FINAL YEAR PROJECT PRESENTATION

FINANCIAL BASED COMPANY VALUATION USING INTEGRATED ANALYTICAL HIERARCHY PROCESS AND DATA ENVELOPEMENT ANALYSIS

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why assess company performance

"Financial statements of a company serve as an information base for decision-making in a transforming economy."
– Osadchy et al., 2018

why use MCDM technique

"Hierarchical analysis [AHP] integrates financial and non-financial criteria side by side, filling the gaps that the traditional approach cannot address due to its lack of flexibility."
– Aljuhaishi & Kadhim, 2023

why use integration of DEA and AHP

"Combining AHP's structured judgment approach with DEA's benchmarking power creates a more comprehensive performance evaluation model."
– Tavana et al., 2023

Analytic Hierarchy Process (AHP)	• Introduced by Saaty (1985) • Expert-driven pairwise comparisons. • Generates priority weights for decision criteria. • Ensures consistency through CR analysis.
Data Envelopment Analysis (DEA)	• Proposed by Charnes et al. (1978) • Objective efficiency benchmarking. • Input–output optimization using linear programming. • Extended by Banker et al. (1984, 1989) to account for Variable Returns to Scale (VRS)
Integration of AHP and DEA	• Combines AHP's expert judgment with DEA's efficiency benchmarking. • Allows for context-sensitive performance evaluation • AHP supplies expert-informed weights. • DEA uses those weights to rank firms on efficiency.
Company Financial focused fundamental analysis	• Method to evaluate a company's value by analyzing its financial statements and economic fundamentals. • Focuses on quantitative metrics such as Profitability, Liquidity, Valuation, Efficiency, and Growth trends • Forms the foundation for selecting financial criteria and subcriteria in the AHP–DEA model.

Problem satement

Traditional valuation methods often overlook the complexity of corporate performance and lack structured expert input, leading to biased outcomes (Gibson, 2004; Aljuhaishi & Kadhim, 2023). AHP and DEA offer improved analysis but have individual limitations. Their integration addresses these gaps, yet application in company valuation and alignment with stock performance remains underexplored—prompting this study to investigate AHP-based weighting, its integration into DEA, and its correlation with market outcomes.

1. How can expert judgment be systematically translated into quantitative priority weights for financial performance metrics using the AHP method?

2. How can AHP-derived expert weightings be integrated into DEA to enable robust ranking of company financial efficiency?

3. To what extent does the financial efficiency measured through AHP-DEA correlate with actual company stock performance?

Objective

In response to the problem, the purpose of these study is:

1. To enhance DEA evaluation by integrating AHP-derived expert weightage into the efficiency analysis framework.

2. To rank companies based on their financial efficiency using a bounded, expert-informed DEA model.

3. To examine the correlation of the company financial efficiency and real-world company stock performance.

3 SIGNIFICANCE OF PROJECT

🔗 Bridging Subjective Judgment and Objective Data

- Integrates AHP and DEA to combine subjective expert judgment with objective performance measurement.
- Addresses the gap in traditional methods that fail to capture both qualitative and quantitative aspects of firm performance..

📚 Academic and Strategic Contribution

- Contributes to MCDM literature (Asadabadi et al., 2019; Vaidya & Kumar, 2006).
- Methodology is reproducible and adaptable—valuable for analysts, investors, and policymakers (Aruldoss et al., 2013).

💡 Enhanced Financial Insight

- Demonstrates how hybrid models support rational, data-driven decision-making.
- Aligns with the increasing need for integrated evaluation tools in dynamic financial environments.

4 SCOPE OF PROJECT

<u>Methodological Framework</u>

Integrates AHP and DEA within an MCDM framework.
Combines subjective weighting with objective efficiency analysis.

<u>Industry Focus</u>

- Targets banking institutions listed on Bursa Malaysia.
- Focuses on a strategically significant and highly regulated sector.

<u>Tools and Techniques</u>

- Computational Analysis: Rstudio and Microsoft Excell
- Spearman's Rank Correlation Coefficient are used to compare with real life data

Criteria
C1 Valuation Ratios
C2 Profitability Ratios
C3 Liquidity Ratios
C4 Cash Flow Analysis
C 5 Operational Efficiency
C6 Debt Metrics
C7 Revenue and Earnings Growth
C8 Dividend Metrics

<u>Data Sources</u>

- Timeframe: 2009-2019 (long-term trends).
- Sources: Bloomberg, Yahoo Finance, BURSA Marketplace, corporate financial statements.
- Expert Opinions: Surveys and interviews for AHP weighting.

5 LITERATURE REVIEW

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Financial Fundamental Analysis

- Rooted in Graham & Dodd (1934)'s classic Security Analysis.
- Focuses on intrinsic value via financial statements and economic fundamentals.
- Evolved into structured use of ratios, trend analysis, and valuation models.

Literature Contribution to This Study

- Graham & Dodd (1951): Established foundational logic for intrinsic value via financial analysis.
- Gibson (2004): Advocated for standardization and benchmarking across firms.
- Penman (2013): Provided practical guidance on interpreting valuation ratios (P/E, P/B).
- Subramanyam (2014): Highlighted how ratio analysis reveals risks, trends, inefficiencies.
- Osadchy et al. (2018): Emphasized financial statements as decision-making tools.
- Tracy (2012): Catalogued 17 financial ratios, supporting indicator selection.
- Palepu et al. (2020): Proposed a strategic-financial-accounting integration approach.

Analytic Hierarchy Process (AHP)

- Purpose: Systematic weighting of criteria using pairwise comparisons (Vaidya & Kumar, 2006).
- Formula (Saaty, 1980):

$$w = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

Where:

w: Weight vector for criteria.

a_{ij}: Pairwise comparison matrix values.

n: Number of criteria.

Literature Contribution to This Study

- Saaty (1985): Laid the theoretical foundation for eigenvalue-based weighting.
- Franek & Kresta (2014): Improved judgment scale accuracy and consistency.
- Wang & Elhag (2006): Tackled rank reversal for stable metric rankings.
- Kułakowski (2015): Emphasized order preservation and matrix consistency.
- Vaidya & Kumar (2006): Validated AHP's relevance in financial decision-making.

Data Envelopment Analysis (DEA)

- Purpose: Evaluates the efficiency of entities by comparing their input-output ratios (Banker et al., 1989; Halkos & Salamouris, 2004).
- CCR Model (Charnes, Cooper, & Rhodes, 1978):

$$max\left(\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}\right)$$

Subject to:

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \forall k.$$

Where:

u_r: Weight for outputs.

v_i: Weight for inputs.

y_{rj}: Output r for DMU j.

x_{ij}: Input i for DMU j.

Literature Contribution to This Study

- Charnes et al. (1978): Pioneered the CCR model forming the foundation of DEA-based performance analysis.
- Banker et al. (1984): Introduced BCC model (VRS), which this study uses to accommodate scale variability across firms.
- Halkos & Salamouris (2004): Used DEA with financial ratios to assess bank performance—relevant to this study's banking focus.
- Nikoomaram et al. (2010): Applied DEA to corporate financial statements, confirming its applicability to standard financial ratios.
- Ismail (2013): Modeled stock selection using DEA in the Malaysian context, validating DEA's use in Bursa Malaysia analysis.

Ranking Using Cross-Efficiency DEA

- advanced extension of the classical DEA model introduced by Sexton, Silkman, and Hogan (1986)
- cross-efficiency incorporates peer evaluations, where each DMU is also assessed using the optimal weights derived by all other DMUs.

$$E_{jk} = \frac{\sum_{r=1}^{s} u_r^{(j)} y_{rk}}{\sum_{i=1}^{m} v_i^{(j)} x_{ik}}$$

$u_r^{(j)}, v_i^{(j)}$: Optimal output and input weights for DMU j

y_{rk}, x_{ik}: Output r and input i of DMU k

Literature Contribution to This Study

- Sexton et al. (1986) introduced the concept of cross-efficiency to enhance the discriminatory power of DEA, laying the theoretical foundation for this study’s ranking approach.
- Lim et al. (2014) applied cross-efficiency DEA in the Korean stock market to rank stocks based on financial ratios.

Integration of AHP and DEA

- AHP: Derives weights for DEA inputs/outputs (Rezaei, 2015).
- DEA: Improves robustness and accuracy in efficiency scoring (Tavana et al., 2023).

$$\omega_{il} \leq v_i \leq \omega_{iu}$$

$$\omega_{rl} \leq u_r \leq \omega_{ru}$$

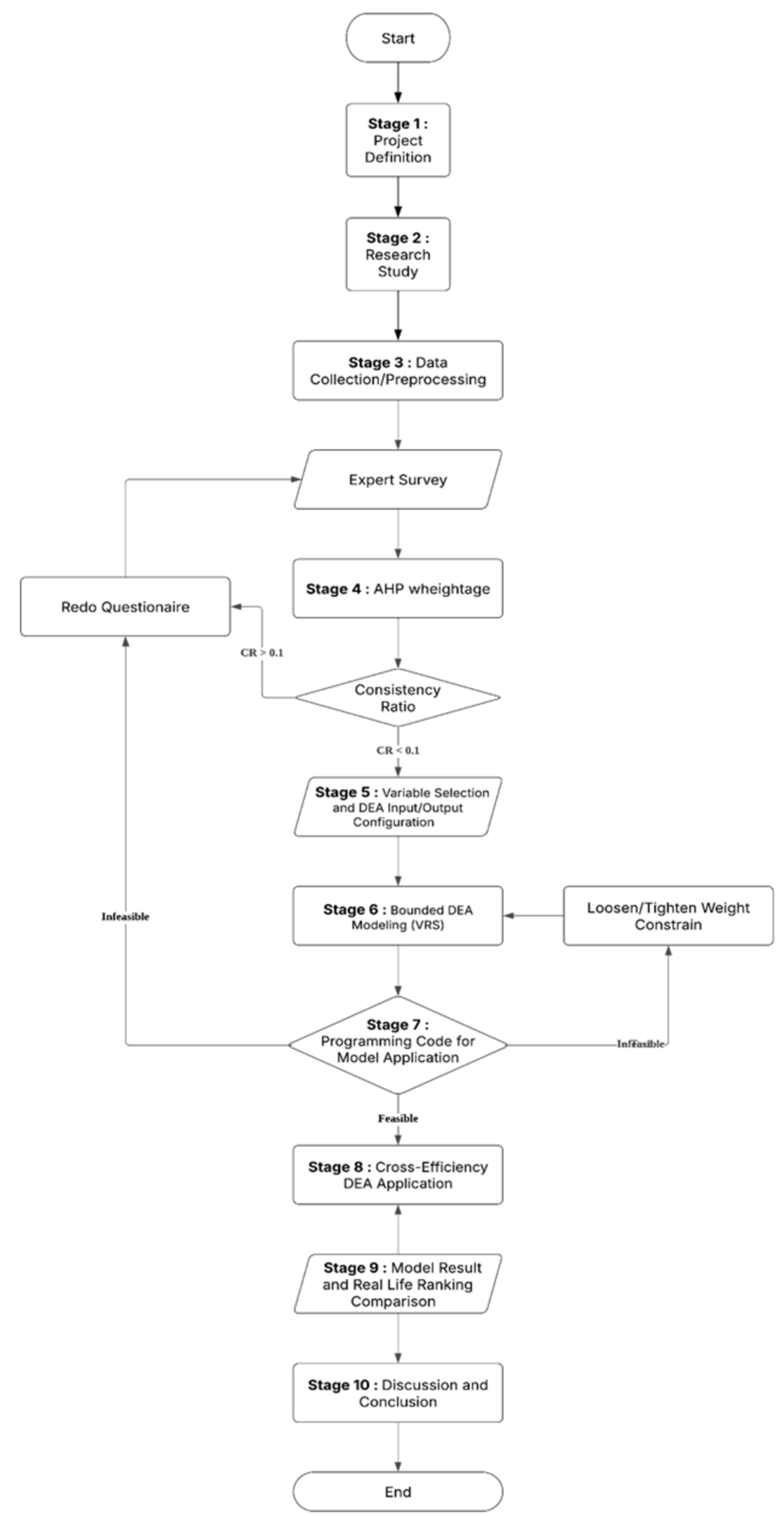
v_i and u_r = weights assigned to inputs and outputs, respectively.

ω_{il}, ω_{iu}, ω_{rl}, and ω_{ru} = upper and lower bound for v_i and u_r, respectively

Literature Contribution to This Study

- Tavana et al. (2023): Categorized AHP–DEA integration techniques, supporting the use of bounded weights.
- Jyoti et al. (2008): Demonstrated the benefit of AHP-informed DEA in evaluating national performance metrics—methodologically similar to firm financial evaluation.
- Zhu et al. (2024): Validated the hybrid's robustness by combining entropy, AHP, and cross-efficiency DEA.
- Abdel-Halim et al. (2023): Applied AHP–DEA in telecom efficiency; supports dynamic, industry-specific applications.
- Kasemi (2022): Used AHP–DEA in food sector finance, validating its financial application.
- Hong and Qu (2024): Used the model for risk-based evaluation in finance—aligned with this study's valuation context.
- Yang (2022): Focused on AHP-optimized DEA in process reengineering; supports structured judgment-to-ranking transformation.
- De Vicente Oliva & Romero-Ania (2022): Reinforced credibility of AHP constraints in DEA for operational analysis.
- Premachandra (2001); Wang et al. (2008): Early empirical/ theoretical validation of hybrid weight control in DEA

Research Flowchart



6 METHODOLOGY

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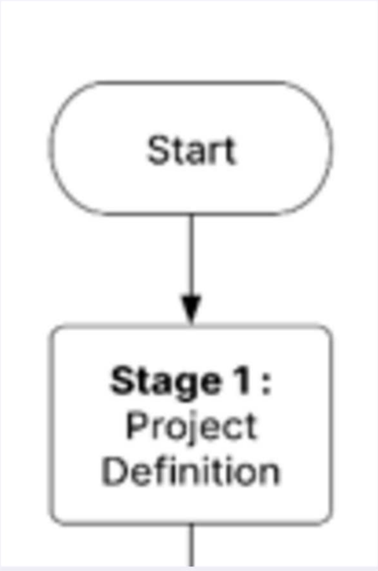
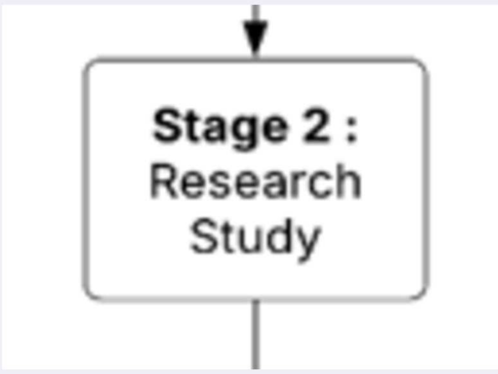


Stage 1: Project Definition

- Defined research objective and problem scope.
- Target: Evaluate financial efficiency using MCDM tools.
- Identified companies (DMUs) and study period (2019–2024).

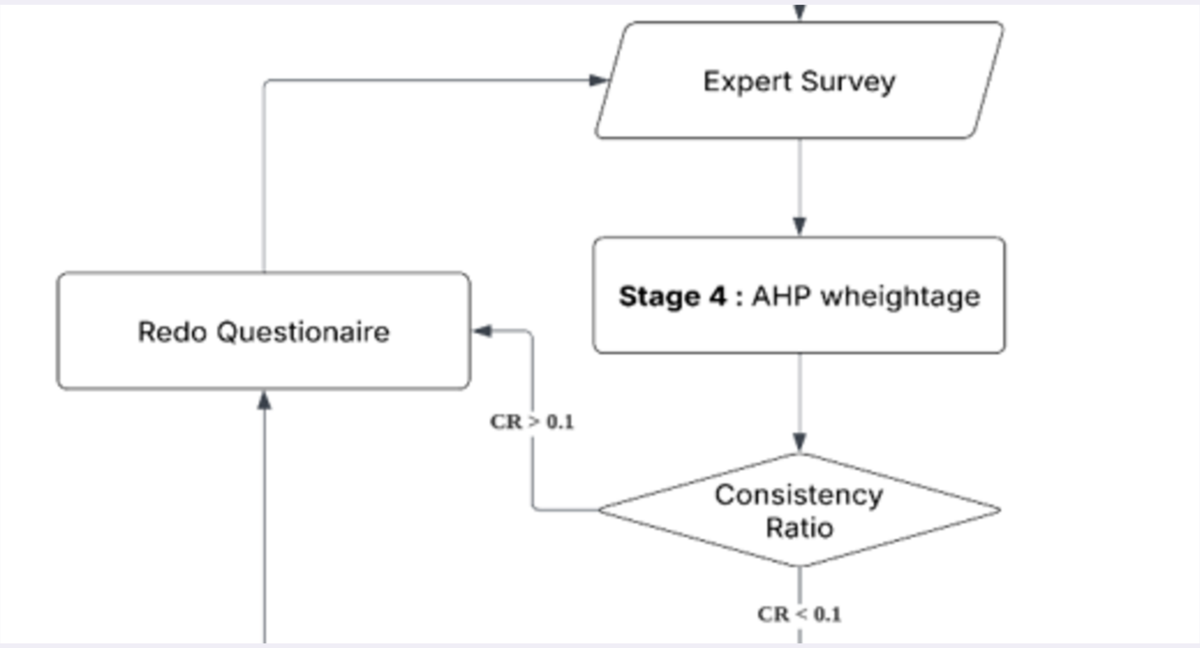


Stage 2: Research Study

- Reviewed AHP, DEA, cross-efficiency, and financial performance evaluation studies.
- Identified key financial ratios and MCDM practices.
- Supported framework development and criteria selection.

Stage 3: Data Collection & Preprocessing

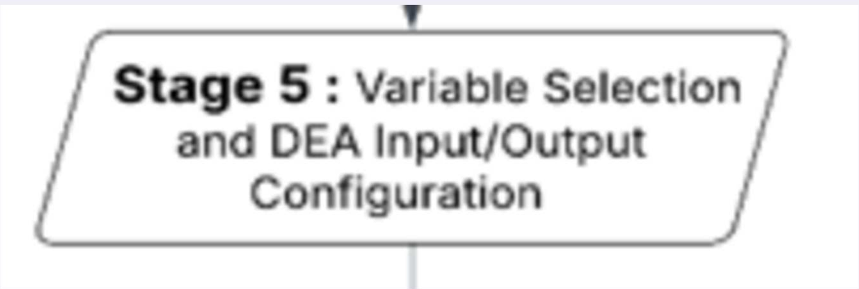
- Secondary data: Company financial statements (ROE, P/E, etc.).
- Primary data: Expert pairwise comparisons via AHP questionnaires.
- Preprocessing: Normalization, rounding, transformation into AHP matrices.



Stage 4: AHP Weight Derivation

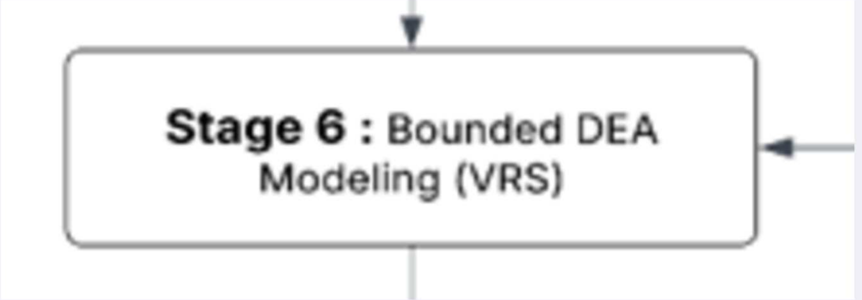
- Constructed pairwise comparison matrices.
- Calculated weights using principal eigenvector.
- Checked consistency (CR $\leqslant$ 0.1); repeated if CR > 0.1.
- Result: Priority weights for each criterion/subcriterion.

METHODOLOGY



Stage 5: Variable Selection for DEA

- Selected top 5 subcriteria based on AHP weights.
- Mapped variables as inputs or outputs for DEA.
- Ensured alignment with expert judgment and financial logic.

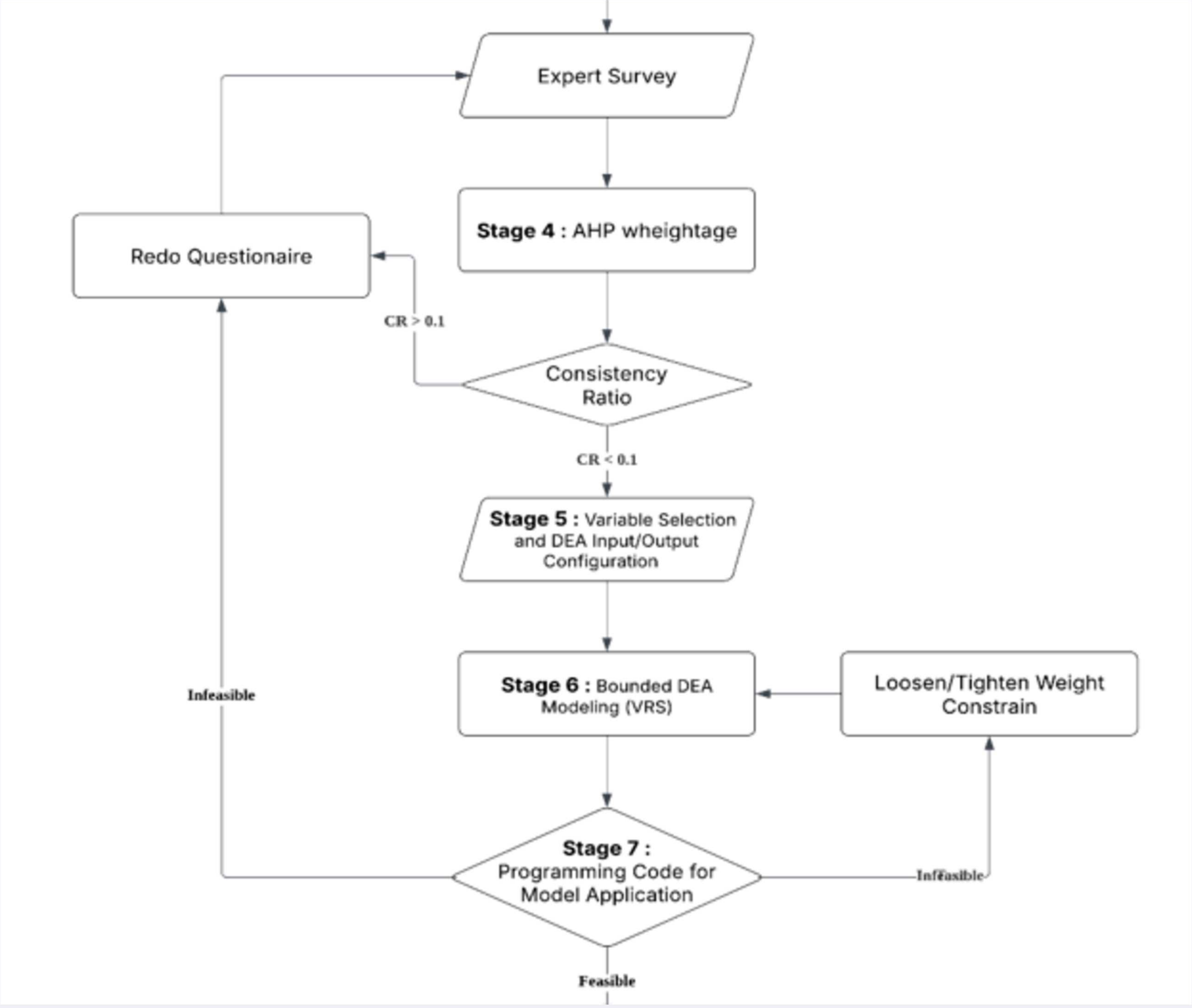


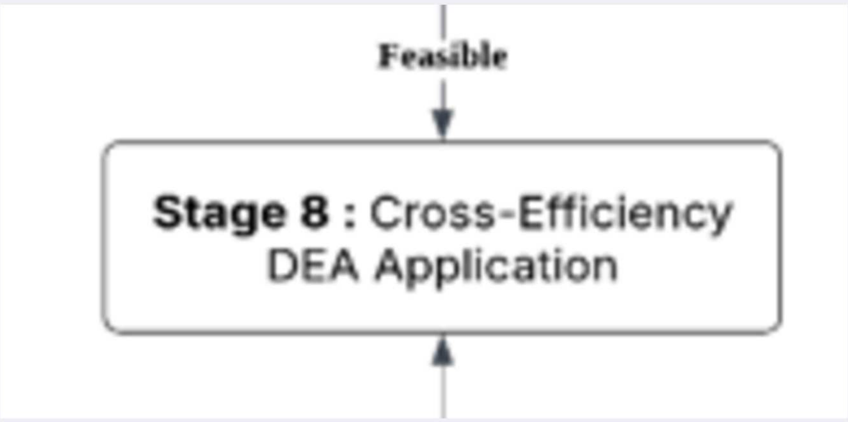
Stage 6: Bounded DEA (VRS) Modeling

- Applied DEA with Variable Returns to Scale (VRS).
- Incorporated AHP weights as upper/lower bounds on multipliers.
- Modeled using R for flexibility and precision.

Stage 7: DEA Execution

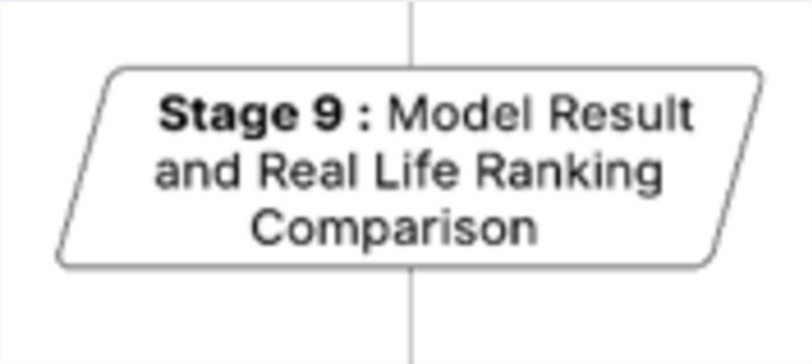
- Ran the bounded DEA model code annually (2019–2024).
- Calculated efficiency scores and multiplier weights.
- Enabled year-over-year performance tracking.





Stage 8: Cross-Efficiency DEA

- Added peer evaluation to enhance discrimination.
- Calculated cross-efficiency matrix (self + peer weights).
- Averaged scores → generated objective rankings.

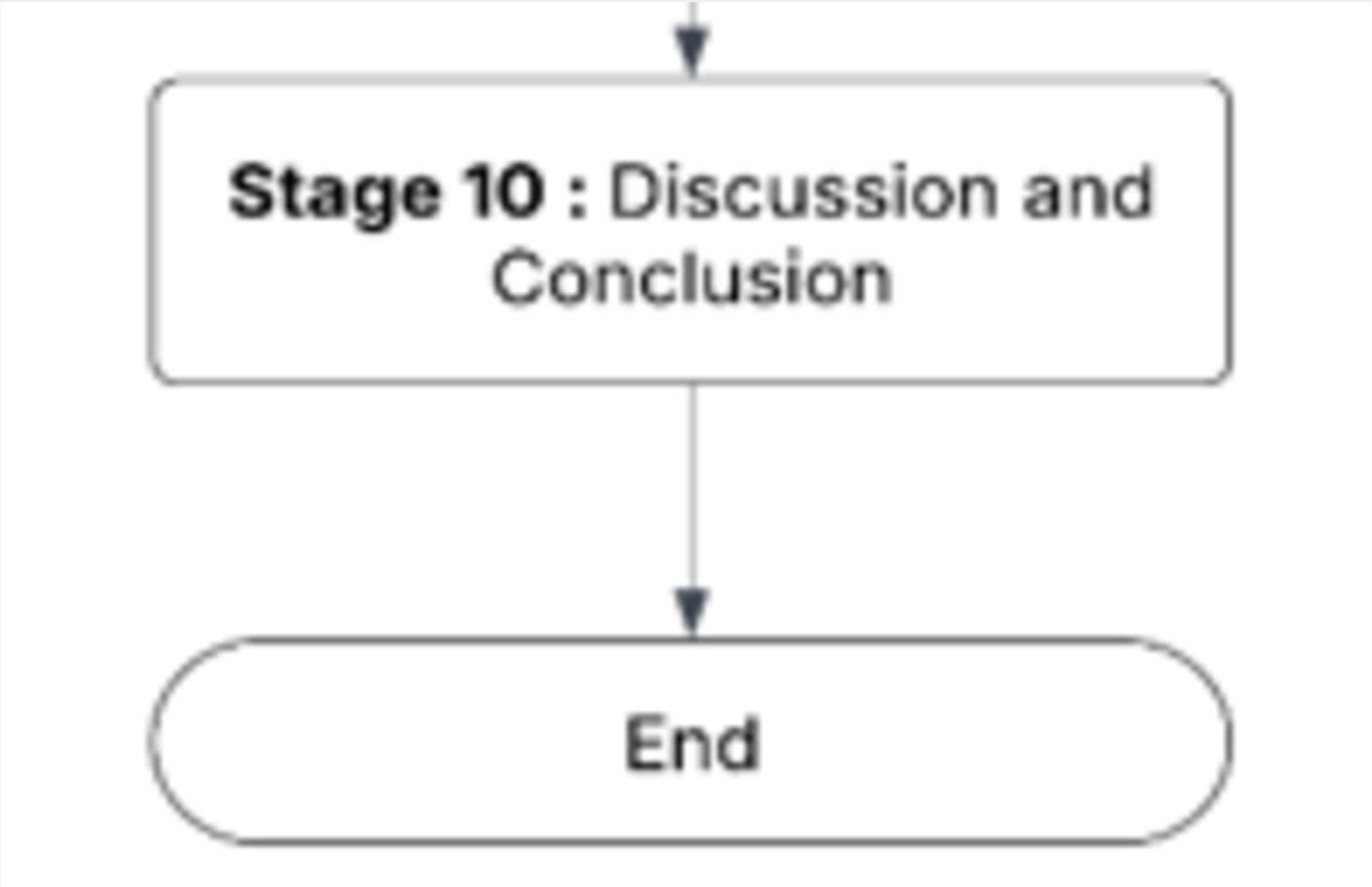


Stage 9: External Validation

- Compared DEA rankings with stock price growth.
- Computed Spearman's Rank Correlation annually.
- Validated predictive accuracy of the AHP–DEA model.

Stage 10: Discussion & Conclusion

- Interpreted results against research objectives.
- Highlighted strengths of hybrid MCDM model.
- Recommended model for analysts, investors, future research.



AHP Survey Design

Question Format

Left-to-right comparative format:

- 1 = LHS is extremely more important
- 5 = Equal importance
- 9 = RHS is extremely more important

C1 Valuation Ratios: *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
P/E	◯	◯	◯	◯	◯	◯	◯	◯	◯	P/B Ratio

Conversion Table

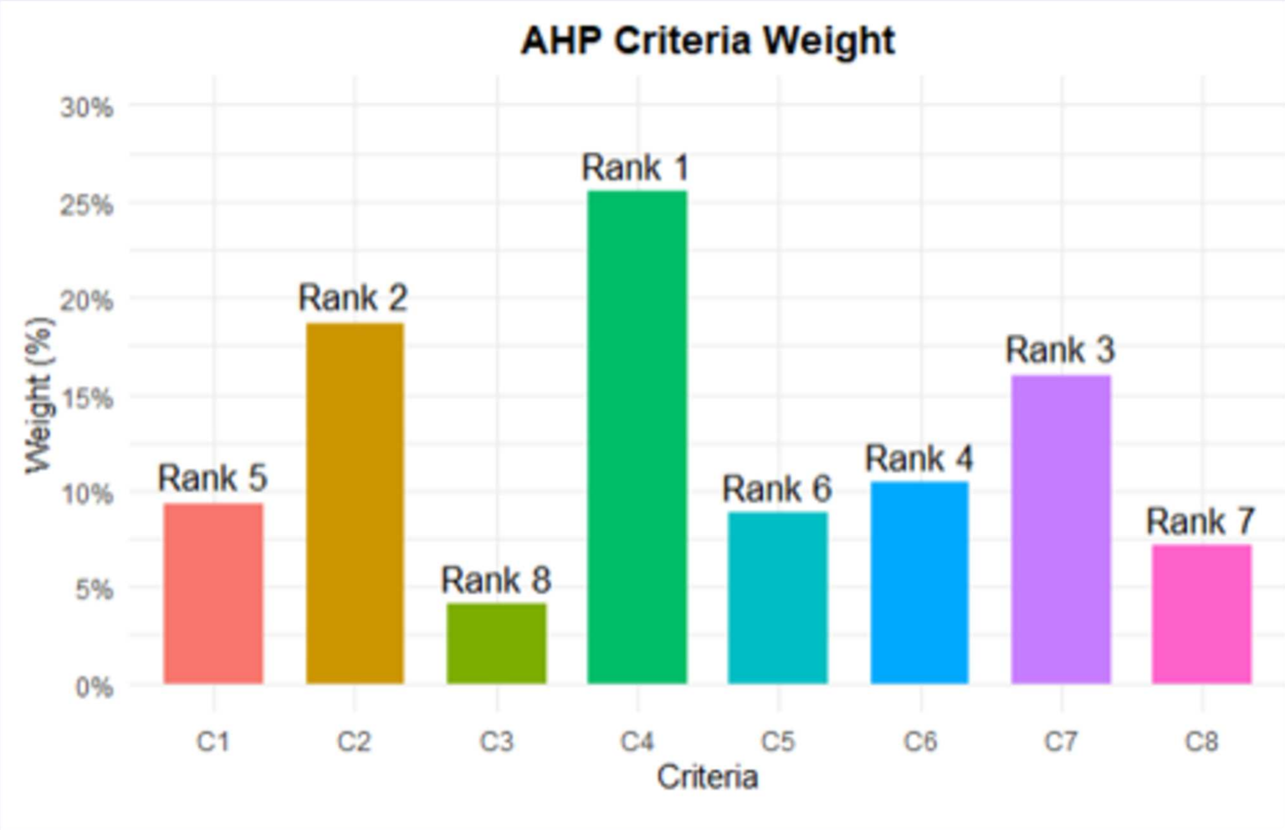
SURVEY SCORE	AHP MATRIX VALUE
1	9
1.5	8
2	7
2.5	6
3	5
3.5	4
4	3
4.5	2
5	1
5.5	1/2
6	1/3
6.5	1/4
7	1/5
7.5	1/6
8	1/7
8.5	1/8
9	1/9

AHP Survey Design

Pairwise Matrix Construction & Weight Derivation

Pairwise Comparison Matrix with Converted Value

	C1	C2	C3	C4	C5	C6	C7	C8
C1	1	1/2	3	1/3	1/2	1	1/2	2
C2	2	1	4	1/2	4	2	1	3
C3	1/3	1/4	1	1/4	1/3	1/3	1/3	1/2
C4	3	2	4	1	4	2	2	3
C5	2	1/4	3	1/4	1	1	1/3	1
C6	1	1/2	3	1/2	1	1	1	1
C7	2	1	3	1/2	3	1	1	3
C8	1/2	1/3	2	1/3	1	1	1/3	1



AHP Criteria weight

CRITERIA	WEIGHT
C1	0.093409
C2	0.186926
C3	0.04083
C4	0.255195
C5	0.088162
C6	0.104299
C7	0.159672
C8	0.071509

AHP Survey Design

Consistency Check

Used CI and CR formulas:

- $\lambda_{max} = 8.963279$
- $CI = (\lambda_{max} - n) / (n - 1) = 0.109$
- $RI\ (n=8) = 1.41$
- $CR = 0.097$
- $CR < 0.10$ → Acceptably consisten

Variable Selection

Subcriteria Weight Determination (AHP)

CRITERIA	SUBCRITERIA	WEIGHT
C1 Valuation Ratios	P/E Ratio	0.49047619
	P/B Ratio	0.19761905
	EV/EBITDA	0.31190476
C2 Profitability Ratios	Net Profit Margin	0.2972583
	Return on Asset (ROA)	0.16378066
	Return on Equity (ROE)	0.53896104
C5 Operational Efficiency	Gross Margin	0.33333333
	Operating Margin	0.66666667
C6 Debt Metrics	Debt-to-Equity (D/E) Ratio	0.75
	Interest Coverage Ratio	0.25
C7 Revenue and Earnings Growth	Revenue Growth Rate	0.66666667
	Earnings Per Share (EPS) Growth	0.33333333
C8 Dividend Metrics	Dividend Yield	0.5
	Dividend Payout Ratio	0.5

Variable Selection

Top 5 Criteria Based on AHP

1. Cash Flow (C4)
2. Profitability (C2)
3. Revenue & Earnings Growth (C7)
4. Debt Metrics (C6)
5. Valuation Ratios (C1)

Highest Weight Variable with New AHP Weight

CRITERIA	SUBCRITERIA	WEIGHT
C1	P/E Ratio	0.112505
C2	Return on Equity (ROE)	0.213245
C4	Free Cash Flow (FCF)	0.347125
C6	Debt-to-Equity (D/E) Ratio	0.142451
C7	Revenue Growth Rate	0.184674

Variable Selection

Consistency Check

Used CI and CR formulas:

- $\lambda\_max = 5.3633$
- $n = 5$
- CI = 0.0908
- RI = 1.12
- CR = 0.0811 $<$ 0.1

DEA Linear Programming

Model Formulation

$$\max_{\theta,u_r,v} \sum_{r=1}^{s} u_r y_{ro} + \mu$$

$$s.t. \sum_{i=1}^{m} v_i x_{io} = 1,$$

$$\sum_{i=1}^{m} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + \mu \leq 0,$$

$$\omega_{il} \leq v_i \leq \omega_{iu}$$

$$\omega_{rl} \leq u_r \leq \omega_{ru}$$

DEA Model Variable Configuration

ROLE	VARIABLE	LABEL	AHP WEIGHT
Input	PE	x_1	0.112505
Output	ROE	y_1	0.213245
Output	FCF	y_2	0.347125
Input	DE	x_2	0.142451
Output	RG	y_3	0.184674

DEA Linear Programming

Example of 2019

$$\max_{\theta,u,v} \sum_{r=1}^{s} u_r y_{ro} + \mu$$

$$s.t. \sum_{i=1}^{m} v_i x_{io} = 1,$$

$$\sum_{i=1}^{m} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + \mu \leq 0,$$

$$\omega_{il} \leq v_i \leq \omega_{iu}$$

$$\omega_{rl} \leq u_r \leq \omega_{ru}$$

	DMU	PE	ROE	FCF	DE	RG
RHB BANK BERHAD	DMU 1	0.146417934	0.193889098	0.194210819	0.244080146	0.196673869
HONG LEONG BANK BHD	DMU 2	0.229189528	0.20350811	0.192305077	0.091074681	0.196619708
CIMB GROUP HOLDINGS BERHAD	DMU 3	0.171813764	0.159751037	0.202529507	0.276867031	0.201844729
PUBLIC BANK BHD	DMU 4	0.26822386	0.245756318	0.202930177	0.118397086	0.194361619
MALAYAN BANKING BHD	DMU 5	0.184354915	0.197095436	0.208024419	0.269581056	0.210500075

2019 Upper and Lower Bound Tightening

VARIABLE	VARIABLE WEIGHT LOWER BOUND	VARIABLE WEIGHT UPPER BOUND
P/E Ratio	0.05625244	0.29251269
Debt-to-Equity (D/E) Ratio	0.071225702	0.370373652
Return on Equity (ROE)	0.106622528	0.554437145
Free Cash Flow (FCF)	0.173562516	0.902525083
Revenue Growth Rate	0.092336814	0.48015143
Multiplier	0.5	2.6

DEA Linear Programming

Result of 2019

$$\max_{\theta,u_r,v} \sum_{r=1}^{s} u_r y_{ro} + \mu$$

$$s.t. \sum_{i=1}^{m} v_i x_{io} = 1,$$

$$\sum_{i=1}^{m} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + \mu \le 0,$$

$$\omega_{il} \le v_i \le \omega_{iu}$$

$$\omega_{rl} \le u_r \le \omega_{ru}$$

Description: df [5 × 8]

DMU <int>	Efficiency <dbl>	mu <dbl>	v1 <dbl>	v2 <dbl>	u1 <dbl>	u2 <dbl>	u3 <dbl>
1	0.8783	0	0.2925	0.2342	0.1066	0.2523	0.0923
2	1.0000	0	0.2891	0.3704	0.2382	0.1736	0.0923
3	0.8154	0	0.2925	0.1797	0.1066	0.2265	0.0923
4	0.9191	0	0.2925	0.1819	0.1576	0.1736	0.0923
5	0.8670	0	0.2925	0.1709	0.1066	0.2223	0.0923

5 rows

Cross-Efficiency DEA Ranking

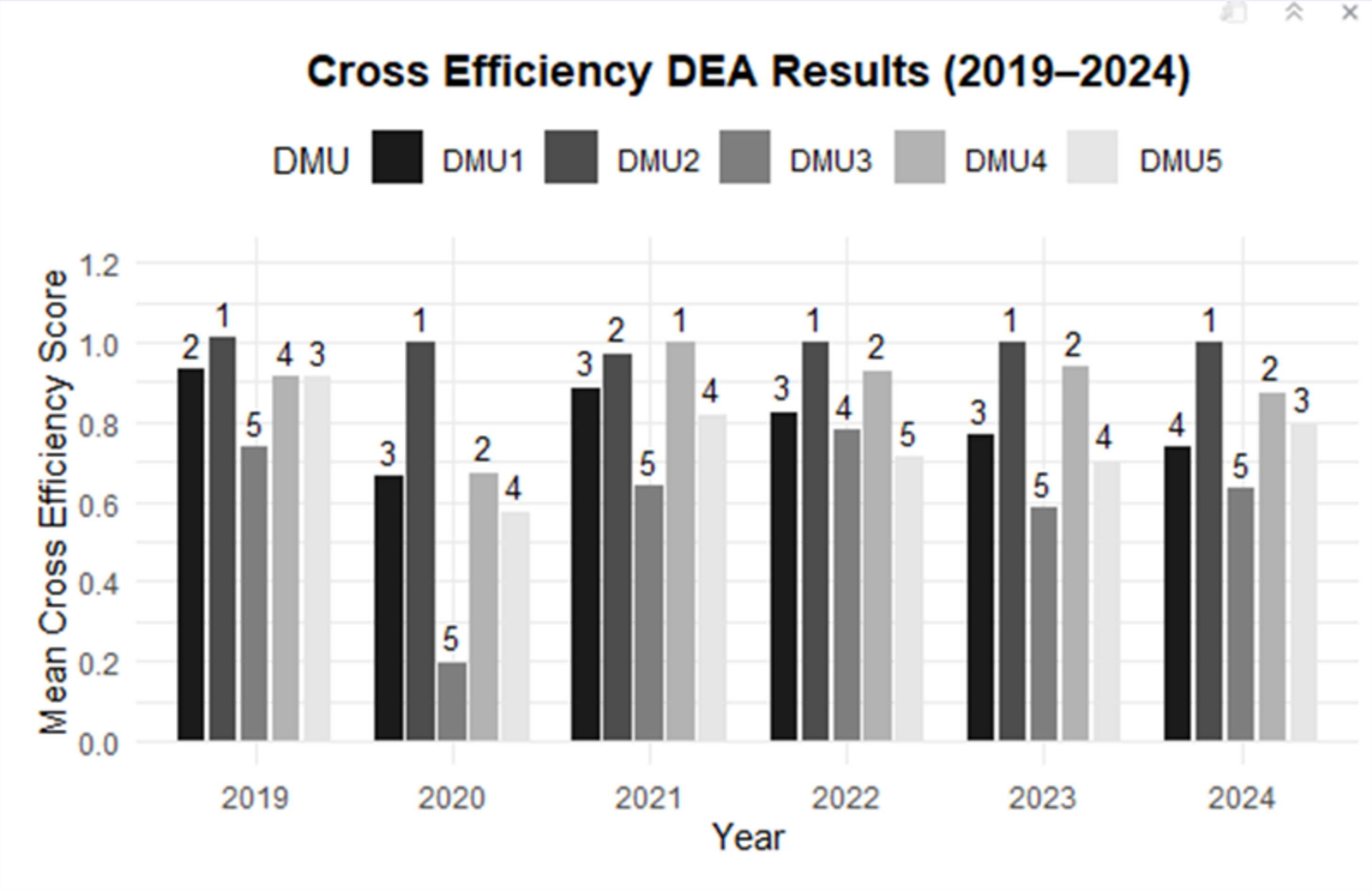
CE-DEA Formula

$$E_{jk} = \frac{\sum_{r=1}^{s} u_r^{(j)} y_{rk}}{\sum_{i=1}^{m} v_i^{(j)} x_{ik}}$$

$$CE_k = \frac{1}{n} \sum_{j=1}^{n} E_{jk}$$

$u_r^{(j)}, v_i^{(j)}$: Optimal output and input weights for DMU j

y_{rk}, x_{ik}: Output r and input i of DMU k



DEA Results (2019-2024)

Financial Efficiency Ranking Across Year

	2019	2020	2021	2022	2023	2024
DMU1	3	3	3	3	3	4
DMU2	1	1	2	1	1	1
DMU3	5	5	5	4	5	5
DMU4	2	2	1	2	2	2
DMU5	4	4	4	5	4	3

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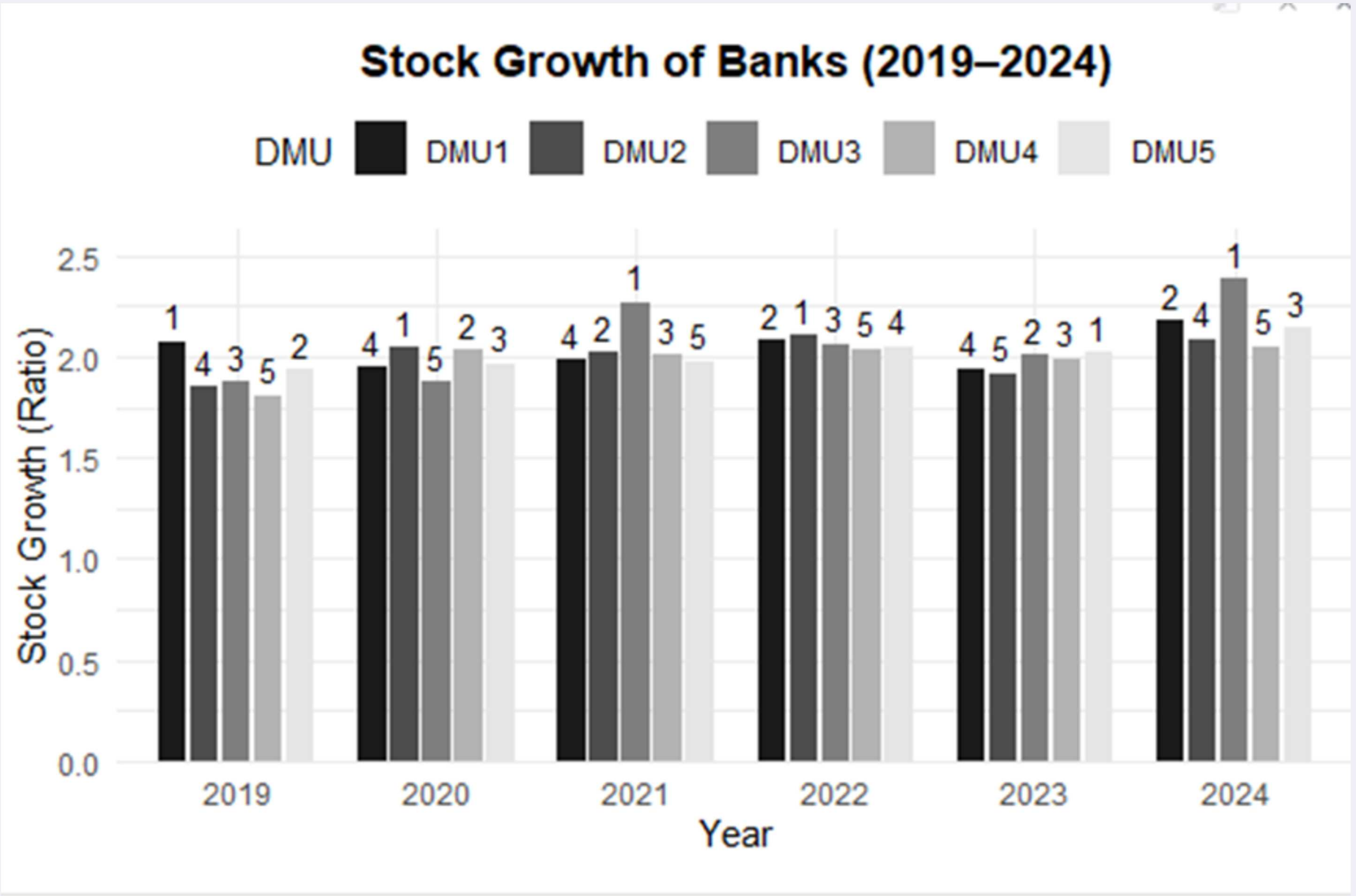
Stock Growth ranking (2019-2024)

YEAR	RHB BANK BERHAD (DMU1)	HONG LEONG BANK BHD (DMU2)	CIMB GROUP HOLDINGS BERHAD (DMU3)	PUBLIC BANK BHD (DMU4)	MALAYAN BANKING BHD (DMU5)
2019	2.076779026	1.850877193	1.877224199	1.807692308	1.935828877
2020	1.947826087	2.042382589	1.872210953	2.032581454	1.966857143
2021	1.985321101	2.023076923	2.26744186	2.009708738	1.98108747
2022	2.078212291	2.104189044	2.064220183	2.038461538	2.048192771
2023	1.941278066	1.9192607	2.00862069	1.993055556	2.02183908
2024	2.179816514	2.084656085	2.386324786	2.048951049	2.140607424



Stock Growth vs DEA

YEAR	SPEARMAN' S RANK CORRELATION, ρ
2019	-0.50 Moderate inverse correlation
2020	0.90 Strong positive correlation
2021	-0.10 Very weak inverse correlation
2022	0.40 Weak positive correlation
2023	-0.80 Strong inverse correlation
2024	-0.90 Very strong inverse correlation

CONCLUSION

This study successfully demonstrated the effectiveness of integrating Analytic Hierarchy Process (AHP) with Data Envelopment Analysis (DEA) to evaluate corporate financial performance. By combining expert-derived weights with empirical data through a bounded DEA-VRS model, the research provided a more informed and robust efficiency assessment. Over six years of analysis across five firms, the model consistently identified high- and low-performing companies, offering clear benchmarking insights. Although efficiency rankings aligned with actual stock returns in some years, the inconsistency in other periods highlighted the influence of non-fundamental market forces. Overall, the AHP-DEA model offers a balanced, rigorous framework for capturing both intrinsic financial health and strategic decision-making value.

RECOMMENDATIONS

It is recommended that investors, financial analysts, and corporate decision-makers adopt the AHP-DEA model as a supplementary tool for evaluating company performance beyond traditional metrics. The model's ability to reconcile expert insights with quantitative rigor makes it particularly useful for identifying performance gaps and guiding strategic improvements. Financial institutions may apply it in credit assessments or investment screenings, while researchers can enhance its reliability by refining survey consistency and expanding input-output variables. Broader application across sectors, along with the inclusion of ESG or qualitative metrics, is encouraged to increase the model's relevance in today's complex financial landscape.

Abdel-Halim, A., Al Khars, M., & Alnasser, A. (2023). Evaluating the technical efficiency of Saudi Arabian telecommunications companies using window DEA and AHP techniques. *International Journal of Islamic and Middle Eastern Finance and Management*, *16*(6), 1306-1325.

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Thank You