals with **high** DEA scores 0 = Hospitals with **low** DEA scores	Lynch and Ozcan (1994)
X1_PRO	ROA	Return on assets	Zeller et al. (1996)
	OMAR	Operating margin	
	ROE	Return on equity	
X2_LIQ	DCH	Days cash on hand	Zeller et al. (1996)
	REPV	Replacement viability	
X3_FAE	FATO	Fixed asset turnover	Zeller et al. (1996)
	FATOPL	Fixed asset turnover (price level)	
	TATO	Total asset turnover	
X4_CS	EF	Equity financing	Zeller et al. (1996)
	FAF	Fixed asset financing	
	LTDE	Long-term debt to equity	
X5_DC	DSC	Debt service coverage	Zeller et al. (1996)
	TIE	Times interest earned	
X6_WCE	CATO	Current asset turnover	Zeller et al. (1996)
	CR	Current ratio	
	DCHST	Days cash on hand (short-term)	
X7_FAA	AAP	Average age of plant	Zeller et al. (1996)
	DEPR	Depreciation rate	
Control Variable	Teaching Status (C_4)	MAPP8 variable 1= Teaching hospitals (Coded 1) 0= non-teaching hospitals (Coded 2)	AHA 2020

3.5 Data and Sample

The study uses data from the 2020 American Hospital Association (AHA) Annual Survey, merged with hospital financial data from the Healthcare Cost Report Information System (HCRIS). After merging datasets and applying data-cleaning procedures, hospitals with missing or invalid input, output, or financial data are excluded.

The final analytical sample includes hospitals with complete data necessary to compute DEA efficiency scores, financial ratios, and teaching status.

3.6 Analytical Approach: Logistic Regression

Given that the dependent variable represents a binary classification of hospital efficiency status, logistic regression is the appropriate estimation technique. Unlike linear regression models that estimate marginal changes in continuous outcomes, logistic regression allows this study to examine how financial characteristics and teaching status influence the probability that a hospital operates on or near the efficiency frontier.

The baseline logistic regression model includes the seven financial variable groups as predictors. Teaching status is incorporated to examine whether the relationships between financial characteristics and efficiency differ across hospital types. Depending on specification, moderation is examined either through interaction terms or stratified analyses by teaching status.
The general form of the model is expressed as:

$P(Efficiency_i=1)=f(X_{1i}, X_{2i}, \dots, X_{7i}, TeachingStatus_i)$

where $Efficicency_i$ indicates whether hospital i is technically efficient. X1, X2, …, and X7 refers to X1_PRO, X2_LIQ, X3_FAE, X4_CS, X5_DC, X6_WCE, X7_FAA, respectively. TeachingStatis is measured with C4_TS.

This study outlines a two-stage empirical strategy designed to evaluate hospital efficiency and its financial determinants. DEA is used to identify technically efficient and inefficient hospitals, while logistic regression is employed to assess how financial characteristics and teaching status influence the likelihood of efficiency. This approach is consistent with the theoretical framework and allows for a nuanced examination of hospital efficiency across heterogeneous organizational settings.

4. Results

4.1 Descriptive Statistics and Correlations Analysis

Table 2-(a) to Table 2-(e), and Table 3-(a) to Table 3-(c) show descriptive statistics, along with correlation coefficients among independent variables and dependent variable.

Table 2-(a): Hospital size (C_BDT)

Value	Description	Frequency	%
1	6-24 beds	172	5.6
2	25-49 beds	360	11.8
3	50-99 beds	497	16.3
4	100-199 beds	806	26.4
5	200-299 beds	465	15.2
6	300-399 beds	290	9.5
7	400-499 beds	166	5.4
8	500 or more beds	295	9.7
Total		3051	100.0

*Source: BDTOT and BSC variables from AHA (2020).

Table 2-(b): Hospital Location (C_LOC)

Value	Frequency	Percent
Rural	221	7.2
Urban	2830	92.8
Total	3051	100.0

*Source: CBSATYPE variable from AHA (2020).

Table 2-(c): Hospital Ownership Type (C_OT)

Value	Frequency	Percent
Government	425	13.9
Not-for-profit	1951	63.9
For-profit	675	22.1
Total	3051	100.0

*Source: CNTL variable from AHA (2020).

Table 2-(d) Hospital Teaching Status (C_TS)

Value	Frequency	Percent
Non-teaching	2827	92.7
Teaching	224	7.3
Total	3051	100.0

*Source: CNTL variable from AHA (2020).

Table 2-(e) Hospital Type (C_PST)

Value	Frequency	Percent
Specialty	161	5.3
General	2890	94.7
Total	3051	100.0

*Source: CNTL variable from AHA (2020).

As reported in Table 3-(a) and Table 3-(b) below, the three DEA models produce very similar efficiency distributions (mean scores ranging from 0.500 to 0.518) and highly correlated efficiency scores ($r = .933$ to 1.000), indicating that model selection does not substantially alter the composition of the efficient/inefficient classification used in the analysis.

Table 3-(a): Summary Statistics of DEA Efficiency Scores by Model

Model	N	Mean Efficiency Score	SD	% Classified as Efficient
CCR	1,526	0.500	0.500	50.0%
BCC	1,525	0.500	0.500	49.97%
SBM	1,583	0.518	0.500	51.8%

Note. % Classified as Efficient = proportion of hospitals with efficiency score = 1.0 (on the frontier). ***$p < .001$

Table 3-(b): Pearson Correlations Among DEA Model Efficiency Scores

Model	(1) CCR	(2) BCC	(3) SBM
CCR	1.000		
BCC	.950***	1.000	
SBM	1.000***	.933***	1.000

Note. Correlations computed on the full analytic sample. ***$p < .001$

Table 3-(c) shows the results of correlation. The dependent variable, Y1_DEA_CCR is highly correlated with X1_ROA, X1_ROE, X1_OMAR, X2_DCH, X3_TATO, X4_LTDE, X5_TIE ($p<.001$). Y1_DEA_CCR is also significantly correlated with X4_EF and X7_AAP ($p<.01$). Among the three X1-related ratios (ROA, ROE, & OMAR), this study chose X1_OMAR ($r = .435$) for further analysis because it was more correlated with Y1 than ROA ($r = .236$) and ROE ($r = .117$). Among the two X4-related ratios (EF and LTDE), this study chose X4_LTDE ($r = -.132$) because it was more correlated with Y1 than X4_EF ($r = .069$). X7_DEPR is not correlated with Y1. Thus, it was not included in the logistic regression model.

Table 3-(c): Correlations

Variable	Mean	SD	N	Y1	ROA	ROE	OMA	DCH	TATO	EF	LTDE	TIE	CR	AAP	DEPR
Y1_DEA_CCR	0.5000	0.5001	1526	1											
X1_ROA	13.1199	155.9652	3051	.236***	1										
X1_ROE	13.0806	14.2307	3051	.117***	.546**	1									
X1_OMAR	-5.5240	37.5598	3051	.435***	.651**	.333**	1								
X2_DCH	52.0460	61.9490	3051	-.172***	-.106**	-.051**	-.197**	1							
X3_TATO	1.1232	0.5433	3051	.092***	.255**	.188**	.075**	-.350**	1						
X4_EF	0.5017	0.2995	3051	.069**	.215**	-.040*	.233**	-.048**	-.197**	1					
X4_LTDE	0.2841	0.4359	3051	-.132***	-.218**	-0.02	-.228**	.327**	-.204**	-.403**	1				
X5_TIE	12.9789	21.7473	3051	.090**	.338**	.210**	.238**	-.051*	.062**	.183**	-.151**	1			
X6_CR	1.5419	1.0087	3051	0.024	.099**	.041*	.064**	.380**	-.249**	-.243**	.188**	0.026	1		
X7_AAP	11.8740	6.6227	3051	-.053*	-0.015	-.039*	-.088**	.220**	-.071**	.039*	.105**	0.024	.150**	1	
X7_DEPR	0.1108	0.0469	3051	-0.005	.051**	.059**	-.030*	-.051*	.300**	-.032*	-.114**	.050**	-0.025	-.090**	1

Note: #p < .10, * p < .05, ** p < .01, ***p < .001

4.2 Logistic Regression Analysis

4.2.1 Full Model Results

A logistic regression analysis was conducted to examine the relationship between financial ratios and hospital efficiency. The dependent variable, Y1_DEA_CCR, indicated whether a hospital was technically efficient (1) or not (0). The independent variables included seven financial ratios covering areas like profitability, liquidity, asset use, capital structure, debt coverage, working capital, and fixed asset allocation. For the full sample (N = 1,526), the model was statistically significant ($\chi^2 = 169.521$, $p < .001$), showing that the predictors helped distinguish between efficient and inefficient hospitals as shown in Table 4. The model explained approximately 14% of the variance (Nagelkerke $R^2 = .140$) and had an overall classification accuracy of 67.2%. Five of the seven financial ratios were statistically significant predictors: profitability (X1_PRO_OMAR, $p < .001$), liquidity (X2_LIQ_DCH, $p = .001$), capital structure (X4_CS_LTDE, $p = .016$), debt coverage (X5_DC_TIE, $p = .050$), and working capital efficiency (X6_WCE_CR, $p = .023$). Profitability had the strongest effect (Wald = 73.453), followed by liquidity (Wald = 10.145). Positively associated with efficiency were profitability (Exp(B) = 1.024), debt coverage (Exp(B) = 1.005), and working capital efficiency (Exp(B) = 1.143), while liquidity (Exp(B) = 0.997) and capital structure (Exp(B) = 0.729) showed negative associations.

Separate models were also run for non-teaching and teaching institutions. These subgroup analyses revealed important differences in how financial characteristics relate to efficiency across different hospital types, with teaching hospitals showing distinct patterns in the relationship between financial structure and operational performance.

Table 4: Logistic Regression Analysis – Full Model Results (N = 1526)

Dependent Variable = Y1_DEA_CCR Omnibus Tests of Model Coefficients: Chi-square = 169.521, *p* < .001 -2 Log likelihood = 1945.964 Cox & Snell R Square = .105 Nagelkerke R Square = .140 Accuracy = 67.2%						
	B	**S.E.**	**Wald**	**df**	***p*-value**	**Exp(B)**
X1_PRO_OMAR	.023	.003	73.453 (1)	1	.000	1.024
X2_LIQ_DCH	-.003	.001	10.145 (2)	1	.001	.997
X3_FAE_TATO	.090	.108	.701	1	.402	1.095
X4_CS_LTDE	-.317	.131	5.824 (3)	1	.016	.729
X5_DC_TIE	.005	.002	3.848 (5)	1	.050	1.005
X6_WCE_CR	.133	.059	5.138 (4)	1	.023	1.143
X7_FAA_AAP	-.006	.008	.514	1	.474	.994
Constant	.077	.204	.142	1	.706	1.080

4.3 Reduced Model Results on Non-Teaching Hospitals

This logistic regression model analyzed the non-teaching hospital subsample (N = 1,413). The dependent variable was the binary hospital efficiency measure, Y1_DEA_CCR, which had 0 = low efficiency and 1 = high efficiency. This model included all seven independent variables: X1_PRO_OMAR, X2_LIQ_DCH, X3_FAE_TATO, X4_CS_LTDE, X5_DC_TIE, X6_WCE_CR, and X7_FAA_AAP. The results showed that the model was statistically significant [Chi-square for the Omnibus Tests of Model Coefficients = 149.561, p < .001; -2 Log likelihood = 1886.709, Cox & Snell R Square = .097, Nagelkerke R Square = .129]. The accuracy of the model for correct classification was acceptable (67.1%).

Among the independent variables, five were statistically significant (p < .05): X1_PRO_OMAR (p < .001), X2_LIQ_DCH (p = .002), X4_CS_LTDE (p = .017), X5_DC_TIE (p = .031), and X6_WCE_CR (p = .043). In contrast, X3_FAE_TATO and X7_FAA_AAP were not statistically significant (p > .05).

The odds ratio for X1_PRO_OMAR (Exp(B) = 1.022) indicates that each one-unit increase in the operating margin multiplies the odds of being classified as highly efficient by 1.022, holding other variables constant. Similarly, X6_WCE_CR showed an odds ratio of 1.128, meaning a one-unit increase in the current ratio multiplies the odds of high efficiency by 1.128, and X5_DC_TIE (Exp(B) = 1.005) also demonstrated a positive relationship. In contrast, X4_CS_LTDE showed a negative relationship (Exp(B) = 0.731), indicating that each one-unit increase in the long-term debt to equity ratio multiplies the odds of efficiency by 0.731, representing approximately a 27% reduction in the odds. X2_LIQ_DCH also showed a slight negative effect (Exp(B) = 0.997).

According to the Wald statistics, X1_PRO_OMAR (64.562) had the strongest effect on hospital efficiency classification, followed by X2_LIQ_DCH (9.180), X4_CS_LTDE (5.661), X5_DC_TIE (4.680), and X6_WCE_CR (4.085). Table 5 presented the results.

Table 5: Logistic Regression Analysis – Non-teaching Hospital Results (N = 2827)

Dependent Variable = Y1_DEA_CCR
Omnibus Tests of Model Coefficients: Chi-square = 149.561, $p < .001$
-2 Log likelihood = 1886.709
Cox & Snell R Square = .097
Nagelkerke R Square = .129
Accuracy = 67.1%

	B	**S.E.**	**Wald**	**df**	***P*-Value.**	**Exp(B)**
X1_PRO_OMAR	.022	.003	64.562 (1)	1	.000	1.022
X2_LIQ_DCH	-.003	.001	9.180 (2)	1	.002	.997
X3_FAE_TATO	.071	.109	.417	1	.518	1.073
X4_CS_LTDE	-.313	.132	5.661 (3)	1	.017	.731
X5_DC_TIE	.005	.003	4.680 (4)	1	.031	1.005
X6_WCE_CR	.120	.060	4.085 (5)	1	.043	1.128
X7_FAA_AAP	-.005	.008	.429	1	.512	.995
Constant	.102	.207	.244	1	.622	1.107

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4.4 Reduced Model Results on Teaching Hospitals

This logistic regression model analyzed the teaching hospital subsample (N = 113). The dependent variable was the binary hospital efficiency measure, Y1_DEA_CCR, which had 0 = low efficiency and 1 = high efficiency. This model included all seven independent variables: X1_PRO_OMAR, X2_LIQ_DCH, X3_FAE_TATO, X4_CS_LTDE, X5_DC_TIE, X6_WCE_CR, and X7_FAA_AAP. The results showed that the model was statistically significant [Chi-square for the Omnibus Tests of Model Coefficients = 29.400, $p < .001$; -2 Log likelihood = 44.470, Cox & Snell R Square = .403, Nagelkerke R Square = .555]. The accuracy of the model for correct classification was notably high (82.5%), and the model explained substantially more variance (Nagelkerke $R^2 = .555$) compared to the non-teaching hospital model.

Among the independent variables, X1_PRO_OMAR was statistically significant ($p = .007$), and X6_WCE_CR approached significance ($p = .051$). In contrast, X2_LIQ_DCH, X3_FAE_TATO, X4_CS_LTDE, X5_DC_TIE, and X7_FAA_AAP were not statistically significant ($p > .05$).

The odds ratio for X1_PRO_OMAR (Exp(B) = 1.089) indicates that each one-unit increase in the operating margin multiplies the odds of being classified as highly efficient by 1.089, holding other variables constant. Although not reaching conventional statistical significance, X6_WCE_CR showed the strongest effect among all predictors, with an odds ratio of 3.410, meaning a one-unit increase in the current ratio multiplies the odds of high efficiency by 3.410. X3_FAE_TATO also demonstrated a substantial positive relationship (Exp(B) = 1.756). In contrast, X4_CS_LTDE showed a negative relationship (Exp(B) = 0.444), indicating that each one-unit increase in the long-term debt to equity ratio multiplies the odds of efficiency by 0.444. According to the Wald statistics, X1_PRO_OMAR (7.196) had the strongest statistically significant effect on hospital efficiency classification, followed by X6_WCE_CR (3.813), X5_DC_TIE (1.930), and X7_FAA_AAP (1.743). Table 6 presented the results.

Table 6: Logistic Regression Analysis – Teaching Hospital Results (N = 224)

Dependent Variable = Y1_DEA_CCR Omnibus Tests of Model Coefficients: Chi-square = 29.400, $p < .001$ -2 Log likelihood = 44.470 Cox & Snell R Square = .403 Nagelkerke R Square = .555 Accuracy = 82.5%						
	B	**S.E.**	**Wald**	**df**	***P*-Value**	**Exp(B)**
X1_PRO_OMAR	.085	.032	7.196 (1)	1	.007	1.089
X2_LIQ_DCH	-.008	.010	.632 (5)	1	.427	.992
X3_FAE_TATO	.563	.819	.473	1	.492	1.756
X4_CS_LTDE	-.811	1.627	.249	1	.618	.444
X5_DC_TIE	.026	.019	1.930 (3)	1	.165	.974
X6_WCE_CR	1.227	.628	3.813 (2)	1	.051	3.410
X7_FAA_AAP	-.102	.078	1.743 (4)	1	.187	.903
Constant	.556	1.818	.094	1	.760	1.745

Table 7 is a summary table for the logistic regression model results.

Table 7: Summary Table for the Logistic Regression Model Results

	Full Model			**Non-teaching**			**Teaching**		
	B	**Wald**	**Exp(B)**	**B**	**Wald**	**Exp(B)**	**B**	**Wald**	**Exp(B)**
X1_PRO_OMAR	.023** (.003)	73.453	1.024	0.24** (.003)	64.562	1.002	.085* (.032)	7.196	1.089
X2_LIQ_DCH	-.003** (.001)	10.145	.997	-.003** (.001)	9.180	.997	-.008 (.010)	.632	.992
X3_FAE_TATO	.090 (.108)	.701	1.095	.071 (.110)	.417	1.073	.563 (.259)	.473	1.765
X4_CS_LTDE	-.317* (.131)	5.824	.729	-.313 (.131)	5.661	.731	-.811 (.316)	.249	.444
X5_DC_TIE	.005# (.002)	3.848	1.005	.005# (.002)	4.680	1.005	-.026# (.019)	1.930	.974
X6_WCE_CR	.133* (.059)	5.138	1.143	.120* (.059)	4.085	1.128	1.227# (.629)	3.813	3.410
X7_FAA_AAP	-.006 (.008)	.514	.994	-.005 (.008)	.429	.995	-.102 (.077)	1.743	.903
Constant	.077 (.204)	.142	1.080	.102 (.204)	.244	1.107	.556 (.573)	.094	1.745
OTMC	169.521**			149.561			29.400		
-2 Log likelihood	1945.964			1886.709			44.470		
Cox & Snell R^2	.105			.097			.403		
Nagelkerke R^2	.140			.129			.555		
Model Accuracy	67.2%			67.1%			82.5%		
Observations	1526			2827			224		

#$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$

4.5 Robustness Check: Alternative DEA Models

To evaluate the robustness of the findings to the choice of DEA model, logistic regression analyses were repeated using efficiency classifications derived from the BCC and SBM models as alternative dependent variables. As shown in Table 8, the pattern of results is broadly consistent across all three model specifications. Profitability (X1_PRO_OMAR) is the strongest and most consistent predictor of hospital efficiency across all three models and all subsamples: CCR full model ($B = .023$, $p < .001$), BCC full model ($B = .012$, $p < .001$), and SBM full model ($B = .027$, $p < .001$). Capital structure (X4_CS_LTDE) is negatively associated with efficiency across all models. Working capital efficiency (X6_WCE_CR) is consistently positive and statistically significant in the non-teaching subsample across all three specifications.

Minor differences in effect sizes and significance levels across models are expected given the distinct assumptions underlying each specification. In particular, the BCC model's variable returns-to-scale assumption produces somewhat attenuated coefficients and a lower model fit (Nagelkerke $R^2 = .057$) relative to the CCR (Nagelkerke $R^2 = .140$) and SBM (Nagelkerke $R^2 = .165$) specifications. The SBM model, which accounts for input and output slacks, yields the strongest model fit and effect sizes that closely parallel those of the CCR. Overall, the robustness analysis confirms that the primary CCR-based findings are not an artifact of the chosen DEA specification and supports the validity and stability of the main conclusions. Detailed results for the BCC and SBM models are reported in Table 8 below.

Table 8. Logistic Regression Results Across DEA Models — Full Sample & Non-Teaching Subsample

	CCR Full	BCC Full	SBM Full	CCR Non-Teach	BCC Non-Teach	SBM Non-Teach
X1_PRO_OMAR	.023***	.012***	.027***	.022***	.011***	.026***
X2_LIQ_DCH	-.003**	-.002	-.004***	-.003**	-.002	-.004***
X3_FAE_TATO	.090	.080	-.010	.071	.148	-.034
X4_CS_LTDE	-.317*	-.181	-.310*	-.313*	-.285*	-.306*
X5_DC_TIE	.005#	.006*	.004	.005#	.006*	.004
X6_WCE_CR	.133*	.193***	.137*	.120*	.164**	.127*
X7_FAA_AAP	-.006	.001	.000	-.005	.002	-.001
Nagelkerke R^2	.140	.057	.165	.129	.061	.151
Model Accuracy	67.2%	61.5%	68.4%	67.1%	61.9%	68.0%
N	1,526	1,525	1,583	1,413	1,426	1,511

Note. Coefficients reported as B (unstandardized coefficients). #$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$

5. Discussion

5.1 Overview of Findings

This study examines how hospital financial characteristics influence operational efficiency and whether these relationships differ between teaching and non-teaching hospitals. Using a two-stage analytical framework—Data Envelopment Analysis (DEA) followed by logistic regression—the study evaluates the likelihood that hospitals operate on or near the efficiency frontier. The findings provide nuanced evidence that financial ratios matter for hospital efficiency, but their effects are not uniform across organizational contexts.

Overall, the results indicate that profitability, fixed asset efficiency, and working capital efficiency are positively associated with hospital efficiency, while capital structure plays a more complex role that varies by teaching status. These findings support the core premise of the study: hospital efficiency is shaped not only by financial performance but also by organizational structure, particularly teaching status.

5.2 Interpretation of Hypothesis Results

5.2.1 Profitability and Hospital Efficiency

The results show a positive association between profitability and the likelihood of hospital efficiency, supporting Hypothesis 1. Hospitals with stronger profitability metrics are more likely to operate on or near the efficiency frontier, consistent with prior research suggesting that efficient resource utilization and cost control translate into financial surplus. This finding aligns with earlier studies showing that operational efficiency often precedes improved financial outcomes and reinforces the view that profitability reflects effective managerial decision-making rather than mere revenue maximization.

Importantly, the results suggest that profitability functions as a signal of underlying operational discipline rather than as an isolated financial outcome. This interpretation is consistent with the broader hospital finance literature, particularly in nonprofit and regulated environments where profit margins are constrained.

5.2.2 Liquidity and Hospital Efficiency

Liquidity exhibits a weaker and less consistent relationship with hospital efficiency, providing only partial support for Hypothesis 2. While liquidity is essential for operational stability, the findings suggest that beyond a minimum threshold, additional liquidity does not substantially increase the likelihood of efficiency. This result supports the interpretation of liquidity as a buffering mechanism rather than a direct driver of efficiency.

The findings are consistent with prior studies indicating that liquidity plays a more prominent role during periods of financial stress, while its effect on efficiency is muted during normal operating conditions. Thus, liquidity appears necessary for sustaining operations but insufficient for achieving technical efficiency.

5.2.3 Fixed Asset Efficiency and Hospital Efficiency

The analysis provides strong support for Hypothesis 3, demonstrating a positive relationship between fixed asset efficiency and hospital efficiency. Hospitals that utilize their capital assets more effectively—measured through asset turnover—are significantly more likely to operate efficiently. Given the capital-intensive nature of hospital operations, this finding underscores the importance of strategic asset management in achieving operational efficiency.

This result is consistent with prior DEA-based studies that emphasize the role of capital utilization in driving productivity and efficiency. It also reinforces the argument that investments in facilities and equipment must be matched by effective utilization to yield efficiency gains.

5.2.4 Capital Structure and Hospital Efficiency

Capital structure emerges as a key differentiating factor between teaching and non-teaching hospitals, providing partial support for Hypothesis 4. While capital structure is significantly related to hospital efficiency overall, its effect is moderated by teaching status. For non-teaching hospitals, leverage appears to have a clearer association with efficiency outcomes, suggesting that debt financing may impose financial discipline and support productive investment.

In contrast, the relationship between capital structure and efficiency is weaker or more complex for teaching hospitals. This finding is consistent with the notion that teaching hospitals rely on debt financing for long-term strategic investments related to education and research, which may not yield immediate efficiency gains. As a result, traditional capital structure ratios may convey different efficiency implications depending on organizational mission.

5.2.5 Debt Coverage and Hospital Efficiency

Debt coverage shows a positive but modest association with hospital efficiency, lending support to Hypothesis 5. Hospitals with stronger debt servicing capacity are more likely to be classified as efficient, reflecting greater financial stability and lower risk of distress. This finding aligns with prior research linking financial resilience and creditworthiness to improved operational performance.

However, the relatively smaller effect size suggests that debt coverage functions more as a supporting condition for efficiency rather than a primary driver. Adequate debt coverage enables hospitals to sustain operations but does not, by itself, guarantee efficient resource utilization.

5.2.6 Working Capital Efficiency and Hospital Efficiency

The results strongly support Hypothesis 6, indicating that working capital efficiency is positively associated with hospital efficiency. Effective management of short-term assets and liabilities increases the likelihood that hospitals operate on the efficiency frontier. This finding highlights the importance of day-to-day financial management practices—such as receivables and cash management—in sustaining efficient operations.

The consistency of this result with decades of prior research suggests that working capital efficiency remains a foundational component of hospital performance, even as financial environments and reimbursement systems evolve.

5.2.7 Fixed Asset Age and Hospital Efficiency

The findings support Hypothesis 7, showing that older fixed assets are negatively associated with hospital efficiency. Hospitals with newer facilities and equipment are more likely to operate efficiently, reflecting lower maintenance costs, better technology, and improved workflow design. This result reinforces the argument that aging infrastructure constrains operational performance and limits hospitals' ability to achieve efficiency gains.

5.3 The Moderating Role of Teaching Status

A central contribution of this study is the explicit examination of hospital teaching status as a moderating factor. The findings demonstrate that financial ratios do not convey uniform efficiency implications across hospital types. Teaching hospitals exhibit distinct efficiency–financial performance dynamics due to their educational mission, higher cost structures, and reliance on long-term capital investment.

In particular, capital structure and profitability measures appear to function differently in teaching hospitals compared to non-teaching hospitals. These differences underscore the importance of considering organizational context when interpreting financial indicators and evaluating hospital performance. Treating teaching status merely as a control variable risks obscuring meaningful heterogeneity in efficiency drivers.

5.4 Contributions to the Literature

This study makes several important contributions to the hospital efficiency and hospital finance literature. First, it integrates DEA-based efficiency measurement with financial ratio analysis in a two-stage framework that emphasizes efficiency as an operational state rather than a marginal outcome. Second, it extends prior research by explicitly modeling hospital teaching status as a moderating mechanism, rather than as a simple control variable. Third, the study provides large-sample, nationally representative evidence using the 2020 AHA dataset, offering timely insights into hospital performance.

By linking financial structure, organizational mission, and efficiency outcomes, this study advances understanding of how hospitals translate financial resources into operational performance under heterogeneous institutional constraints.

5.5 Managerial and Policy Implications

The findings offer practical implications for hospital administrators and policymakers. For managers, the results highlight the importance of asset utilization and working capital management in achieving efficiency gains. Financial strategies that emphasize effective use of existing resources may yield greater efficiency improvements than strategies focused solely on revenue growth.

For policymakers, the results suggest that performance benchmarking and financial oversight should account for hospital teaching status. Uniform financial benchmarks may misrepresent efficiency in teaching hospitals and risk incentivizing short-term financial behavior at the expense of long-term mission objectives.

Table 9: Executive Summary of Financial Impacts on Hospital Performance

Priority	All Data	Non-teaching	Teaching
1	Profitability	Profitability	Profitability
2	Liquidity	Liquidity	Working Capital Efficiency
3	Capital Structure	Capital Structure	Debt Coverage
4	Working Capital Efficiency	Debt Coverage	Fixed Asset Age
5	Debt Coverage	Working Capital Efficiency	Liquidity

6. Conclusion

This study examines how hospital financial characteristics are associated with operational efficiency and whether these relationships differ between teaching and non-teaching hospitals. Using a two-stage empirical framework, hospital efficiency is first measured through Data Envelopment Analysis (DEA), and hospitals are classified as technically efficient or inefficient. Logistic regression is then employed to assess how financial ratios and teaching status relate to the likelihood of operating on or near the efficiency frontier. By integrating efficiency measurement, financial ratio analysis, and organizational context, this study provides a unified framework for understanding hospital efficiency in heterogeneous institutional settings.

This study makes three primary contributions to the hospital efficiency and healthcare finance literature. First, it conceptualizes hospital efficiency as an operational state rather than a marginal outcome, supporting a DEA-based classification approach combined with probability modeling. Second, it advances prior research by explicitly modeling hospital teaching status as a moderating factor, rather than treating it solely as a control variable. Third, the study provides recent, nationally representative evidence on the financial drivers of hospital efficiency using U.S. hospital data. Together, these contributions extend existing research by demonstrating that financial indicators do not convey uniform efficiency implications across hospital types.

The findings have several high-level implications. For hospital administrators, the results highlight the importance of financial structure and resource utilization—particularly asset management and working capital practices—in supporting efficient operations. For policymakers, the results suggest that efficiency assessment and financial benchmarking should account for organizational mission and structure, as uniform benchmarks may mischaracterize performance in teaching hospitals. These implications underscore the need for context-sensitive evaluation frameworks in healthcare management and policy.

This study has several limitations. The analysis is based on cross-sectional data from a single year, which limits the ability to assess efficiency dynamics over time or draw causal inferences. DEA provides relative efficiency measures that depend on the sample composition, and the classification of hospitals into efficient and inefficient groups abstracts from variation within these categories. In addition, other organizational and market characteristics, such as ownership type and regional competition, are not explicitly examined.

Lastly, the full-sample logistic regression model demonstrates modest explanatory power (Nagelkerke R^2 = 0.140), indicating that financial ratios alone explain only a portion of the variation in hospital efficiency classification. This is not unexpected, as hospital efficiency is influenced by multiple factors beyond financial characteristics, including management quality, operational processes, physician practice patterns, patient case-mix severity, local market conditions, and regulatory environments. The non-teaching hospital subsample shows similar explanatory power (Nagelkerke R^2 = 0.129), while the teaching hospital subsample demonstrates substantially higher explanatory power (Nagelkerke R^2 = 0.555), suggesting that financial structure may be more directly linked to efficiency in teaching institutions. The modest R^2 values in the full sample and non-teaching subsample suggest that important efficiency determinants remain unobserved in our model.

Future research could extend this study by employing longitudinal data to examine changes in efficiency and financial structure over time. Alternative efficiency measurement approaches or hybrid models could be used to test the robustness of the findings. Further work could also explore additional sources of organizational heterogeneity, such as ownership form or market competition, to deepen understanding of how institutional context shapes hospital efficiency. In addition, future research could enhance explanatory power by incorporating additional variables such as quality metrics, technology adoption indicators, workforce characteristics, patient satisfaction measures, and detailed market structure variables. Moreover, efficiency may be influenced by unobservable factors such as organizational culture, leadership effectiveness, and strategic decision-making processes that are difficult to capture in quantitative models. Despite these limitations, our findings provide valuable insights into how observable financial characteristics relate to efficiency classification and how these relationships differ by teaching status.

In conclusion, this study demonstrates that hospital efficiency is shaped by financial characteristics in ways that depend on organizational context. Teaching status plays a meaningful role in conditioning how financial indicators relate to efficiency, highlighting the importance of moving beyond one-size-fits-all approaches to hospital performance evaluation. By integrating efficiency measurement, financial analysis, and institutional heterogeneity, this study contributes to a more nuanced understanding of hospital efficiency and informs both research and practice.

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