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Physician-hospital integration and hospital financial performance: A necessity condition analysis of U.S. Acute care hospitals, 2019 to 2022

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Abstract

Physician-hospital integration (PHI) is often discussed as a strategy for improving hospital performance, yet most prior studies ask whether integration changes outcomes on average. This study addresses a different question by examining whether PHI function as necessary conditions for hospital financial outcomes. Using pooled cross-sectional data from 2019 to 2022, we classify eight American Hospital Association-featured PHI arrangements into financial PHI and collaborative PHI and examine four financial outcomes: net profit margin, operating profit margin, days cash on hand, and the total-salaries-to-total-expense ratio. Our results of the necessary conditional analysis show no necessity effect for financial PHI on net profit margin, operating profit margin, or days cash on hand. Financial PHI shows a statistically detectable but trivial necessity effect for the total-salaries-to-total-expense ratio, with effect size 0.026, while collaborative PHI shows a statistically detectable but trivial necessity effect for net profit margin, with effect size 0.027. Complementary partial least squares structural equation modeling does not identify robust sufficiency-based pathways from PHI type to the latent financial performance construct. In summary, our results did not support the view that PHI is broadly required for hospital financial success. Instead, they suggest that specific integration arrangements may operate as weak boundary conditions for a narrow subset of financial outcomes.

Introduction

Hospitals in the United States (U.S.) exhibit substantial variation in financial performance. Some hospitals continue to face labor cost growth, liquidity pressure, and operating strain (Morse, 2025, Cass, 2025), while others maintain strong margins and stable balance sheets (Landi, 2025, Swanson, 2025). This variation cautions against viewing hospital financial pressure as a uniform national problem and suggests that organizational responses will vary with resources, market conditions, and strategic priorities.

One response that has expanded over time is physician-hospital integration (PHI). PHI includes a range of arrangements, from direct employment and ownership models to looser contractual and collaborative affiliations (Tsai et al., 2025, Arnold et al., 2025, Godt, 2024, Leblanc, 2024). Hospitals may pursue these arrangements for several reasons, including care coordination, managerial alignment, referral stability, revenue capture, responses to payment reform, and broader competitive pressures (Burns and Muller, 2008, Burns et al., 2010, Brinsfield et al., 2024, Short et al., 2017, Goes and Zhan, 1995). As a result, PHI should be understood as a multidimensional organizational strategy rather than a single intervention with one uniform purpose or one predictable effect.

Most prior research on PHI has asked a sufficiency question. In other words, previous research has examined whether integration changes outcomes on average, such as prices, spending, quality, referrals, or organizational performance (Upadhyay et al., 2024, Cooper et al., 2025, Van Parys, 2022, Post et al., 2021). This study instead asks whether low levels or the absence of specific PHI arrangements constrain the upper range of selected hospital financial outcomes. That is a necessity question and requires a different analytic logic from a standard average-effect analysis.

To address that question, we distinguish between two types of PHI. The first is financial PHI, which includes arrangements characterized by direct economic control, such as salaried employment, equity participation, or foundation-based integration. The second is collaborative PHI, which includes loose arrangements that support coordination and alignment without full financial internalization. Hybrid forms may also exist (Li et al., 2025, Li et al., 2024), but they are not the focus of this study.

Using nationwide secondary data from 2019 to 2022, we examined whether financial PHI and collaborative PHI function as necessary conditions for four hospital financial outcomes: net profit margin, operating profit margin, days cash on hand, and the total-salaries-to-total-expense ratio. We complemented the necessity analysis with partial least squares structural equation modeling as a sufficiency-based sensitivity analysis. The goal was not to claim that PHI universally improves hospital finances, nor to evaluate patient welfare or market-level consequences of consolidation. Instead, the goal was to clarify whether PHI arrangements operate as empirical boundary conditions for hospital financial outcomes.

New Contribution

We make two primary contributions. First, this study contributes to PHI literature by bringing necessity logic into a literature that is dominated by sufficiency-based reasoning. Necessary condition analysis (NCA) does not estimate average marginal effects and does not substitute for regression-based or policy-evaluation designs. Instead, it examines whether an outcome reaches higher levels when a condition is absent or low. By applying NCA alongside a complementary sufficiency-based sensitivity analysis, this study clarifies that the question of whether a condition is required is analytically distinct from the question of whether that condition increases outcomes on average.

Second, this study also contributes by distinguishing financial and collaborative forms of PHI rather than treating all integration arrangements as equivalent. This distinction matters because different integration forms may relate differently to profitability, liquidity, and labor cost structure. From a practical perspective, our findings suggest that hospital leaders should not treat PHI as a single strategic instrument. Instead, they should align the form of integration with the specific organizational objective they are trying to achieve.

Methods

Data Sources

This study employed pooled-section data analyses using secondary data from 2019 to 2022, compiled from six sources: the American Hospital Association (AHA) Annual Survey, the National Academy for State Health Policy (NASHP) data, the RAND Hospital Data, the Area Health Resources Files (AHRF), the Health Service Area (HSA) Files from the National Center for Health Statistics, and the Centers for Medicare & Medicaid Services (CMS) Case Mix File-Hospital Integrated Personnel and Pay System, as

compiled by the National Bureau of Economic Research. We merged these datasets using the Medicare provider number, which serves as a consistent hospital-level identifier across sources, and supplemented it with Federal Information Processing Standards (FIPS) codes for geographic alignment.

Study Sample

The AHA Annual Survey (2019–2022, N = 24,721) was merged sequentially with the NASHP data (N = 18,108), CMS Case Mix File (N = 13,222), and the RAND Hospital Data (N = 17,739). After these merges, the combined dataset included 9,870 hospitals. This dataset was then merged using FIPS codes and supplemented with contextual variables from the HSA Files and the AHRF (N = 12,943), resulting in 9,692 hospitals. After removing records with missing information, the final analytical sample comprised 5,095 acute care hospitals from 2019 to 2022 (See Appendix 1 for data derivative). Institutional Review Board (IRB) approval was waived because all study data is publicly available.

Measures

Outcome

Our outcome measures were measured using four key indicators of hospital financial performance: 1) Net profit margin, calculated as net income divided by net patient revenue, representing the percentage of revenue retained after all expenses, reflecting overall profitability. 2) Operating profit margin, defined as operating profit (or loss) divided by net patient revenue, which focuses specifically on earnings from core hospital operations, excluding non-patient-related revenues and costs. 3) Days cash on hand, calculated as cash and cash equivalents divided by one day's worth of cash-based operating expenses. This metric measures the number of days a hospital can sustain operations using its available cash, serving as a proxy for liquidity and short-term financial resilience. And 4) Total-salaries-to-total-expense ratio, calculated as total salaries divided by total hospital expenses. This ratio reflects the proportion of expenditures allocated to personnel, a major driver of hospital costs and a key indicator of financial structure. We selected these four measures because they capture distinct yet complementary dimensions of hospital financial performance: profitability, liquidity, and cost structure (Singh and Wheeler, 2012, Pradhan et al., 2024, Soumya Upadhyay and Smith, 2016, Ginn et al., 2011, Dubas-Jakóbczyk et al., 2025).

Predictors

The key predictors in this study were based on eight PHI arrangement models reported in the AHA Annual Survey (See Appendix 2 for the models and definitions). Building on the typology developed by Li et al. (2025), we classified these PHI models into two conceptual categories: 1) financial PHI, which includes the Integrated Salary Model, Equity Model, and Foundation Model, characterized by direct financial control and hospital ownership or employment structures; and 2) collaborative PHI, which includes the remaining five models that reflect looser, often contractual or relational clinical integration without direct financial control. We created two binary variables to capture these PHI types. For each hospital-year observation: a

value of 1 was assigned to a hospital that reported at least one financial PHI arrangement; otherwise, a 0 was assigned. Same approach with collaborative PHI models.

Covariates

To account for confounders previously shown to be associated with hospital financial performance, we included hospital organizational characteristics and market-level characteristics (Henke et al., 2018, Herrel et al., 2021, Upadhyay et al., 2024, Offodile II et al., 2021, Rosko et al., 2020, Bruch et al., 2020, Gidwani and Damberg, 2023). Hospital ownership was categorized as non-profit, for-profit, or governmental to account for differing governance structures and financial incentives. Hospital size was measured by the number of available inpatient beds, excluding beds in outpatient units and emergency departments. To address right-skewed distribution, bed size was log-transformed, in line with prior studies (Feng et al., 2014). Teaching affiliation was included as a binary variable, indicating whether a hospital served as a participating site for one or more Accreditation Council for Graduate Medical Education-accredited programs. System membership captured whether a hospital was affiliated with a health system, based on the 2018 Compendium of U.S. Health Systems.

We also included two additional organizational-level variables related to service mix and patient complexity. Medicare payer mix was defined as the percentage of total hospital charges attributable to Medicare patients, reflecting reliance on federal reimbursement. Case mix index, a proxy for patient complexity, was calculated by summing the diagnosis-related group weights for all Medicare discharges and dividing by the number of discharges. Finally, we included a variable which was measured as if a hospital received federal Public Health Emergency COVID-19 funds to hospital net income in a given year, to account for the potential short-term financial impact of pandemic-era government support.

We further controlled for financial burden from uncompensated care using two measures. The first is net charity care as a percentage of total operating expenses, calculated as net charity care cost divided by net patient revenue, representing the share of patient revenue applied to covering the costs of charity care. The second is the combined percentage of uninsured and bad debt, defined as the proportion of hospital operating costs devoted to uncompensated care for uninsured or unpaid insured patients, also expressed relative to net patient revenue.

Finally, market characteristics were captured using two measures. Market concentration was measured by the Herfindahl-Hirschman Index (HHI), calculated at the health service area level based on hospital market shares. The HHI values were standardized (scaled) to facilitate model interpretation and ensure suitability for the NCA analysis. County-level poverty rate, defined as the percentage of residents living below the federal poverty threshold, was included to account for socioeconomic context.

Statistical Analyses

Descriptive statistics were used to summarize the characteristics of the study sample. We reported frequencies and proportions, categorical variables, while for continuous variables, we presented the minimum and maximum values, mean, median [interquartile range], and standard deviation to describe central tendency and variability.

To assess whether these two specific types of PHI are necessary for achieving strong hospital financial performance, we employed NCA, a methodology developed to identify conditions that are essential but not sufficient for a given outcome (Dul, 2016). Unlike traditional regression approaches that estimate average effects across population, NCA identifies structural constraints that limit the outcome in the absence of specific conditions. NCA emphasizes a deterministic or typicality logic, where the presence of a particular factor is required for high levels of an outcome to occur, even if that factor alone is insufficient to produce the outcome (Dul, 2016). Rather than focusing on probabilistic influence, NCA examines the extent to which certain variables function as essential enablers: threshold conditions without which higher performance is unattainable (Dul, 2024). NCA therefore addresses a boundary-condition question rather than an average-effect question.

The primary analysis used pooled repeated cross-sectional data from 2019 to 2022. This approach is appropriate for NCA because the method evaluates cross-sectional ceiling constraints rather than within-hospital change over time (Dul, 2016, Neprash et al., 2015). Pooling broadens the observed range of conditions and outcomes, but it does not convert the analysis into causal panel inference. Accordingly, our results are interpreted as empirical necessity patterns in pooled observational data.

We conducted the NCA using the “nca” R package, specifying the theoretical direction of association for each independent variable/predictor and covariate in advance. This directional assumption guided how ceiling lines were constructed and interpreted. We used the Ceiling Envelopment-Free Disposal Hull (CE-FDH) technique to define the ceiling line, which is appropriate for binary and discrete predictors such as the presence of financial or collaborative PHI. CE-FDH constructs a non-parametric, stepwise ceiling line that follows the shape of the data distribution, allowing for a non-linear (stair-step) representation of the necessity relationship. NCA generates an effect size, which quantifies the proportion of the outcome space constrained by the independent variable/predictor and covariates. These effect sizes were interpreted based on established thresholds, with values below 0.1 considered trivial, and those above 0.5 considered large (Dul, 2016).

To assess statistical significance, we performed permutation tests with 1,000 resamples for each independent variable/predictor and covariate. These tests determine whether the observed necessity relationship is greater than what would be expected by chance under the null hypothesis. We also generated bottleneck tables to show the minimum level of each condition associated with specific outcome thresholds.

To evaluate the robustness of our results, we conducted additional analyses using an alternative ceiling line technique: the Ceiling Regression-Free Disposal Hull (CR-FDH). CR-FDH is a parametric approximation of the CE-FDH method that places a linear regression line along the top of the data cloud. While CE-FDH

provides a conservative, data-driven boundary, CR-FDH provides a more generalized and interpretable linear representation. Results across both methods were compared to confirm the consistency of the necessity relationships.

Sensitivity Analysis

Following the recommendations from Richter et al. (2020), we complemented the necessity analysis with partial least squares structural equation modeling (PLS-SEM) as a sufficiency-based sensitivity. This analysis was not intended to test necessity. Instead, it was used to examine whether the data also supports additive pathways from PHI type to financial outcomes. In these models, the total-salaries-to-total-expense ratio was specified as a potential mediator. We used a non-parametric bootstrapping procedure with 1,000 resamples to assess the significance of path coefficients and bias-corrected and accelerated (BCa) 95% confidence intervals were calculated. While NCA identifies 'must-have' conditions that are necessary for an outcome to occur, PLS-SEM allows for the identification of 'should-have' factors that contribute incrementally to the outcome through additive effects. This combined approach allows us to test alternative causal pathways within our established models.

We estimated two model specifications to assess robustness and model parsimony: 1) The individual-predictors specification included all exogenous constructs described in the measures section, with the total-salaries-to-total-expense ratio modeled as a mediator and hospital financial performance as a latent outcome indicated by net profit margin, operating profit margin, and days cash on hand; and 2) the grouped-predictors specification was designed to assess parsimony and potential multicollinearity by combining related indicators into two higher-order composites. The mediator and outcome were specified as in the individual-predictors model. Comparing the two models enabled us to confirm that our findings were consistent across different structural representations of the data. In addition, we included a category labeled "Non-AHA-Featured PHI" to identify hospitals that reported none of the eight PHI models in the AHA Annual Survey was implemented in their hospitals. This category serves as a reference group, allowing us to compare hospitals that adopt any model of PHI with those that do not, capture the full variation in PHI adoption, and isolate the independent effects of financial and collaborative PHI.

All analyses were performed with the R Programming software (R Foundation, Boston, MA, USA, Version 4.6.0). The significance level was set at alpha = 0.05.

Results

Sample Characteristics

Table 1 presents the characteristics of the study sample. On average, hospitals reported a net profit margin of 5% (SD = 16%) and an operating profit margin of 12% (SD = 19%). The average days cash on hand was 175.44 (SD = 296.81), and the mean total salaries to total expenses ratio was 36.48% (SD = 7.36%).

Table 1
Hospital Descriptive Statistics in 2019–2022 (N = 5,095)

Measures	Statistic	Value
Hospital financial performance		
Net Profit Margin	Min / Max	-2.06 / 1.57
	Med [IQR]	0.05 [-0.01;0.12]
	Mean (std)	0.05 (0.16)
Operating Profit Margin	Min / Max	-2.69 / 0.79
	Med [IQR]	0.15 [0.06;0.23]
	Mean (std)	0.12 (0.19)
Days Cash on Hand	Min / Max	0.04 / 1.00e + 04
	Med [IQR]	104.19 [27.36;224.49]
	Mean (std)	175.44 (296.81)
Total-Salaries-To-Total-Expenses Ratios	Min / Max	4.97 / 62.61
	Med [IQR]	36.65 [31.43;41.54]
	Mean (std)	36.48 (7.36)
PHI Types		
Financial PHI (Yes)	Mean/%	1,643/32.25%
Collaborative PHI (Yes)	Mean/%	954/18.72%
Hospital Characteristics & Market Characteristics		
Hospital Ownership (Non-profit)	Mean/%	3780/74.19%
Hospital Ownership (For profit)	Mean/%	402/7.89%
Hospital Ownership (Governmental)	Mean/%	913/17.92%
Hospital Size (Bed Size)	Min / Max	4.00 / 2850.00
	Med [IQR]	159.00 [69;316]
	Mean (std)	236 (249)
Teaching Status (Yes)	Mean/%	2,887/56.66%

Measures	Statistic	Value
Hospital financial performance		
System Affiliation (Independent)	Mean/%	674/13.23%
Case Mix Index	Min / Max	0.79 / 3.73
	Med [IQR]	0.26 [0.21;0.32]
	Mean (std)	1.62 [1.43;1.85]
Payer Mix Index (Medicare Percentage)	Min / Max	0.001 / 0.63
	Med [IQR]	0.26 [0.21;0.32]
	Mean (std)	0.27 (0.09)
Net Charity Care Cost %	Min / Max	-0.82 / 0.63
	Med [IQR]	0.01 [0.01;0.03]
	Mean (std)	0.02 (0.05)
Uninsured & Bad Debt Cost %	Min / Max	5.28e-06 / 0.31
	Med [IQR]	0.01 [0.01;0.02]
	Mean (std)	0.02 (0.02)
Ever COVID Funds (Yes)	Mean/%	2,814 / 55.23%
Market Competition (Herfindahl-Hirschman Index) at the Health Service Area level	Min / Max	0.69 / 100.00
	Med [IQR]	8.05 [3.05;13.43]
	Mean (std)	9.68 (7.47)
Poverty at the county level	Min / Max	3.10 / 38.70
	Med [IQR]	12.70 [9.40;15.80]
	Mean (std)	13.05 (4.84)

Insert Table 1 about here

Financial PHI was present in 32.25% of hospitals, while collaborative PHI was present in 18.72%. In addition, 56.41% of hospitals were categorized as non-AHA-featured PHI. Regarding ownership, 74.19% of hospitals were nonprofit, 17.92% were governmental, and 7.89% were for-profit. The average bed size was 236 (SD = 249), and 56.7% of hospitals were teaching hospitals. Furthermore, 13.23% of hospitals were independent (not system-affiliated). The average Medicare payer mix was 0.27 (SD = 0.09), and the average case-mix index was 1.66 (SD = 0.35). More than half of hospitals (55.23%) received COVID-19 relief funds. The average HHI-scaled market concentration was 9.68 (SD = 7.47), and the average county-level poverty rate was 13.05% (SD = 4.84). Regarding financial burden, the average net charity care cost was 2% of net patient revenue (SD = 5%), and the median uninsured and bad debt cost was also approximately 2% (SD = 2%).

NCA Results

Table 2 presents the NCA results for financial PHI and collaborative PHI across the four financial outcomes.

Table 2
NCA Results

Conditions	Net Profit Margin						
	Method	**Effect Size**	**Ceiling Zone**	**Fit**	**p-value**	**Slope**	**Intercept**
Financial PHI	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Collaborative PHI	CE-FDH	0.027	0.492	ϕ	0.035	0.492	1.076
	CR-FDH	0.014	0.246	50%	0.035		
Hospital Ownership (Non-profit)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Hospital Ownership (For-profit)	CE-FDH	0.146	0.531	ϕ	0.792	-0.531	1.568
	CR-FDH	0.073	0.266	50%	0.792		
Hospital Ownership (Governmental)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Hospital Size (Bed Size)	CE-FDH	0.001	14.247	ϕ	0.981	0.084	-0.018
	CR-FDH	0	9.378	ϕ	0.987		
Teaching Status (Yes)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		

ϕ stands for 100%

Conditions	Net Profit Margin						
	Method	Effect Size	Ceiling Zone	Fit	p-value	Slope	Intercept
System Affiliation (Independent)	CE-FDH	0.159	0.575	ϕ	0.570	-0.575	1.568
	CR-FDH	0.079	0.288	50%	0.570		
Medicare Payer Mix	CE-FDH	0.088	0.201	ϕ	0.632	6.158	0.113
	CR-FDH	0.075	0.170	84.6%	0.766		
Case Mix Index	CE-FDH	0.034	0.360	ϕ	0.941	5.345	-4.564
	CR-FDH	0032	0.339	94%	0.948		
Net Charity Care Cost %	CE-FDH	0.105	0.553	ϕ	0.982	-1.427	1.308
	CR-FDH	0.089	0.469	84.8%	0.972		
Uninsured & Bad Debt Cost %	CE-FDH	0.229	0.255	ϕ	0.960	-3.144	1.311
	CR-FDH	0.203	0.226	88.7%	0.933		
Ever COVID Funds	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
HHI (Scaled) at the Health Service Area level	CE-FDH	0.001	0.513	ϕ	0.940	1.238	-0.087
	CR-FDH	0	0257	50%	0.945		
Poverty at the county level	CE-FDH	0.230	29.726	ϕ	0.064	-0.045	1.709
	CR-FDH	0.220	28.738	95.5%	0.106		

ϕ stands for 100%

Conditions	Net Profit Margin						
	Method	**Effect Size**	**Ceiling Zone**	**Fit**	**p-value**	**Slope**	**Intercept**
	Operating Profit Margin						
Conditions	Method	Effect Size	Ceiling Zone	Fit	p-value	Slope	Intercept
Financial PHI	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Collaborative PHI	CE-FDH	0	0.006	ϕ	0.183	0.006	0.787
	CR-FDH	0	0.003	50%	0.183		
Hospital Ownership (Non-profit)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Hospital Ownership (For-profit)	CE-FDH	0.085	0.295	ϕ	0.103	-0.295	0.793
	CR-FDH	0.042	0.147	50%	0.103		
Hospital Ownership (Governmental)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Hospital Size (Bed Size)	CE-FDH	0.002	17.047	ϕ	0.402	0.002	0.401
	CR-FDH	0.003	30.555	99.8%	0.385		
Teaching Status (Yes)	CE-FDH	0.002	0.006	ϕ	1	-0.006	0.799
	CR-FDH	0	0.003	50%	1		

ϕ stands for 100%

Conditions	Net Profit Margin						
	Method	Effect Size	Ceiling Zone	Fit	p-value	Slope	Intercept
System Affiliation (Independent)	CE-FDH	0.049	0.170	ϕ	0.370	-0.170	0.793
	CR-FDH	0.024	0.085	50%	0.370		
Medicare Payer Mix	CE-FDH	0.031	0.067	ϕ	0.311	3.000	0.165
	CR-FDH	0.030	0.065	-	0.479		
Case Mix Index	CE-FDH	0.035	0.353	ϕ	< 0.001	0.663	-0.448
	CR-FDH	0.038	0.387	-	0.004		
Net Charity Care Cost %	CE-FDH	0.126	0.635	ϕ	< 0.001	-2.463	0.634
	CR-FDH	0.117	0.592	93.2%	< 0.001		
Uninsured & Bad Debt Cost %	CE-FDH	0.140	0.149	ϕ	0.003	-1.971	0.603
	CR-FDH	0.141	0.151	99.8%	0.002		
Ever COVID Funds	CE-FDH	0.002	0.006	ϕ	0.003	0.006	0.787
	CR-FDH	0	0.003	50%	0.553		
HHI (Scaled) at the Health Service Area level	CE-FDH	0.004	1.542	ϕ	0.040	0.039	0.406
	CR-FDH	0.005	1.675	-	0.098		
Poverty at the county level	CE-FDH	0.091	11.240	ϕ	0.001	-0.023	0.954
	CR-FDH	0.091	11.327	-	0.003		

ϕ stands for 100%

Conditions	Net Profit Margin						
	Method	**Effect Size**	**Ceiling Zone**	**Fit**	**p-value**	**Slope**	**Intercept**
	Days Cash on Hand						
Conditions	Method	Effect Size	Ceiling Zone	Fit	p-value	Slope	Intercept
Financial PHI	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Collaborative PHI	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Hospital Ownership (Non-profit)	CE-FDH	0.434	4,361.408	ϕ	0.261	-4,361.408	10,046.147
	CR-FDH	0.217	2,180.704	50%	0.261		
Hospital Ownership (For-profit)	CE-FDH	0.964	9,682.491	ϕ	< 0.001	-9,682.491	10,046.147
	CR-FDH	0.482	4,841.245	50%	< 0.001		
Hospital Ownership (Governmental)	CE-FDH	0.434	4,361.408	ϕ	0.181	4,361.408	5,684.739
	CR-FDH	0.217	2,180.704	50%	0.181		
Hospital Size (Bed Size)	CE-FDH	0.013	379,997.097	ϕ	0.800	191.198	-1,304.560
	CR-FDH	0.010	292,288.991	76.9%	0.831		
Teaching Status (Yes)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		

ϕ stands for 100%

Conditions	Net Profit Margin						
	Method	Effect Size	Ceiling Zone	Fit	p-value	Slope	Intercept
System Affiliation (Independent)	CE-FDH	0.887	8,907.094	ϕ	< 0.001	-8,907.094	10,046.147
	CR-FDH	0.443	4,453.547	50%	< 0.001		
Medicare Payer Mix	CE-FDH	0.415	2,610.568	ϕ	0.096	20,942.227	26.098
	CR-FDH	0.379	2,382.463	91.3%	0.119		
Case Mix Index	CE-FDH	0.051	1,504.318	ϕ	0.993	58,572.393	-46,664.333
	CR-FDH	0.031	916.745	60.9%	0.996		
Net Charity Care Cost %	CE-FDH	0.370	5,387.055	ϕ	0.733	-8,250.725	4,684.511
	CR-FDH	0.461	6,726.930	-	0.435		
Uninsured & Bad Debt Cost %	CE-FDH	0.239	735.134	ϕ	0.998	-120,376.719	35,613.978
	CR-FDH	0.170	522.689	71.1%	0.998		
Ever COVID Funds	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
HHI (Scaled) at the Health Service Area level	CE-FDH	0.134	133,477.540	ϕ	0.029	289.468	2,526.874
	CR-FDH	0.093	92,520.650	69.3%	0.055		
Poverty at the county level	CE-FDH	0.498	178,143.002	ϕ	0.844	-261.567	9,057.459
	CR-FDH	0.637	227,644.41	-	0.239		

ϕ stands for 100%

Conditions	Net Profit Margin						
	Method	**Effect Size**	**Ceiling Zone**	**Fit**	**p-value**	**Slope**	**Intercept**
	Total-Salaries-To-Total-Expenses Ratios						
Conditions	Method	Effect Size	Ceiling Zone	Fit	p-value	Slope	Intercept
Financial PHI	CE-FDH	0.026	4.569	ϕ	0.038	4.569	58.045
	CR-FDH	0.013	2.284	50%	0.038		
Collaborative PHI	CE-FDH	0	0	100%	1	-	-
	CR-FDH	0	0	-	1		
Hospital Ownership (Non-profit)	CE-FDH	0.031	1.810	ϕ	0.262	-1.810	62.613
	CR-FDH	0.016	0.905	50%	0.262		
Hospital Ownership (For-profit)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Hospital Ownership (Governmental)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Hospital Size (Bed Size)	CE-FDH	0.001	184.865	ϕ	0.971	0.735	44.417
	CR-FDH	0	158.434	85.7%	0.966		
Teaching Status (Yes)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		

ϕ stands for 100%

Conditions	Net Profit Margin						
	Method	Effect Size	Ceiling Zone	Fit	p-value	Slope	Intercept
System Affiliation (Independent)	CE-FDH	0	0	ϕ	1	-	-
	CR-FDH	0	0	-	1		
Medicare Payer Mix	CE-FDH	0.064	2.294	ϕ	0.358	51.801	46.226
	CR-FDH	0.071	2.568	-	0.285		
Case Mix Index	CE-FDH	0.017	2.917	ϕ	0.987	30.504	26.188
	CR-FDH	0.015	2.476	84.9%	0.986		
Net Charity Care Cost %	CE-FDH	0.118	9.854	ϕ	0.418	-34.294	59.335
	CR-FDH	0.107	8.992	91.3%	0.480		
Uninsured & Bad Debt Cost %	CE-FDH	0.148	2.605	ϕ	0.960	-81.504	68.870
	CR-FDH	0.122	2.144	82.3%	0.973		
Ever COVID Funds	CE-FDH	0.031	1.810	ϕ	0.557	1.810	60.803
	CR-FDH	0.016	0.905	5	0.557		
HHI (Scaled) at the Health Service Area level	CE-FDH	0.009	51.753	ϕ	0.202	1.082	54.380
	CR-FDH	0.005	25.877	50%	0.493		
Poverty at the county level	CE-FDH	0.129	264.458	ϕ	0.601	-0.910	76.515

ϕ stands for 100%

Conditions	Net Profit Margin						
	Method	Effect Size	Ceiling Zone	Fit	p-value	Slope	Intercept
	CR-FDH	0.122	249.562	94.4%	0.652		
ϕ stands for 100%							

Insert Table 2 about here

Financial PHI did not demonstrate a necessity effect for net profit margin, operating profit margin, or days cash on hand. For each outcome, the estimated effect size was zero, and the permutation test provided no evidence of a ceiling relationship. This indicates that hospitals without financial PHI were still observed at high levels of profitability and liquidity. In the NCA sense, financial PHI therefore does not function as a required boundary condition for these three outcomes.

In contrast, financial PHI did show a statistically detectable but trivial necessity effect for the total-salaries-to-total-expense ratio (effect size = 0.026, p = 0.038). Figure 1 illustrates this ceiling pattern. Given its small magnitude, this result is better interpreted as a weak boundary condition related to labor cost structure than as evidence that financial PHI is necessary for strong financial performance.

Insert Fig. 1 about here

Collaborative PHI showed a statistically detectable but trivial necessity effect for net profit margin (effect size = 0.027, p = 0.035). Figure 2 demonstrated this ceiling pattern. This result suggests that collaborative PHI may operate as a weak empirical bottleneck for higher net profit margins in the observed data. Since the effect size is trivial by established NCA benchmarks, the findings should be interpreted cautiously and not as evidence of a strong or universal necessity relationship. In addition, collaborative PHI did not show a statistically meaningful necessity effect for operating profit margin, and neither form of PHI showed a necessity effect for days cash on hand.

Insert Fig. 2 about here

In summary, our NCA results do not support the claim that financial PHI is required for hospital profitability or liquidity. Instead, they point to two narrow and weak patterns: a trivial necessity effect of financial PHI for the labor cost structure measure and a trivial necessity effect of collaborative PHI for net profit margin.

Sensitivity Analyses: PLS-SEM Results

We have two results for PLS-SEM models: First, the individual-predictor model (see Appendix 3) explained 22% of the variance in total-salaries-to-total-expense ratio and 11.2% in the latent hospital financial performance (including net profit margin, operating profit margin, and days cash on hand) (Adjust $R^2 =$ 0.218 and 0.110). The direct path from PHI type to the latent financial performance construct was not significant, and the mediator-to-outcome path was also not significant. Measurement diagnostics were mixed: the reflective hospital financial performance construct loaded strongly on operating margin ($\lambda \approx$ 0.965) and net profit margin ($\lambda \approx$ 0.592), but weakly on days cash on hand ($\lambda \approx$ 0.018), yielding modest convergent validity ($\mathrm{Composite\ Reliability}\ (\rho\,\mathrm{C}) =$ 0.591, Average Variance Extracted (AVE) $=$ 0.427). The individual-predictors model does not provide evidence of a sufficiency-based pathway from PHI type to the latent financial performance measure.

Second, the grouped-predictor model (See Appendix 4) explained 21.4% of the variance in total-salaries-to-total-expense ratio and 10.4% in hospital financial performance (including net profit margin, operating profit margin, and days cash on hand) (Adjusted R^2 = 0.213 and 0.103). As in the individual-predictors model, the path from PHI type to the mediator was positive but not statistically robust, the direct path to the latent financial performance construct was not significant, and the mediator-to-outcome path was not significant. Measurement reliability was mixed. The reflective financial performance construct loaded strongly on operating profit margin ($\lambda \approx$ 0.959) and net profit margin (λ = 0.603), but weakly on days cash on hand ($\lambda \approx$ -0.017), yielding modest convergent validity (ρC = 0.582, AVE = 0.428). Higher-order composites, particularly organizational and market characteristics, exhibited low internal consistency (ρC = 0.127 and 0.023, respectively).

Taken together, the overall pattern was consistent. Financial PHI did not show a robust direct or indirect relationship with the latent financial performance construct, and the total-salaries-to-total-expense ratio did not function as a statistically significant mediator. These results align with the main conclusion from the NCA analyses that PHI should not be treated as a universal financial lever. The NCA and PLS-SEM results should not be read as testing the same question, because necessity and sufficiency address different inferential logics.

Discussion

This study examined whether financial and collaborative PHI were necessary conditions for hospital financial outcomes. Across most outcomes, neither form of PHI showed a substantive necessity effect. The only statistically detectable NCA results were trivial effects of financial PHI on the total-salaries-to-

total-expense ratio and of collaborative PHI on net profit margin. These findings suggest that PHI is not broadly required for hospitals to achieve higher profitability or liquidity in the observed data.

Our findings for financial PHI are more consistent with a governance and cost-structure interpretation than with a profitability interpretation. Financial PHI can offer hospitals greater formal control over physicians and may improve managerial coordination, standardization, and internal oversight (Reay et al., 2017, Scott, 2005). Viewed through Resource Dependence, financial PHI can also be understood as a way to stabilize a critical resource relationship by internalizing physician labor, a key input to hospital operations (Pfeffer and Salancik, 2015). At the same time, internalizing physician employment can increase fixed personnel costs and reduce cost flexibility as (Lin et al., 2025) noted. This interpretation fits our findings: financial PHI was not a necessity condition for profitability or liquidity, but it showed a trivial necessity effect for the labor cost structure measure. The observed effect for the total-salaries-to-total-expense ratio is therefore more consistent with increased labor cost exposure than with improved profitability. Consistent with prior work showing that PHI effects are heterogeneous and context dependent rather than uniformly positive (Burns and Muller, 2008, Cuellar, 2006), our findings suggest that financial PHI functions less as a route to stronger financial performance than as a structural alignment strategy through which hospitals formalize relationships with physicians, strengthen organizational control, and manage dependency and uncertainty.

By contrast, the statistically detectable but trivial necessity effect of collaborative PHI for net profit margin suggests a mechanism different from formal structural or financial control. Rather than relying on administrative oversight or cost absorption, collaborative PHI may preserve physician autonomy while still fostering coordination, alignment, and relational commitment to hospital goals. This interpretation is consistent with scholarship on hybrid organizations operating under multiple institutional logics (Reay et al., 2017, Doolin, 2002, Salvatore et al., 2018). By balancing managerial and professional logics, collaborative arrangements may allow hospitals to draw on physicians' intrinsic motivation, clinical expertise, and responsiveness to patient needs without substantially increasing labor costs. From a stewardship theory (Caers et al., 2006, Young et al., 2016), physicians in such arrangements may act less as agents requiring close monitoring and more as stewards whose goals align with the hospital's mission when autonomy and mutual trust are preserved. Because the observed necessity effect was trivial, however, this pattern is better interpreted as a weak boundary condition than as evidence that collaborative PHI is a strong prerequisite for profitability.

In addition, the sufficiency-based sensitivity analyses help clarify what the NCA findings do and do not mean. The PLS-SEM models did not identify robust additive relationships between PHI type and the latent financial performance construct. This result does not contradict the NCA findings because sufficiency and necessity address different causal questions. Instead, the two approaches converge on the same practical conclusion: PHI should not be treated as a universally reliable route to stronger hospital financial outcomes. Whether and how integration matters appears to depend on the type of integration, the outcome examined, and the broader organizational and market context.

Our findings have implications for both hospital management and future research. For hospital leaders, the findings caution against assuming that tighter financial PHI will, by itself, improve margins or liquidity. PHI choices should instead be matched to the organizational problem at hand, such as governance, referral alignment, labor management, or care coordination. For researchers, the findings highlight the importance of distinguishing necessity from sufficiency and of disaggregating PHI into more specific forms. Future work should measure PHI intensity more directly, examine hybrid arrangements, and use designs that better account for repeated observations and within-hospital change over time.

5.1. Limitation

While providing innovative insights, our study has several limitations. First, the pooled cross-sectional design does not support strong conclusions about directional causality or within-hospital change over time. The NCA results identify necessity patterns in the observed data rather than causal necessity in a strict sense. Second, PHI in this study was measured using the eight AHA-reported arrangement models and operationalized as binary indicators. This approach does not capture the intensity, scope, or scale of integration (e.g., the proportion of physicians engaged or level of financial risk-sharing). Third, this study does not include all possible alignment mechanisms, such as value-based payment arrangements, co-management agreements, or informal collaboration structures that may also influence hospital financial outcomes. Additionally, our observed operating profit margin of approximately 12% was higher than expected for U.S. hospitals under normal conditions (Ly and Cutler, 2018, Ly et al., 2011). This elevated margin likely reflects the lingering impact of COVID-19 Provider Relief Fund distributions, which began in 2019 and continued to appear in hospital financial statements through 2022. As a result, these temporary funding effects may have artificially inflated hospital profitability during the study period, thereby limiting the interpretation and generalizability. Finally, the PLS-SEM model exhibited suboptimal fit indices, suggesting that future studies should consider model refinement or alternative estimation techniques to validate the robustness of the findings.

Conclusions

This study examined whether financial and collaborative PHI function as necessary conditions for hospital financial outcomes. Using pooled cross-sectional data from 2019 through 2022 and necessity condition analysis, we found little evidence that PHI is broadly required for stronger hospital financial performance. Financial PHI was not necessary for profitability, although it showed a trivial necessity effect for the total-salaries-to-total-expense ratio, while collaborative PHI showed a trivial but statistically detectable necessity effect for net profit margin. These findings suggest that PHI is better understood as a context-dependent governance arrangement than as a universal financial strategy for hospitals.

Abbreviations

AHA	American Hospital Association
AHRF	Area Health Resources Files
CMS	Centers for Medicare & Medicaid Services
CE-FDH	Ceiling Envelopment-Free Disposal Hull
CR-FDH	Ceiling Regression-Free Disposal Hull
FIPS	Federal Information Processing Standards
'HSA	Health Service Area
HHI	Herfindahl-Hirschman Index
IRB	Institutional Review Board
NASHP	National Academy for State Health Policy
NCA	Necessary condition analysis
PHI	Physician-Hospital Integration
U.S.	United States

Declarations

Author Contributions: Conceptualization, X.L., J.Z., and W.D.; methodology, X.L. and J.Z.; software, J.Z.; validation, X.L.; formal analysis, J.Z.; investigation, J.P.; resources, X.L. and W.D.; data curation, X.L. and J.Z.; writing—original draft preparation, X.L.; writing—review and editing, All authors.; visualization, J.Z.; supervision, W.D.; project administration, X.L. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: Not applicable

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Conflicts of Interest: The authors declare no conflicts of interest.

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Figures

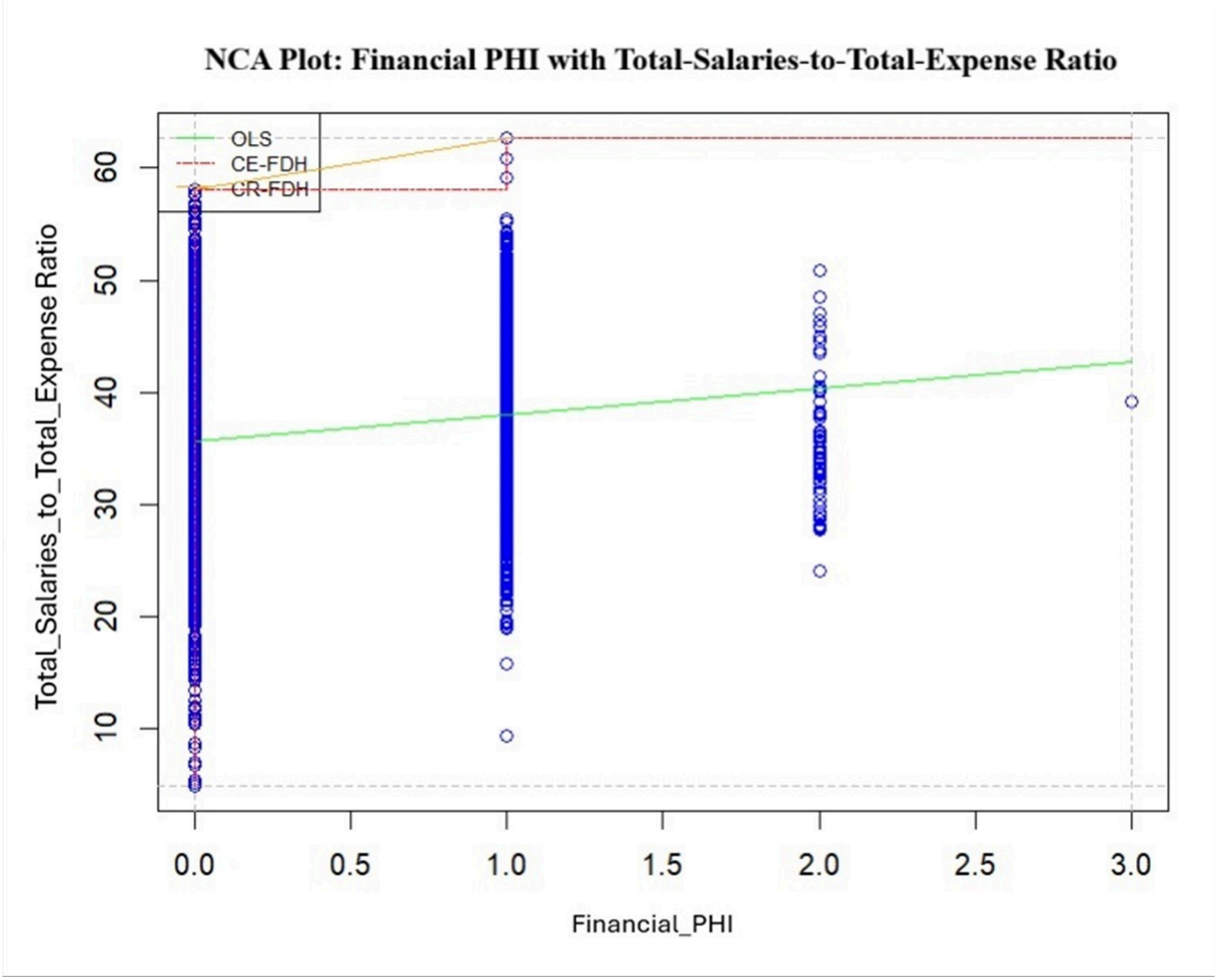


Figure 1

NCA Plot (Financial PHI with Total-Salaries-to-Total-Expense Ratio)

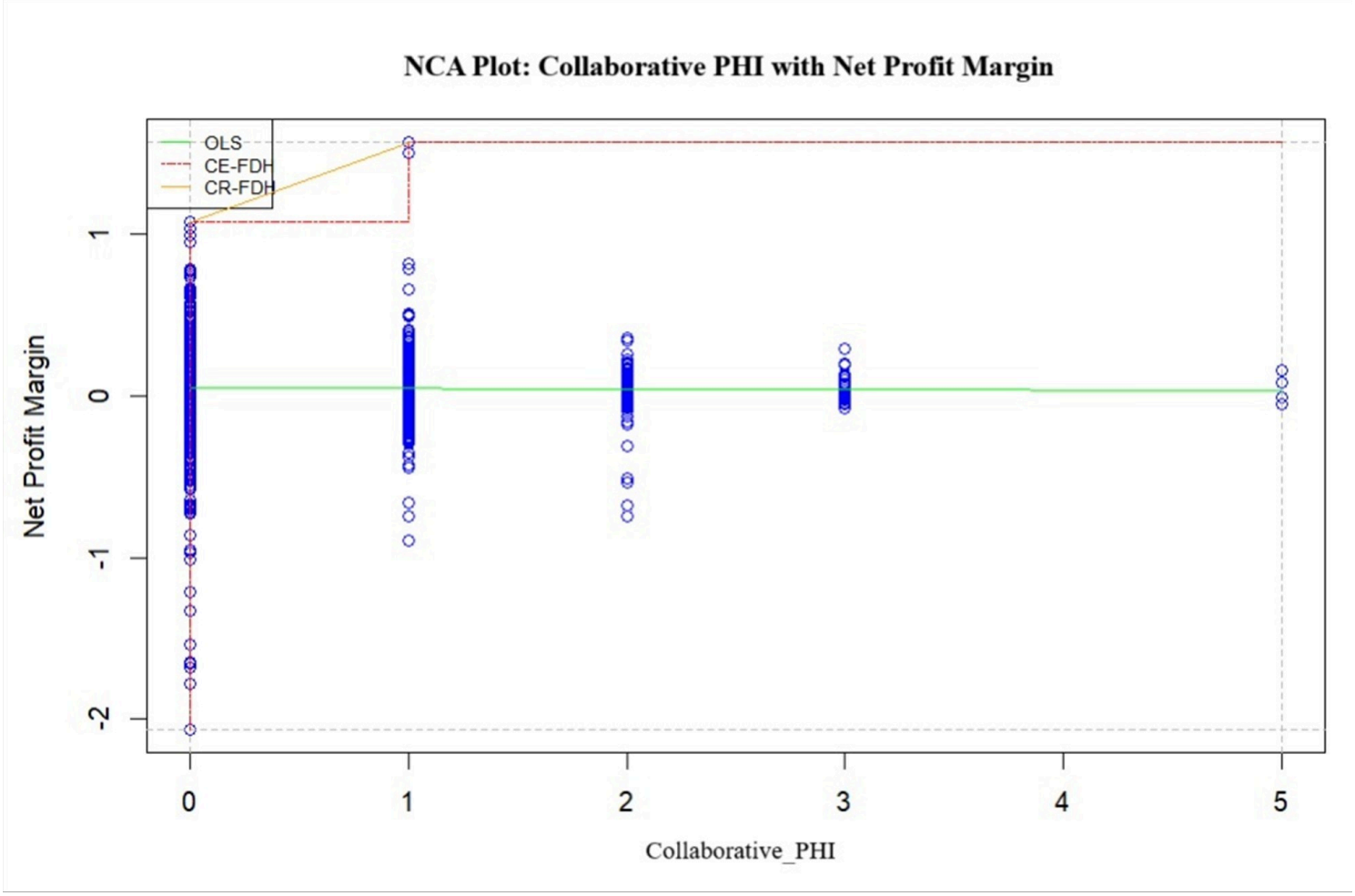


Figure 2

NCA Plot (Collaborative PHI with Net Profit Margin)

Supplementary Files

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- Appendices.docx