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Corporate Governance and Stage-Wise Banking Efficiency: Evidence from a Multi-Layer Two-Stage Network DEA Framework

[1]Khadim Hussain", [2]Prof. Dr. Muhammad Abbas

Khadim Hussain*
PhD Scholar (Finance) Department of Business Administration, Air University, Multan Campus
sskhadimhussain@gmail.com
Prof. Dr. Muhammad Abbas
Chairman Department of Business Administration, Air University Multan Campus
mam@aumc.edu.pk

Abstract

This paper revisits the issue of the relationship between corporate governance and banking efficiency by suggesting a stage-wise framework that separates operational performance and market performance. Most previous studies have mainly focused on efficiency as one of the outcomes, which ignores the mechanisms through which governance influences value creation. The analysis results were obtained after a two-step Network Data Envelopment Analysis (NDEA), Tobit regression, and a multi-layer governance model (individual variables, dimensions, and composite index) were used on panel data of commercial banks, which yielded a dual and asymmetric effect. Governance systems, especially those with a high level of monitoring, lower operational efficiency (Stage-1), as an indicator of coordination costs and managerial rigidity. On the other hand, there is the governance which increases the efficiency in the market/value (Stage-2) through increased transparency and investor confidence. Notably, there is a negative transmission effect, which suggests that market performance is not based on operational efficiency. The findings, in turn, contradict the belief of consistently positive governance effects and a trade-off between monitoring and value creation.

Keywords: Corporate governance Index; Network Data Envelopment Analysis (NDEA); Two-stage efficiency; Tobit; Pakistan banking sector; Efficiency transmission.

Introduction

The efficiency of banking is a decisive factor of financial stability and economic growth, as the banking sector is at the heart of financial intermediation and the distribution of resources. Efficient banks not only improve profitability and competitiveness but also resilience and sustainable development of the system. This has led to much scholarly interest in measurement and determinants of bank efficiency. Data Envelopment Analysis (DEA) has become a popular non-parametric method among other approaches since it is flexible and avoids a definite form of functional form (Berger & Humphrey, 1997;Cooper et al., 2007). In empirical uses, there is always a high heterogeneity of banking efficiency with the institutional and regulatory regime (Fethi & Pasiouras, 2010).

In this respect, corporate governance has been identified as a major tool to enhance the performance of firms and to reduce agency conflicts. Governance structures that are based on agency theory seek to harmonize the interests of managers and shareholders by monitoring and controlling (Jensen & Meckling, 1976 ; Fama & Jensen, 1983) . Governance is especially relevant in the banking system, where most of the agency problems are exacerbated by a lack of transparency, complicated regulatory frameworks, and a variety of stakeholders (Levine, 2004; Adams, 2012). Recent data across some of the emerging markets, such as Pakistan, points to the extent of governance characteristics, like board independence, audit effectiveness, and diversity in defining the performance of banks, risk management, and transparency (Athar et al., 2023; Gulzar et al., 2024; Farooq et al., 2024).

The relationship between governance and efficiency is inconclusive despite its stronger theoretical basis and the increased interest in empirical studies. Some of the studies also indicate that stronger governance results in positive efficiency (Fethi & Pasiouras, 2010; Khan & Mirza, 2019), when other studies indicate that it has negative or statistically insignificant effects, especially on board structure and ownership characteristics (De Andres & Vallelado, 2008; Pathan & Faff, 2013). According to meta-analytic data, these discrepancies are extremely context-dependent on institutional context, measurement decisions, and model specifications (Fethi & Pasiouras, 2010; Lagasio, 2018).

One of the main reasons these mixed results are due to methodological limitations. The majority of the available literature is based on single-stage DEA or stochastic frontiers models, which assume that banks are black boxes (implicitly a direct conversion of inputs into outputs). The process of banking is, however, multi-stage in nature: labor, capital, and deposits are initially converted into intermediate financial products (e.g., revenue, profit), which are then converted into market-based products (e.g., shareholder value). By reducing these processes into one efficiency metric, traditional models blur the processes by which governance affects various steps of the value creation process (Kao, 2014; Tone & Tsutsui, 2009).

Simultaneously, corporate governance measurement is still disjointed (Riipa, et al., 2026; Hossain, et al., 2025). The majority of the literature is based on personalized variables of governance, and many yield inconsistent and context-specific findings. Despite the fact that composite measures of governance are more representative of the quality of governance, little has been done to integrate them into efficiency analysis, especially when multi-stage frameworks are involved (Brown & Caylor, 2006 ; Larcker et al., 2007) . In addition, the econometric issues like limited efficiency scores and lack of endogeneity between governance and performance are often under-considered, which questions the strength of current results (Simar & Wilson, 2008).

Combined, these constraints suggest a critical void: a lack of an effort to approach banking efficiency in multi-stages and corporate governance in multi-dimensional terms, especially in emerging economies where the structures of institutions are significantly different from those in developed markets.

The present study fills this gap by establishing a multi-dimensional Corporate Governance (CG) index and integrating it into a two-stage Network Data Envelopment Analysis (NDEA) framework. The approach divides the overall bank efficiency into (i) operational/profitability efficiency, which measures the ability to convert inputs into intermediate financial outputs, and (ii) value created/market efficiency, which measures the ability to convert these outputs into shareholder value. The NDEA framework is a more realistic model of the banking production process, with explicit modeling of intermediate variables like revenue and profit, and allows the identification of stage-specific effects of governance (Kao, 2014; Tone & Tsutsui, 2009).

Contribution of the Study

This research paper contributes to the body of knowledge in corporate governance and banking effectiveness in a number of ways.

First, it enhances efficiency measurement, using a two-stage Network Data Envelopment Analysis (NDEA) structure, which explicitly characterizes the internal structure of banking. The study advances beyond the traditional DEA model black box assumption by breaking down overall efficiency into both operational and market-based efficiencies and offers a realistic picture of the banking production process.

Second, the research has an impact on the body of literature on corporate governance by creating a multi-dimensional and integrative Corporate Governance (CG) index that incorporates board structure, diversity, audit committee effectiveness, and risk governance. This method, as compared to previous ones, which depend on single governance variables, can capture the overall quality of institutional governance and avoid measurement dispersion.

Third, and most significantly, the research offers new findings regarding the effect of corporate governance on banking efficiency differently in both stages. The results show that the mechanisms of governance have varying effects at different stages, as it has a negative influence on the efficiency of its operations but a positive impact on the performance in the market. This is a crucial trade-off between trade monitoring intensity and operational flexibility, which has been greatly ignored in previous studies.

Fourth, the research recognizes the occurrence of a strong negative transmission implication between operational and market efficiency, indicating that the increase in efficiency at the initial stages does not necessarily translate to an increase in value creation. This observation questions the implicit efficiency continuity assumption in the literature and presents the idea of efficiency trade-offs at the various levels of the banking value chain.

Another contribution of this research is its hierarchical modelling approach of corporate governance. This study is systematic in exploring the impact of governance on three levels of aggregation: composite governance index (macro-level), dimensions of governance (meso-level), and individual variables (micro-level), unlike previous studies, which have determined effects of governance only based on either individual variables (micro-level) or aggregate variables (macro-level). Using this multi-layer strategy enables a better insight into the functioning of the governance mechanisms on various levels and offers strong resilience by comparing the outcomes of alternative model specifications (Khan, Hussain & Ahmad, 2023). Notably, the results indicate that the effects of governance are sensitive to the degree of aggregation, and therefore, model specification is crucial in the studies of governance and performance.

Lastly, through the Pakistani banking industry, the research will present context-specific evidence on an emerging economy, whereby the governance frameworks, regulatory regimes, and institutional settings vary dramatically from those of developed economies. This makes the findings more relevant externally, as well as adding to the body of literature on governance and performance in emerging financial systems.

Literature Review

Banking Methodological Foundations and Efficiency

Frontier approaches, especially Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA), have been widely used to measure the efficiency of banks. DEA is particularly salient because of its adaptability to deal with several inputs and outputs without any parametric assumptions (Berger & Humphrey, 1997Cooper et al., 2007). There is always empirical evidence that shows great cross-country banking efficiency variance, which is attributed to the variation in the institutional and regulatory environment (Fethi & Pasiouras, 2010).

Despite these developments, there is a major weakness: the majority of studies assume that banks are black boxes and provide a direct conversion of inputs to outputs. This method does not recognize the sequencing characteristic of banking business, where the input is initially transformed into the intermediate financial performance (e.g., revenue, profit) and then into the market-based performance (Kao, 2014b; Tone & Tsutsui, 2009b). This simplification is especially problematic when it comes to governance research, as the internal processes of decision-making are at the core of the research.

Bank Performance and Corporate Governance

The agency theory is the main approach in corporate governance, which assumes that the conflicts between the managers and shareholders are reduced, and the resource allocation is enhanced by the mechanisms of governance (Jensen & Meckling, 1976; Fama & Jensen, 1983). The role of governance is more essential in banking as it is characterized by some levels of opacity, complexity in the regulations, and exposure to systemic risks (Levine, 2004; Adams, 2012).

Empirical evidence on the nexus between governance and efficiency is inconclusive. Whereas a positive correlation between governance quality and efficiency is reported in some studies (Fethi & Pasiouras, 2010; Khan & Mirza, 2019)The effects are negative or insignificant when it comes to board structure and ownership variables (De Andres & Vallelado, 2008; Pathan & Faff, 2013). The meta-analytic evidence explains these discrepancies as differences in the institutional setting, the measure of governance, and econometric specifications (Lagasio, 2018).

The relevance of the governance systems, including the independence of boards of directors, the effectiveness of auditors, and the diversity, is further supported by evidence in emerging markets, including Pakistan, to influence the performance of banks and their risk management (Athar et al., 2023; Gulzar et al., 2024; Farooq et al., 2024). But, there is a mixed nature of findings, indicating that the effects of governance may be situation-specific and even non-linear.

Limitations in methodology and measurement

The biggest weakness of the existing literature is the use of single-stage efficiency models that consolidate all the banking operations into one measure and mask the effects of governance by stages. Despite two-stage DEA-regression methods trying to relate efficiency ratings to governance factors, they have issues with econometricity, such as limited dependent variables and possible endogeneity (Simar & Wilson, 2008). More to the point, these still do not capture the inner production of banking.

A second constraint is related to the measurement of governance. A lot of literature is based on the variables of individual governance, which produces scattered and rather unrelated results. Composite indices of corporate governance, in turn, are more comprehensive scores of the quality of governance (Brown & Caylor, 2006; Larcker et al., 2007), but their use in the efficiency analysis, especially in the multi-stage frameworks, is not so prevalent.

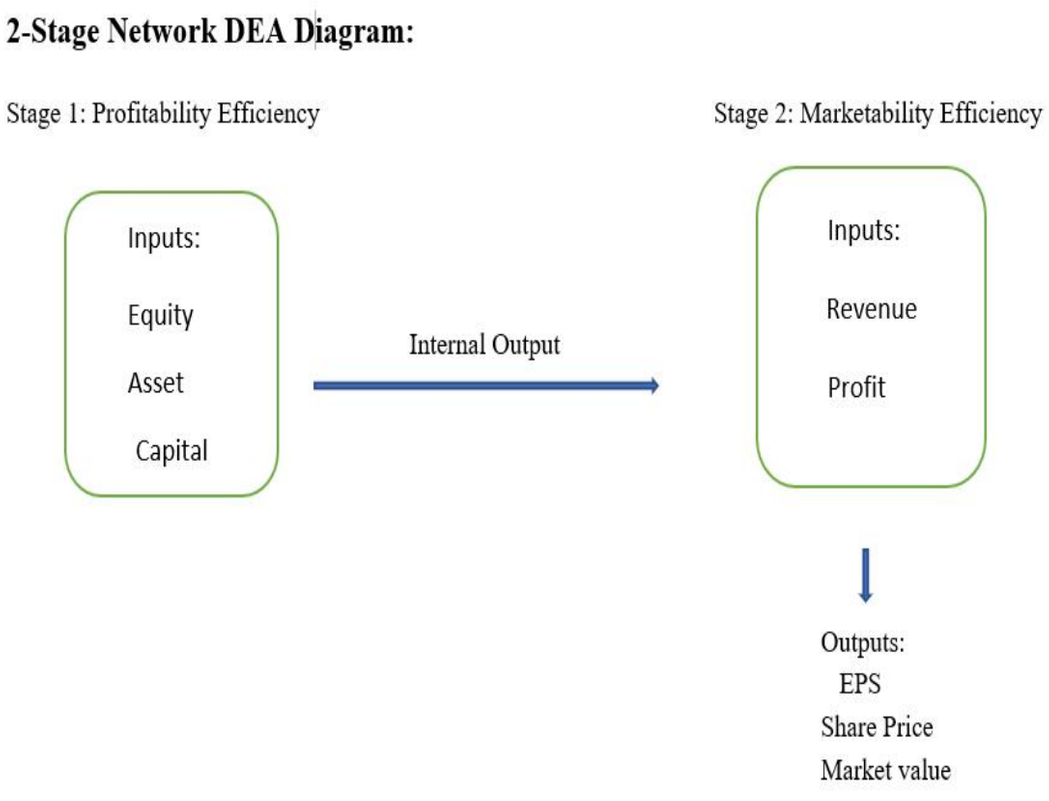

Figure:1.Two-Stage Network Basic Model

Theoretical Framework

Various theoretical views are used in this study. The theory of agency describes governance as a method of diminishing managerial opportunism (Jensen & Meckling, 1976), and the theory of resource dependence states that boards play a part in supplying external resources, expertise, and legitimacy (Pfeffer & Salancik, 2015) . Moreover, the perspectives of stakeholders and stewardship emphasize governance as the source of transparency, accountability, and the creation of long-term value (Donaldson & Davis, 1991).

Together, these theories imply that governance can affect both internal performance (how things are done) and external performance (market performance) via different avenues.

Research Gaps

There are three gaps in the literature. Firstly, much of the previous literature does not pay much attention to the stage-based character of banking performance, as it does not differentiate between operational and market-based performance. Second, Network DEA frameworks have not been studied extensively in terms of the integration of corporate governance in their models, even though they are capable of describing internal production structures. Third, the governance measurement is a limitation to single variables as opposed to overall indices.

This paper fills these gaps with the creation of a multi-dimensional Corporate Governance (CG) index and incorporation into a two-step Network DEA (NDEA) model. This methodology breaks down efficiency into Stage-1 Operational/Profitability Efficiency and Stage-2 Value created /Market-based efficiency, so that analysis of governance effects further down the banking value chain can be more finely focused.

Control Variables and Institutional Context

The study uses firm-specific controls to isolate the governance effects. Bank age is an indicator of experience, reputation, and organizational learning (Berger & DeYoung, 1997 ; Athanasoglou et al., 2008). The branch network is an indicator of the size and complexity of operations (Berger & Humphrey, 1997; Fethi & Pasiouras, 2010). Awards are used as a proxy for external reputation and signaling effect (Spence, 1973; Fombrun, 2005).

The research is placed in the context of the changing governance system in Pakistan due to efforts made by the State Bank of Pakistan and the Securities and Exchange Commission of Pakistan. The governance codes established over the years (2002-2019) have reinforced board independence, audit control, and transparency, thus creating an applicable context of study regarding the governance-efficiency linkages in an emergent market environment.

Hypotheses Development

Based on the theoretical and empirical insights presented above, the following hypotheses are made in the study:

H1: Corporate governance affects Operational/Profitability efficiency Stage-1, but the effects may vary depending on the trade-off between the need to monitor effectively and the need to be flexible.

H2: Corporate governance is positively related to Stage-2 market-based efficiency because of increased transparency, legitimacy, and investor confidence.

H3: Market-based efficiency is strongly linked to operational efficiency as it demonstrates the conduct of performance in stages.

H4: There is a mediator between corporate governance and market-based efficiency, profitability efficiency.

Methodology

Research Design

The type of research adopted in this study is quantitative research, including a longitudinal design to investigate the effect of Corporate Governance on banking efficiency in the banking industry of Pakistan. The longitudinal structure enhances the robustness of the empirical analysis by controlling for unobserved heterogeneity and capturing dynamic changes in CG practices and bank performance.

In this study, a two-stage Network Data Envelopment Analysis (NDEA) model combined with two-stage econometric estimation has been used to explore the multidimensional association between CG and banking efficiency. The methodological framework is designed to reflect the internal operational effects of CG as well as the external value-creation effects in the banking production process (Ahmed, 2023). This integrated approach is consistent with recent best practices in banking efficiency research (Benbachir, 2025; Istaiteyeh et al., 2024; Berhe, 2025) and specifically extends the pioneering framework of (Seiford & Zhu, 1999), as refined by (Chao et al., 2018).

The empirical analysis is conducted in two steps through the software "Max DEA" by using a Network DEA model. The NDEA framework differs from traditional single-stage DEA models in that it explicitly acknowledges the internal structure of banking operations, and intermediate products can connect various production stages (Imran, Sultana, & Ahmed, 2023). Second, the estimated efficiency scores are used to examine the effect of CG Index on the operational efficiency and value-creation efficiency by employing Tobit regression models with the help of" R Studio".

Multi-layer Governance Modeling and Methodological Contribution

The current research adds to the existing body of literature by incorporating the inner workings of the banking activities with a multi-dimensional system of governance. To begin with, it includes a two-stage Network Data Envelopment Analysis (NDEA) model, which explicitly embraces the internal structure of production of banks. Second, it inserts intermediate variables, i.e., revenue and profit, on which the operational performance and the market performance are connected. Third, it creates a composite corporate governance framework, which allows evaluating the governance effects more comprehensively.

The study is a three-layer modeling approach: macro, meso, and micro.

At the former layer (macro-level), we form a composite Index of Corporate Governance (CG) to measure the quality of generally good governance. That is similar to the previous literature on the governance indexes (Brown & Caylor, 2006; Larcker et al., 2007).

At the second level (meso-level), the variables are combined into larger governance dimensions, which include the board structure, board diversity, the effectiveness of the audit committee, and the effectiveness of the risk committee. This aggregation makes the models less complex and reflects the functional role of governance mechanisms.

At the third layer (micro-level), the governance variables at an individual level are studied. There are three econometric specifications estimated at every level of analysis. To begin with, a Stage-1 model will assess the effect of governance on the efficiency of operation/profitability. Second, a Stage-2 model analyzes the effects of governance on market efficiency. Third, the transmission model entails the incorporation of Stage-1 efficiency as an explanatory variable of Stage-2 efficiency, which allows the inter-stage dynamics to be analysed.

Measurement and Data Sources

The annual reports of listed commercial banks in Pakistan were used to collect the panel data for this study between the year 2014 and 2024. Each of the governance attributes is assessed annually, according to the framework of ROSC (Report on the Observance of Standards and Codes, 2005) and the governance provisions of SECP (2017): a four-point compliance scale is used: 0, 50, 80, and 100, with the first one signifying the non-observance of the practice and the last one being. Later transformed into their decimal counterparts (0.00, 0.50, 0.80, 1.00) so that the econometric suitability and the comparability of the variables can be achieved in the regression-based analysis. The multilevel design will enable a more delicate analysis of how governance impacts the efficiency of banks.

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Table 1: Corporate Governance Index Scoring Criteria adopted for this study

Governance Dimension	Variable	Scoring Criteria (0–50–80–100)	Decimal Conversion (0–0.50–0.80–1.00)
Board Structure	Board Size	<5 directors = 0; 5–6 = 50; 7–8 = 80; ≥9 = 100	0 – 0.50 – 0.80 – 1.00
	Independent Directors	Very low independence = 0; Moderate = 50; High = 80; Majority independent = 100	0 – 0.50 – 0.80 – 1.00
	Non Executive Directors	Low proportion = 0; Moderate = 50; High = 80; Strong majority = 100	0 – 0.50 – 0.80 – 1.00
Board Activity	Board Meetings	<4 meetings = 0; 4–5 = 50; 6–7 = 80; ≥8 = 100	0 – 0.50 – 0.80 – 1.00
Board Diversity	Female Directors on the Board	0 female = 0; 1 = 50; 2 = 80; ≥3 = 100	0 – 0.50 – 0.80 – 1.00
Audit Committee Effectiveness	Audit Committee Size	≤2 members = 0; 3 = 50; 4 = 80; ≥5 = 100	0 – 0.50 – 0.80 – 1.00
	Audit Committee Meetings	≤2 meetings = 0; 3–4 = 50; 5–6 = 80; ≥7 = 100	0 – 0.50 – 0.80 – 1.00
	Female in Audit Committee	0 = 0; 1 = 50; 2 = 80; ≥3 = 100	0 – 0.50 – 0.80 – 1.00
Risk Committee Effectiveness	Risk Committee Size	≤2 members = 0; 3 = 50; 4 = 80; ≥5 = 100	0 – 0.50 – 0.80 – 1.00
	Risk Committee Meetings	≤2 meetings = 0; 3–4 = 50; 5–6 = 80; ≥7 = 100	0 – 0.50 – 0.80 – 1.00
	Female in Risk Committee	0 = 0; 1 = 50; 2 = 80; ≥3 = 100	0 – 0.50 – 0.80 – 1.00

Note: Each variable is scored on a 0–50–80–100 scale based on compliance with the requirements of the Regulations of Socially Oriented Corporate Governance (ROSC). For analysis, the scores are converted into decimals (0, 0.50, 0.80, 1.00) to standardize the measurement and compute the overall CG Index.

Computation of CG Index

The CG Index is the aggregated score of all variables across the three dimensions. Since the variables are converted into decimal values (0, 0.50, 0.80, 1.00), the overall CG Index ranges from 0 (lowest governance compliance) to 1 (highest governance compliance).

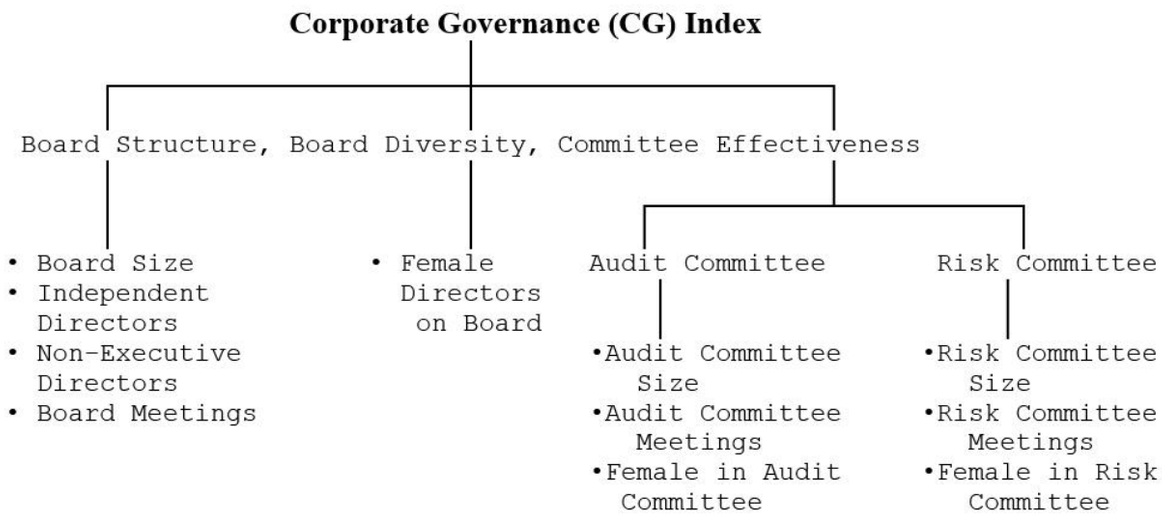

Figure:2 Corporate Covernance Index Composition

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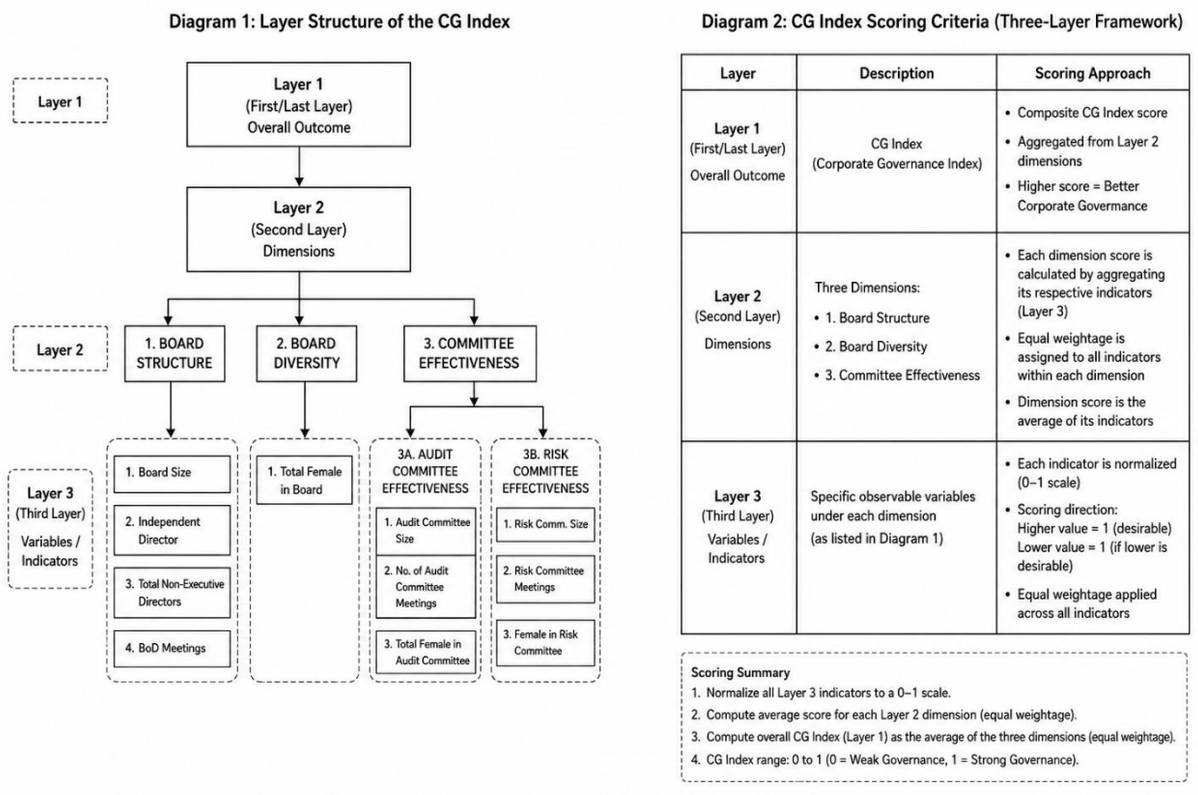

Diagram 2: CG Index Scoring Criteria (Three-Layer Framework)

Layer	Description	Scoring Approach
Layer 1 (First/Last Layer) Overall Outcome	CG Index (Corporate Governance Index)	• Composite CG Index score • Aggregated from Layer 2 dimensions • Higher score = Better Corporate Governance
Layer 2 (Second Layer) Dimensions	Three Dimensions: • 1. Board Structure • 2. Board Diversity • 3. Committee Effectiveness	• Each dimension score is calculated by aggregating its respective indicators (Layer 3) • Equal weightage is assigned to all indicators within each dimension • Dimension score is the average of its indicators
Layer 3 (Third Layer) Variables / Indicators	Specific observable variables under each dimension (as listed in Diagram 1)	• Each indicator is normalized (0–1 scale) • Scoring direction: Higher value = 1 (desirable) Lower value = 1 (if lower is desirable) • Equal weightage applied across all indicators

Scoring Summary
1. Normalize all Layer 3 indicators to a 0–1 scale.
2. Compute average score for each Layer 2 dimension (equal weightage).
3. Compute overall CG Index (Layer 1) as the average of the three dimensions (equal weightage).
4. CG Index range: 0 to 1 (0 = Weak Governance, 1 = Strong Governance).

Figure 2: Layers of the CG Index Conceptual Model

Data and Sample

The analysis is based on a balanced sample of 18 out of 35 listed Pakistani commercial banks during 2014-2024. The data are gathered from Commercial banks' annual reports, the State Bank of Pakistan (SBP), and the Securities and Exchange Commission of Pakistan (SECP).

Econometric Model -Tobit Regression

Since the NDEA efficiency scores range from 0 to 1, the dependent variables are censored, so the current study uses a Tobit regression model (Tobin,1958) to investigate the factors affecting efficiency. which is also widely used due to its simplicity and interpretability. Ordinary Least Squares (OLS) estimation can then lead to biased and inconsistent estimates.

Bank Efficiency Measurement Approach and Network DEA Model.

Banking institutions are multidimensional in nature and have multiple inputs and multiple outputs. Traditional financial ratios/models are unable to fully capture this multidimensional production structure. In this study, a two-stage Network Data Envelopment Analysis (NDEA) model is used according to the model proposed by Tone & Tsutsui, (2014). The principal benefit of NDEA is that it breaks down the overall efficiency into stage efficiency, without altering the internal structure of banking operations.

Stage 1: Operational (Profitability) Efficiency

The first stage assesses the effectiveness of banks' operational resources in yielding intermediate financial results.

Inputs: Total employees, Total assets, Equity

Intermediate Outputs: Revenue and Profit

The Stage-1 efficiency rating indicates banks' ability to operate efficiently and make effective use of internal resources.

Two-Stage Network DEA (NDEA) Framework

Stage 2: Value-Creation (Marketability) Efficiency

The second stage measures the effectiveness of intermediate products in the financial market.

Inputs (Intermediate Products): Revenue, Profit

Final Outputs: Earnings per share (EPS), Market value, and Value per share

The Stage-2 efficiency score is a measure of banks' efficient performance in generating value for shareholders and market performance.

The linkage between stages via intermediate outputs makes it possible to identify the transmission effects between operational efficiency and value-creation efficiency.

Operational Form of the NDEA Model

Stage-1 Efficiency

$$\theta\_it^{\wedge}(1) = (u1 \cdot REV\_it + u2 \cdot PROF\_it) / (v1 \cdot EMP\_it + v2 \cdot AST\_it + v3 \cdot EQ\_it)$$

Stage-2 Efficiency

$$\theta\_it^{\wedge}(2) = (w1 \cdot EPS\_it + w2 \cdot MV\_it + w3 \cdot VPS\_it) / (u1 \cdot REV\_it + u2 \cdot PROF\_it)$$

Overall Efficiency

$$\theta\_it = \theta\_it^{\wedge}(1) \times \theta\_it^{\wedge}(2)$$

Econometric Model/Equations With CG Index, Dimensions, and Individual Variables

LAYER 1: CG Index Models

Model 1: Stage-1 Operational/ Profitability Efficiency (CG Index)

$$E1_{it} = \beta 0 + \beta 1\ CGI_{it} + \beta 2\ B.Awards_{it} + \beta 3\ B.AGE_{it} + \beta 4\ Branches\_it + \varepsilon\_it$$

Model 2: Stage-2 Value Creation/Marketability Efficiency (CG Index)

$$\boldsymbol{E2\_it = \beta 0 + \beta 1\ CGI\_it + \beta 2\ B.Awards_{it} + \beta 3\ B.AGE_{it} + \beta 4\ Branches\_it + \varepsilon\_it}$$

Model 3: Transition Model (CG Index)

$$E2\_it = \beta 0 + \beta 1\ E1\_it + \beta 2\ CGI\_it + + \beta 3\ B.Awards_{it} + \beta 4\ B.AGE_{it} + \beta 5\ Branches\_it + \varepsilon\_it$$

LAYER 2: CG DIMENSIONS MODELS

CG dimensions include:

Model 4: Stage-1 Operational/ Profitability Efficiency (CG Dimensions)

$$E1it = \beta 0 + \beta 1\ ABSit + \beta 2\ ABDit + \beta 3\ AACEit + \beta 4\ ARCEit + \beta 5\ Awardit + \beta 5\ Ageit + \beta 5\ Branchit + \varepsilon it$$

Model 5: Stage-2 Value Creation/Marketability Efficiency (CG Dimensions)

$$E2it = \beta 0 + \beta 1\ ABSit + \beta 2\ ABDit + \beta 3\ AACEit + \beta 4\ ARCEit + \beta 5\ Awardit + \beta 6\ Ageit + \beta 7\ Branchit + \varepsilon it$$

Model 6: Transition Model (CG Dimensions)

$$E2it = \beta 0 + \beta 1\ E1it + \beta 2\ BSit + \beta 3\ BDit + \beta 4\ AACEit + \beta 5 ARCEit + \beta 56\ Awardit + \beta 7\ Ageit + \beta 8\ Branchit + \varepsilon it$$

LAYER 3: CG Individual Variables

This layer replicates index-based models again (often used as robustness/alternative specification).

Model 7: Stage-1 Efficiency (CG Individual Variables)

$$E1it = \beta 0 + \beta 1 \ CGIit + \beta 2 \ Xit + \ldots + \varepsilon it$$

Model 8: Stage-2 Efficiency (CG Individual Variables)

$$E2it = \beta 0 + \beta 1 \ CGIit + \beta 2 \ Xit + \ldots + \varepsilon it$$

Model 9: Transition Model (CG Individual Variables)

$$E2it = \beta 0 + \beta 1 \ E1it + \beta 2 \ CGIit + \beta 3 \ Xit + \ldots + \varepsilon it$$

Model 10: Transition Model (CG Index – robustness)

$$E2it = \beta 0 + \beta 2 \ CGIit + \beta 3 \ Xit + \ldots + \varepsilon it$$

Latent Tobit Specification

$$\theta_{it} = \beta 0 + \beta 1 \ CGI_{it} + \beta 2 \ B.Awards\_it + \beta 3 \ B.AGE\_it + \beta 3 \ \text{BRANCH}ES_{it} + \varepsilon\_it$$

Observed Efficiency (Censored)

θ_it =

0 if θ_it ⩽ 0

θ_it if 0 < θ_it < 1

1 if θ_it ⩾ 1

Control Variables

To isolate the effect of CSR on banking efficiency, several bank-specific control variables are incorporated into the regression models.

Bank Branches

A bank's overall performance and operational efficiency are significantly influenced by the total number of its branches. Empirical research has demonstrated that branching expansion is positively correlated with performance metrics, suggesting that branch proliferation supports revenue generation and cost efficiency (Sufian & Habibullah, 2010) . Additionally, by allowing banks to access local markets, broad branch coverage enhances market presence and competitive advantage, and increases market power in funding and lending (Ullah et al., 2023).

Bank Awards (Recognition)

As a proxy of reputation and external recognition of quality performance and governance, bank awards are highly sought after and aligned with the corporate reputation theory (Fombrun, 2005); (Berger & Bouwman, 2013).

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Bank Age

The term "bank age" refers to how long a bank has been in business. Bank age has been a popular proxy in the banking literature as a measure of institutional maturity, experience, and organisational learning, which could affect efficiency and risk management practices (Athanasoglou et al., 2008; Sufian & Habibullah, 2010; Berger & DeYoung, 1997).

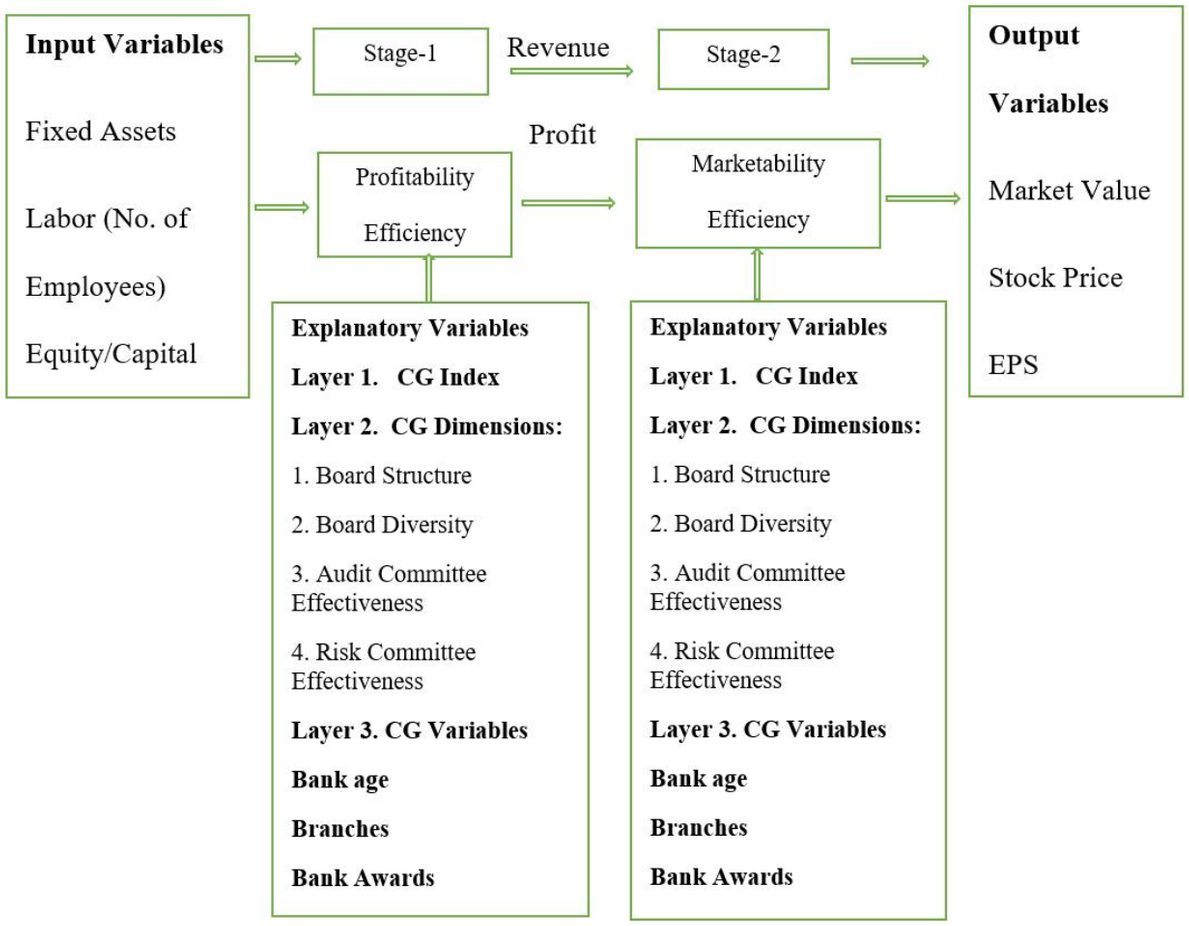

Figure 3: Conceptual Framework of the Study

Results and Findings

There are three layers, and each layer has three analysis tables: impact on first stage-1, Stage-2, and then as a transition effect model.

Layer-1 CG Index Model,

Layer-2 CG Dimensions/Aggregated Governance Model,

Layer-3 CG Individual Variables Model

1. Stage-1 Operational/ Profitability Efficiency
2. Stage-2 Value Creation/ Marketability Efficiency
3. Transition model (efficiency transmission effect)

Diagnostic Tests (VIF and bootstrap) and Robustness Tests.

Dynamics of Two-Stage Efficiency

Table 1: Year-wise Summary of Two-Stage Network DEA Efficiency Scores

Year	No. of Banks	Mean Efficiency (Stage-2)	SD (Stage-2)	Mean Efficiency (Stage-1)	SD (Stage-1)
2014	18	0.73	0.26	0.82	0.21
2015	18	0.54	0.31	0.74	0.28
2016	18	0.85	0.15	0.87	0.19
2017	18	0.84	0.20	0.91	0.13
2018	18	0.81	0.20	0.81	0.21
2019	18	0.84	0.19	0.71	0.23
2020	18	0.75	0.22	0.77	0.20
2021	18	0.85	0.18	0.77	0.21
2022	18	0.84	0.18	0.68	0.26
2023	18	0.83	0.19	0.68	0.23
2024	18	0.83	0.20	0.67	0.22
Total	198	0.79	0.22	0.77	0.23

The time-based analysis shows a shift in efficiency. In 2014-2018, Stage-1 efficiency is more prevalent than Stage-2 efficiency, but from 2019 onwards, Stage-2 efficiency predominates over Stage-1 efficiency, implying a shift in value creation through a market lens.

In general, the findings reflect a dynamic shift from efficiency to market performance, confirming the value of a two-stage Network DEA to trace the evolution of a relationship between internal efficiency and value creation in banks.

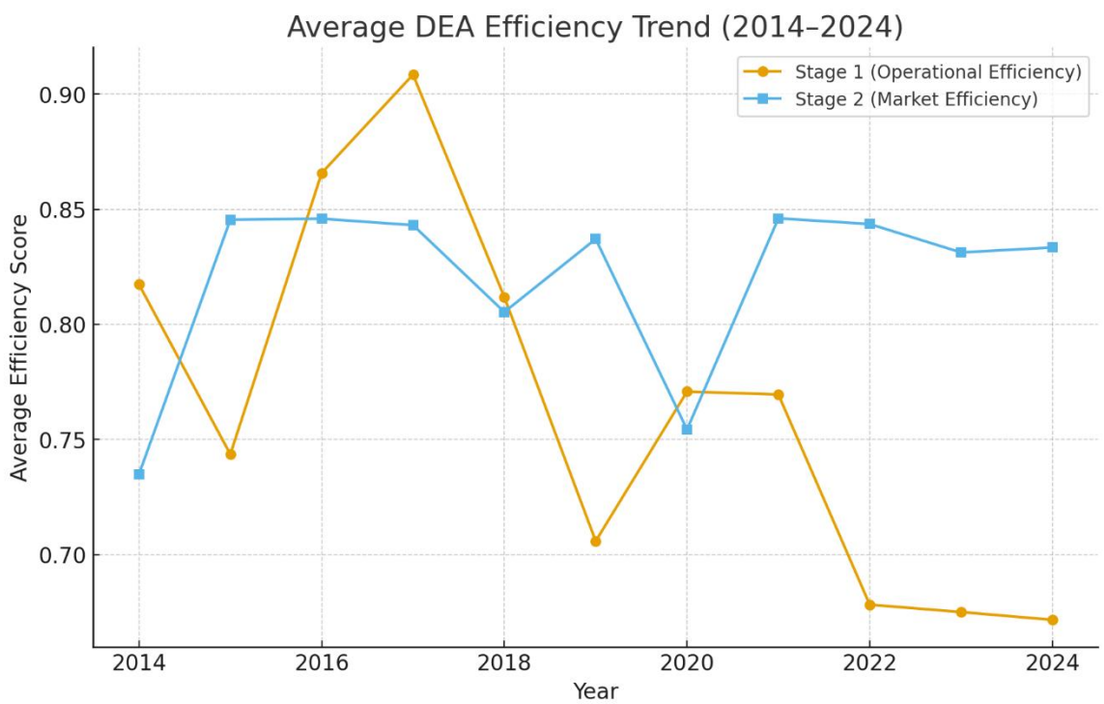

Figure 4: Year-wise Trends in Stage-1 and Stage-2 Efficiency

Table 2: Descriptive Statistics of the Study

Variable	Mean	Std. Dev	Min	Max
Efficiency-1	0.77	0.23	0.04	1.00
Efficiency-2	0.79	0.22	0.04	1.00
Awards	3.64	5.40	0.00	26
bank_age	47.17	36.16	7.00	162
Branches	716.29	515.63	28	1758
CG Index	0.48	0.09	0.29	0.69
ln_branches	6.19	1.04	3.33	7.47
ln_awards	0.96	1.04	0.00	3.30

The summary tables show the distribution of the variables of interest for the sample of 198 observations. This suggests that Stage-1 efficiency (mean = 0.77) and Stage-2 efficiency (mean = 0.79) are already high, which means that banks in the sample are already close to the efficiency frontier at both stages of production at banks.

The corporate governance index (mean = 0.48, SD = 0.09) has a small standard deviation, implying that banks have a comparable level of governance. But awards (SD = 5.40), bank age (SD = 36.16), and branches (SD = 515.63) have a high standard deviation, which suggests a high degree of variability in bank size, age, and awards in the banking industry.

The transformation (ln) branches (SD = 1.04) and ln_awards (SD = 1.04) have a more stable distribution than branches and awards, respectively, implying that the log transformation is effective in stabilising distributions and making the data suitable for statistical analysis. Overall, the data are not too homogeneous and normally distributed, and can be analysed with Tobit regression and other multivariate techniques.

Table 3: Correlation Matrix

Variables	Efficiency-1	Efficiency-2	CG Index	ln_awards	bank_age	ln_branches
Efficiency-1	1.000	-0.258	-0.243	0.047	0.323	0.195
Efficiency-2	-0.258	1.000	0.335	0.134	0.011	-0.139
CG Index	-0.243	0.335	1.000	0.182	0.012	0.166
ln_awards	0.047	0.134	0.182	1.000	0.254	-0.032
bank_age	0.323	0.011	0.012	0.254	1.000	0.075
ln_branches	0.195	-0.139	0.166	-0.032	0.075	1.000

The results of the correlation analysis provide some indication of how the variables of interest are related. Efficiency-1 is negatively correlated with Efficiency-2 (r = -0.258), which means that operational efficiency may not translate to value efficiency, implying that there is a trade-off between the two efficiency measures.

The measure of corporate governance (CG Index) has a positive correlation with Efficiency-2 (r = 0.335), implying that corporate governance increases value efficiency. However, it has a negative correlation with Efficiency-1 (r = -0.243), suggesting that corporate governance might harm operational efficiency in the beginning.

In terms of the control variables, bank age is positively correlated with Efficiency-1 (r = 0.323) but has a very low correlation with Efficiency-2 (r = 0.011), implying that older banks are more efficient in their operational efficiency but not in their value efficiency. Lastly, ln_branches is negatively correlated with Efficiency-2 (r = -0.139), suggesting that an increase in the number of branches harms value efficiency due to complexity.

Overall, the correlation analysis reveals moderate correlations between the variables, and there are no extremely high correlations, suggesting that multicollinearity may not be a problem in our data set.

Table 4. Comparative Tobit Regression Results for Stage-Wise Banking Efficiency Layer-1

Variables	Stage-1 Efficiency	Stage-2 Efficiency	Stage-2 Transition Model
CG Index	-0.9930***	0.9811***	0.7684***
Efficiency-1	—	—	-0.3015***
ln_awards	0.0175	0.0227	0.0247
bank_age	0.0034***	-0.0002	0.0004
ln_branches	0.0380*	-0.0679***	-0.0555***
Intercept	0.9024***	0.7645***	0.9963***
logSigma	-1.2750***	-1.3730***	-1.3924***

Note: *** p < 0.01, ** p < 0.05, * p < 0.10.

The Tobit results are presented in comparative terms to show the effect of corporate governance on banking efficiency across the different stages. The negative impacts of corporate governance on Stage-1 operational efficiency (β = -0.9930, p < 0.01) indicate that governance-related monitoring and compliance measures can reduce the flexibility of operations in the short-term. However, governance has a positive impact on stage-2 value creation efficiency (β = 0.9811, p < 0.01) which makes it relevant in improving market-oriented, value-based performance.

Additionally, the transition model reveals that the Stage-1 efficiency has a negative relationship with Stage-2 efficiency (β = -0.3015, p < 0.01), which suggests and supports the existence of an efficiency trade-off between stage-1 efficiency (optimization of operations) and stage-2 efficiency (value creation). In the meantime, the positive coefficient of the CG index in the transition model demonstrates that governance is a positive enabler for transforming the operational performance into value generation efficiency.

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The control variables, except for bank age, have a negative impact on Stage-1 efficiency and a positive impact on Stage-2 efficiency in both models, suggesting that for value creation activities, there may be diseconomies of scale. In all the specifications, there is no significance for awards.

Overall, the results are compatible with the existence of a non-linear and stage-dependent efficiency structure in banking in which the role of corporate governance is to limit the operational efficiency but enhance value creation and market-oriented performance.

Table 5. Comparative Tobit Regression Results for CG Dimensions Layer-2

Variables	Stage-1 Efficiency	Stage-2 Efficiency	Stage-2 Transition Model
Efficiency-1	—	—	-0.2887**
ABS	-0.5881*	0.0959	0.0137
ABD	-0.1277	0.1494*	0.1195
AACE	-0.1377	0.2195	0.1944
ARCE	-0.5427**	0.5291***	0.4139**
ln_branches	0.0463*	-0.0659***	-0.0529**
ln_awards	0.0063	0.0331	0.0332
bank_age	0.0033***	-0.0002	0.0003
Intercept	1.1483***	0.7509***	1.0015***
logSigma	-1.2848***	-1.3820***	-1.3992***

Overall, the Tobit analysis of the governance measures aggregated by their stages suggests an obvious governance effect on banking efficiency across stages. The results of Stage-1 show that risk committee effectiveness (ARCE) has a negative relationship with operational efficiency, indicating that better risk governance could include monitoring and compliance demands that may curtail operational efficiency. Board structure also has a weak negative effect, and board diversity and the performance of the audit committee are insignificant.

From that point onward, governance mechanisms turn into value-enhancing at the marketability stage, as shown by Stage-2 results. ARCE are positively and significantly associated with Stage-2 efficiency, suggesting that the effectiveness of risk governance positively impacts on the value creation and strategic performance. There is a moderate positive relationship between board diversity and performance, while other dimensions of governance have no impact.

The transition model also illustrates that when Stage-1 efficiency is achieved, it has a negative impact on Stage-2 efficiency, suggesting an efficiency trade-off between operational efficiency and value. Importantly, ARCE remains in a positive relationship, indicating risk governance as the most consistent governance mechanism across all models.

The control variables are found to have a positive effect on Stage-1 efficiency and a negative effect on Stage-2 efficiency, suggesting economies of scale in operations but diseconomies of value creation. Bank age only has a positive effect on Stage-1 efficiency; there is no significant effect on awards in any of the models.

In general, the results showed that aggregated governance dimensions offer more consistent and meaningful insights into the governance–efficiency nexus, with risk governance standing out as the leading governance factor that connects the operational processes to value-based banking performance.

Table 6. Comparative Tobit Regression Results with Individual CG Variables Layer-3

Variables	Stage-1 Efficiency	Stage-2 Efficiency	Stage-2 Transition Model
Efficiency-1	—	—	-0.3433***
BS	-0.0995	0.4672***	0.4588***
ID	-0.2019	0.2561**	0.2266*
NED	0.1823	-0.3017**	-0.2602*
BM	-0.3382**	-0.3783***	-0.4615***
FBM	-0.1198	0.0196	-0.0163
ACS	-0.3393**	0.0647	-0.0218
ACM	0.1621	-0.2321	-0.1855
FAC	-0.0938	0.0955	0.0781

Variables	Stage-1 Efficiency	Stage-2 Efficiency	Stage-2 Transition Model
RCS	0.1635	-0.0118	0.0152
RCM	-0.6590***	0.1748	0.0055
FRC	-0.1973*	0.2738***	0.2305**
ln_branches	0.0403	-0.0441**	-0.0293
ln_awards	-0.0075	0.0368*	0.0351*
bank_age	0.0040***	0.0002	0.0009*

The comparative Tobit results show that strong stage-specific effects of corporate governance on banking efficiency. It is found that in Stage-1 governance intensity variables have a negative impact on operational efficiency, including the number of board meetings, the number of meetings of the audit committee, and the number of meetings of the risk committee, which indicates that more monitoring and compliance activities result in more coordination and operational costs.

Conversely, governance structure elements like board size and independent directors are positively associated with Stage-2 efficiency, suggesting that strategic oversight and board skill have a positive impact on value creation. However, intensive monitoring is still found to be negatively significant at the value creation level, implying that efficiency costs from intensive monitoring are still incurred in this phase.

One common theme in the Stage-2 models is the positive effect of female representation on the risk committee (FRC) on value-based efficiency—hence, the need for diversity in risk governance. On the other hand, non-executive directors have a negative impact on Stage-2 efficiency, suggesting that there may be related constraints on strategic responsiveness.

Additionally, the transition model demonstrates that the improvement of Stage-1 efficiency comes at the expense of Stage-2 efficiency, suggesting a negative relationship between the two and thus an efficiency trade-off between the two stages. This indicates that a more efficient internal operation is not assured to lead to a market-oriented result.

The results suggest that governance mechanisms have a varying impact on banking efficiency through the stages. Governance intensity is a constraint on operational efficiency, while governance quality and risk oversight boost value creation and transitional efficiency.

Robustness Analysis: Bootstrap Estimates

Table 7. Comparative Variance Inflation Factor (VIF) Results Across All CG Layers 1-3

Variable	CG Index Model	CG Dimensions Model	CG Individual Variables Model
CG Index	1.176	—	—
Efficiency-1	1.269	—	—
ABS	—	1.377	—

Variable	CG Index Model	CG Dimensions Model	CG Individual Variables Model
ABD	—	1.347	—
AACE	—	1.543	—
ARCE	—	1.508	—
BS	—	—	1.732
ID	—	—	1.431
NED	—	—	1.613
BM	—	—	1.810
FBM	—	—	1.585
ACS	—	—	1.946
ACM	—	—	2.004
FAC	—	—	1.694
RCS	—	—	1.994
RCM	—	—	1.467
FRC	—	—	1.446
ln_branches	1.104	1.426	1.631
ln_awards	1.116	1.313	1.357
bank_age	1.196	1.128	1.327

Note: VIF = Variance Inflation Factor. Thresholds: VIF > 10 = serious multicollinearity; VIF > 5 = moderate concern; VIF < 3 = acceptable.

Comparative VIF results show that there is no multicollinearity problem in the data for all governance specifications. The VIF values are all within range from 1.104 to 2.004, which is well below the critical value of 5. The VIFs are relatively high in the individual governance model, but are within acceptable limits in both ACM and RCS. In general, the results indicate that the explanatory variables are not highly correlated with each other, and the estimate obtained from the Tobit model is robust and reliable in all model specifications.

Table 8: Bootstrap Estimates of Model Coefficients with Bias and Standard Errors

Parameter	Original Estimate	Bias	Standard Error
t1*	0.9963	-0.0176	0.1614
t2*	-0.3015	0.0027	0.1014
t3*	0.7684	0.0111	0.2177
t4*	0.0247	0.0006	0.0185

t5*	0.0004	0.0002	0.0005
t6*	-0.0555	0.0002	0.0194
t7*	-1.3924	-0.0266	0.0601

The robustness and stability of the model estimates are also supported by the bootstrap results, which show that the coefficient biases are small, and the standard errors are relatively low. The positive parameters like t1 and t3 are found to be beneficial for efficiency, while t2, t6, and t7 are found to be negative, with t7 being the most negative.

In conclusion, the results confirm the different phases of corporate governance impacts. Governance intensity also decreases operational effectiveness in Stage-1 due to monitoring and compliance expenses, and governance processes, especially risk-governance, increase the efficiency of value-creation in Stage-2. Finally, the transition model also suggests that operational efficiency is not necessarily value efficient, indicating that governance is a conditionally determinative efficiency transmission mechanism between banking stages.

Discussion

The general contribution of this study is the demonstration of a stage dependency, heterogeneity, and non-linearity of governance effects in the banking production process, which enriches the corporate governance efficiency literature. The results show that corporate governance has a negative impact on Stage-1 profitability efficiency and a positive impact on Stage-2 market efficiency when applying a two-stage Network DEA and multi-layer governance framework.

Governance intensity factors (board meetings, activity of the audit committee, and risk committee monitoring) have an adverse effect on efficiency at the operational stage, consistent with the idea that too much monitoring results in coordination costs, delays, and inflexibility in management. This discovery is in line with the research that puts governance-related operational costs at the forefront of emerging markets.

Stage-2 results show, in contrast, that governance enhances the efficiency of the market/value. In support of agency theory and resource dependency, governance quality, board independence, board size, and risk governance have positive effects on value creation. The results indicate that good governance contributes to external legitimacy, transparency, and investor confidence, while it may limit the internal flexibility in operations.

One of the key findings of the study is the negative transmission effect between the efficiency of Stage-1 and the efficiency of Stage-2. The findings indicate that operational efficiency does not necessarily mean value efficiency; there is a disconnect between cost and value. This is the reason for the different findings on governance efficiencies found in earlier work.

The multi-layer analysis also shows that governance effects differ in their magnitude and impact at various levels of aggregation. Individual governance variables result in disjointed and inconsistent results and dimensional and index-based measures yield more consistent and theoretically meaningful results. This indicates that governance should be assessed using a complementary governance mechanism, not a single one.

The results suggest that the overall impact of corporate governance is a contingent mechanism in banking efficiency, as it reduces operational efficiency and increases market-oriented efficiency and value creation.

Conclusion

This paper combines the two-stage Network DEA model and the multi-layer corporate governance system to explore the relationship between governance and banking efficiency. The results show that the corporate governance has a stage-specific effect: firstly, it decreases the operational efficiency, and secondly, it increases the market/value efficiency.

In addition, the study finds that the operational efficiency and market efficiency relationship is negative, suggesting that operational benefits do not lead to market efficiency benefits. The results put into question the generally held view that governance is inevitably more effective in increasing efficiency and suggest that there is a balance between the level of governance and value creation.

The study has three contributions to the literature. It brings in a stage-wise approach for governance-efficiency analysis for the first time. Second, it demonstrates a negative efficiency transmission between the banking stages. Third, it shows that a combination of governance measures has higher reliability than single variables in governance.

Policy Implications

The results confirm that there is a need to balance the intensity of governance with operational flexibility. While improved governance improves transparency, market confidence, and value creation, too much monitoring can lead to less efficiency in operations due to compliance and coordination costs.

Such a positive role of governance in market efficiency underscores the need to further enhance the independence of the board, disclosure requirements, and risk governance arrangements, including in emerging markets.

The negative transmission effect also implies that banks should not become too focused on short-term efficiency, at the cost of innovation and the creation of long-term value. For this reason, management should implement efficient and balanced strategies that combine operations and strategy.

Lastly, the findings highlight the need to evaluate governance as a relational system, with governance indicators excluded. Thus, the use of composite governance indices and multidimensional governance assessment frameworks should be considered as a priority for researchers and regulators.

Limitations

Although it has contributed to this, this study has some limitations, which ought to be mentioned.

To begin with, the sample is a set of 18 commercial banks in Pakistan, so the results might be less applicable to other nations or financial systems that have different institutional and regulatory frameworks. Future studies can further examine the study in cross-country environments or have a greater number of banks in the sample to increase external validity.

Second, despite the two-step NDEA model used in the study to identify the inner structure of banking operations, the model is based on certain assumptions related to the choice of inputs, intermediate variables, and outputs. Other model specifications or the introduction of more variables in the middle can give varying efficiency estimates.

Third, although the Corporate Governance (CG) index is an all-inclusive gauge of the quality of governance, it is built based on information that is publicly announced in annual reports. In this regard, it might not adequately represent informal governance practice or how well governance mechanisms work in practice. Future research can include data in the form of qualitative measures or survey data to supplement the index.

Fourth, the paper uses the Tobit regression to examine the predictors of the efficiency scores. Though the approach incorporates the fact of the limited nature of the dependent variable, it can still be susceptible to possible econometric drawbacks that have been emphasized in the literature, including those of distributional assumptions and the possible endogeneity between governance and performance. The future study can use other estimation methods, including bootstrap-based methods or dynamic panel models, to overcome these issues.

Lastly, the research concentrates on fixed relations between governance and efficiency and does not explicitly consider changes that can occur over time. The inclusion of a dynamic efficiency model or lagged governance effects can give more information about the long-term effects of governance mechanisms.

References

Adams, R. B. (2012). Governance and the Financial C risis. *International Review of Finance*, *12*(1), 7–38.

Adeabah, D., Gyeke-Dako, A., & Andoh, C. (2019). Board gender diversity, corporate governance and bank efficiency in Ghana: a two stage data envelope analysis (DEA) approach. *Corporate Governance: The International Journal of Business in Society*, *19*(2), 299–320.

Ahmad, S., & Imran, M., (2024). Exploring the Drivers of Youth Unemployment in Pakistan: A Comprehensive Review. *Spry Journal of Economics and Management Sciences (SJEMS), 2(1),*12-21. https://doi.org/10.62681/sprypublishers.sjems/2/1/2

Ahmad, S., (2023). Analyzing the Influence of Exchange Rate Dynamics on Foreign Direct Investment in Pakistan: A 13-Year Analysis. *Spry Journal of Economics and Management Sciences (SJEMS)*, 1(2),122-132. https://doi.org/10.62681/sprypublishers.sjems/1/2/5

Ahmed, S., Ahmed, S., & Buriro, A. (2023). Strategies and Best Practices for Managing Cost Overruns in the Construction Industry of Pakistan. *Propel Journal of Academic Research, 3(1),* 28-55.

Athanasoglou, P. P., Brissimis, S. N., & Delis, M. D. (2008). Bank-specific, industry-specific and macroeconomic determinants of bank profitability. *Journal of International Financial Markets, Institutions and Money*, *18*(2), 121–136. https://doi.org/10.1016/J.INTFIN.2006.07.001

Athar, M., Chughtai, S., & Rashid, A. (2023). Corporate governance and bank performance: evidence from banking sector of Pakistan. *Corporate Governance (Bingley)*, *23*(6), 1339–1360. https://doi.org/10.1108/CG-06-2022-0261

Atuahene, S. A., & Xusheng, Q. (2024). A multidimensional analysis of corporate governance mechanisms and their impact on sustainable economic development: A case study of Ghana's financial sector. *Heliyon*, *10*(3). https://doi.org/10.1016/j.heliyon.2024.e24673

Benbachir, S. (2025). Determinants of banking efficiency in the MENA region: A two-stage DEA-Tobit approach. *Banks and Bank Systems*, *20*(1), 83.

Berger, A. N., & Bouwman, C. H. S. (2013). How does capital affect bank performance during financial crises? *Journal of Financial Economics*, *109*(1), 146–176.

Berger, A. N., & DeYoung, R. (1997). Problem loans and cost efficiency in commercial banks. *Journal of Banking & Finance*, *21*(6), 849–870.

Berger, A. N., & Humphrey, D. B. (1997). EUROPEAN JOURNAL OF OPERATIONAL Efficiency of financial institutions: International survey and directions for future research. In *European Journal of Operational Research* (Vol. 98).

Berhe, A. G. (2025). Intellectual capital and bank profitability: the case of Ethiopia. *Cogent Business & Management*, *12*(1), 2557963.

Bhattacharya, & Ritter. (1983). Innovation and communication: Signalling with partial disclosure. *Academic.Oup.Com*. https://academic.oup.com/restud/article-abstract/50/2/331/1516192

Brown, L. D., & Caylor, M. L. (2006). Corporate governance and firm valuation. *Journal of Accounting and Public Policy*, *25*(4), 409–434. https://doi.org/10.1016/j.jaccpubpol.2006.05.005

Chao, C.-M., Yu, M.-M., Hsiung, N.-H., & Chen, L.-H. (2018). Profitability efficiency, marketability efficiency and technology gaps in Taiwan's banking industry: meta-frontier network data envelopment analysis. *Applied Economics*, *50*(3), 233–250.

Cooper, W. W. ., Seiford, L. M. ., & Tone, Kaoru. (2007). *Data envelopment analysis : a comprehensive text with models, applications, references and dea-solver software*. Springer.

Dar, A. H., Mathur, S. K., & Mishra, S. (2021). The efficiency of Indian banks: A DEA, Malmquist and SFA analysis with bad output. *Journal of Quantitative Economics*, *19*(4), 653–701.

De Andres, P., & Vallelado, E. (2008). Corporate governance in banking: The role of the board of directors. *Journal of Banking & Finance*, *32*(12), 2570–2580.

Donaldson, L., & Davis, J. H. (1991). Stewardship theory or agency theory: CEO governance and shareholder returns. *Australian Journal of Management*, *16*(1), 49–64.

Fama, E. F., & Jensen, M. C. (1983). Separation of Ownership and Control. In *Source: Journal of Law and Economics* (Vol. 26, Number 2).

Farooq, M., Khan, I., Kainat, M., & Mumtaz, A. (2024). Corporate social responsibility and firm value: the role of enterprise risk management and corporate governance. *Corporate Governance (Bingley)*. https://doi.org/10.1108/CG-08-2023-0341

Fethi, M. D., & Pasiouras, F. (2010). Assessing bank efficiency and performance with operational research and artificial intelligence techniques: A survey. In *European Journal of Operational Research* (Vol. 204, Number 2). https://doi.org/10.1016/j.ejor.2009.08.003

Fombrun, C. J. (2005). Corporate reputations as economic assets. *The Blackwell Handbook of Strategic Management*, 285–308.

Gulzar, R., Bhat, A. A., Mir, A. A., Athari, S. A., & Al-Adwan, A. S. (2024). Green banking practices and environmental performance: navigating sustainability in banks. *Environmental Science and Pollution Research*, *31*(15), 23211–23226.

Hendrawan, R., Indonesia, M. S.-, & 2019, undefined. (2019). Cost Efficiency and Profit Efficiency Analysis and Its Effect on Profitability in Islamic Banks in Indonesia. *Researchgate.Net*. https://www.researchgate.net/profile/Riko-Hendrawan-2/publication/341573172_Cost_Efficiency_and_Profit_Efficiency_Analysis_and_Its_Effect_on_Profitability_in_Islamic_Banks_in_Indonesia/links/5ec7c2c9a6fdcc90d68d38b2/Cost-Efficiency-and-Profit-Efficiency-Analysis-and-Its-Effect-on-Profitability-in-Islamic-Banks-in-Indonesia.pdf

Hossain, A., Tasnim, A. F., Akhter, F., Semi, M. M. A., Khan, R., Rahman, R., ... & Sabeena, A. A. (2025). Transforming Healthcare Decisions in the US Through Machine Learning. Artificial Intelligence, 1(2).

Imran, M., Sultana, Z., & Ahmed, S. (2023). The Influence 0f Student-Teacher Interactions on Secondary School Students' academic Performance. *Benazir Research Journal of Humanities and Social Sciences, 2(1)*.

Istaiteyeh, R., Milhem, M. M., & Elsayed, A. (2024). Efficiency Assessment and Determinants of Performance: A Study of Jordan's Banks Using DEA and Tobit Regression. *Economies*, *12*(2). https://doi.org/10.3390/economies12020037

Jensen, M. C., & Meckling, W. H. (1976). Also published in Foundations of Organizational Strategy. In *Journal of Financial Economics* (Number 4). Harvard University Press. http://ssrn.com/abstract=94043Electroniccopyavailableat:http://ssrn.com/abstract=94043http://hupress.harvard.edu/catalog/JENTHF.html

Kao. (2014a). Network data envelopment analysis: A review. *ElsevierC KaoEuropean Journal of Operational Research, 2014•Elsevier*, *239*(1), 1–16. https://doi.org/10.1016/J.EJOR.2014.02.039

Kao. (2014b). Network data envelopment analysis: A review. *Elsevier*. https://www.sciencedirect.com/science/article/pii/S037722171400174X

Khan, H., & Mirza, H. H. (2019). *THE CORPORATE GOVERNANCE AND EFFICIENCY OF COMMERCIAL BANKS IN PAKISTAN: APPLICATION OF THE NON-PARAMETRIC APPROACH*.

Khan, R., Hussain, A., & Ahmad, S. (2023). Revolutionizing Human Resource Management: The Transformative Impact of Artificial Intelligence (AI) Applications. International Journal of Social Science & Entrepreneurship, 3(4), 306-326.

Lagasio, V. (2018). Corporate governance in banks: Systematic literature review and meta-analysis. *Corporate Ownership & Control*, *16*(1).

Larcker, D. F., Richardson, S. A., & Tuna, I. rem. (2007). Corporate governance, accounting outcomes, and organizational performance. *The Accounting Review*, *82*(4), 963–1008.

Levine, R. (2004). *The corporate governance of banks: A concise discussion of concepts and evidence* (Vol. 3404). World Bank Publications.

Loderer, C., & Waelchli, U. (2010). *Firm age and performance*. https://mpra.ub.uni-muenchen.de/id/eprint/26450

Nader Alber. (2011). The effect of banking expansion on profit efficiency of Saudi Banks. *Papers.Ssrn.ComN AlberAvailable at SSRN 1688939, 2010•papers.Ssrn.Com*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1688939

Pathan, S., & Faff, R. (2013). Does board structure in banks really affect their performance? *Journal of Banking & Finance*, *37*(5), 1573–1589.

Pfeffer, J., & Salancik, G. (2015). External control of organizations—Resource dependence perspective. In *Organizational behavior 2* (pp. 355–370). Routledge.

Prakash, N., Singh, S., & Sharma, S. (2022). A non-parametric framework for evaluating governance–efficiency–productivity associations in commercial banking. *Journal of Economic Studies*, *49*(7), 1159–1180.

Rehman, R. U., Zhang, J., Ali, R., & Qadeer, A. (2015). Does growing economy and better governance impede banking efficiency? A DEA analysis. *Journal of Applied Business Research*, *31*(6), 2213.

Riipa, M. B., Ahmed, F., Rony, M. K. K., Hossain, A., Islam, A., Utsho, M. R., ... & Tasnim, A. F. (2026). The role of artificial intelligence in predicting cardiovascular outcomes: a systematic review and meta-analysis. *Biostatistics & Epidemiology*, *10*(1), e2670804.

Seiford, L. M., & Zhu, J. (1999). Profitability and marketability of the top 55 U.S. commercial banks. *Management Science*, *45*(9), 1270–1288. https://doi.org/10.1287/mnsc.45.9.1270

Simar, L., & Wilson, P. W. (2008). Statistical inference in nonparametric frontier models: recent developments and perspectives. *The Measurement of Productive Efficiency and Productivity Growth*, 421–521.

Spence. (1973). l the MIT press. *Cies.Org.Pe*. https://cies.org.pe/wp-content/uploads/2016/07/spence_1973.pdf

Sufian & Habibullah. (2010). Developments in the efficiency of the Thailand banking sector: a DEA approach. *Emerald.ComF Sufian, M Shah HabibullahInternational Journal of Development Issues, 2010•emerald.Com*, *9*(3), 226–245. https://doi.org/10.1108/14468951011073316/FULL/HTML

Sultana, Z., Ahmed, S., & Imran, M. (2024). Corporate Social Responsibility (CSR) Reporting in Pakistan: Insights from Stakeholder Perspectives. *Spry Journal of Economics and Management Sciences*, *2*(1).

Thaker, K., Charles, V., Pant, A., & Gherman, T. (2022). A DEA and random forest regression approach to studying bank efficiency and corporate governance. *Journal of the Operational Research Society*, *73*(6), 1258–1277.

Tone & Tsutsui. (2014). Dynamic DEA with network structure: A slacks-based measure approach. *Elsevier*. https://www.sciencedirect.com/science/article/pii/S0305048313000510

Tone, K., & Tsutsui, M. (2009a). *GRIPS Policy Information Center Network DEA: A slacks-based measure approach*.

Tone, K., & Tsutsui, M. (2009b). Network DEA: A slacks-based measure approach. *European Journal of Operational Research*, *197*(1), 243–252.

Ullah, S., Majeed, A., & Popp, J. (2023). Determinants of bank's efficiency in an emerging economy: A data envelopment analysis approach. *PLoS ONE*, *18*(3 March). https://doi.org/10.1371/journal.pone.0281663.