

Fuzzy ANP-TOPSIS Analysis of Transaction Costs and Relational Capital in Governance of Private HEIs across the Taiwan Strait

Yanrong Li^{1,a#}, Lyusheng Li^{2,b#}, Yucheng Shen^{3,c,*}

¹ International Education School, Guangzhou College of Technology and Business, Guangzhou, China

² International College, Shinawatra University, Pathum Thani, Thailand

³ Teacher Education College, University of Idaho, Moscow, USA

^aliyanrong2022@126.com, ^bmswinter@126.com, ^croscoeshen@gmail.com

*Corresponding author

#Co- first author

Abstract: This study employs a Fuzzy Analytic Network Process (FANP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to examine the impact of transaction costs and relational capital on governance performance in private higher education institutions (HEIs) across the Taiwan Strait. Using 200 stakeholder surveys and 10 expert questionnaires conducted in 2025, the analysis highlights stakeholder trust and information-sharing as critical drivers. Taiwan's decentralized governance prioritizes trust, while Chinese mainland's centralized model emphasizes coordination efficiency. Financial data from Taiwanese HEIs, revealing 65% tuition reliance, underscores the need for cost-effective governance. Visual Figures illustrate regional differences, offering comparative insights. The findings provide actionable strategies for HEI administrators to enhance governance, foster trust, and optimize resources, contributing to higher education policy in East Asia.

Keywords: Fuzzy ANP, Institutional Governance, Private HEIs, Relational Capital, TOPSIS

1. Introduction

Private higher education institutions (HEIs) across the Taiwan Strait play a vital role in advancing academic excellence and economic growth, yet they face pressures to improve governance efficiency amid financial constraints and shifting stakeholder demands. Taiwan's decentralized, market-driven private HEIs contrast with Chinese mainland's centralized, regulatory-focused institutions, each navigating distinct governance challenges. Transaction costs, such as expenses for coordinating tasks and monitoring compliance, and relational capital, including trust and stakeholder networks, are key drivers of governance performance. However, traditional models often overlook their interdependencies and uncertainties, limiting effectiveness in complex educational contexts ^[7].

This study applies a hybrid Fuzzy Analytic Network Process (FANP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to evaluate how transaction costs and relational capital shape governance in private HEIs across the Taiwan Strait. FANP integrates fuzzy logic with the Analytic Network Process (ANP) to model interdependencies (e.g., trust reducing coordination costs) and address uncertainties, providing a robust multi-criteria decision-making (MCDM) framework ^[12, 14]. TOPSIS ranks governance strategies by their proximity to optimal performance, offering practical insights ^[5]. Using a survey of 200 stakeholders (administrators, faculty, students) and 10 expert questionnaires, the study develops a tailored governance framework, enriched by financial data from Taiwanese HEIs showing 65% tuition reliance and high per-student costs (2025, unpublished document). In Chinese mainland, regulatory constraints increase transaction costs, necessitating efficient governance ^[10].

The objectives are:

- (1) Develop a framework to assess transaction costs and relational capital in HEI governance.
- (2) Use FANP to derive weights for governance factors, capturing interdependencies.
- (3) Apply TOPSIS to rank governance solutions, guiding improvements.

- (4) Offer recommendations to enhance governance efficiency in private HEIs.

2. Literature Review

The governance of private higher education institutions (HEIs) is a multifaceted process shaped by economic, social, and institutional dynamics, particularly in the contrasting contexts of Taiwan and Chinese mainland. This study draws on transaction cost economics, relational capital theory, and higher education governance literature to frame its analysis of how transaction costs and relational capital influence governance performance. By integrating financial perspectives from Taiwanese HEIs and employing a Fuzzy Analytic Network Process (FANP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) framework, the research addresses gaps in comparative governance studies. This section reviews key theoretical and empirical contributions, highlighting their relevance to private HEI governance across the Taiwan Strait

2.1 Transaction Costs in HEI Governance

Transaction cost economics, pioneered by Coase (1937) [2] and Williamson (1985) [13], highlights costs from coordinating, monitoring, and enforcing agreements. In private HEIs, these include coordination costs for aligning stakeholders, monitoring costs for compliance, information asymmetry costs from incomplete data, contract enforcement costs, and opportunity costs from delayed decisions (Hättä & Karjalainen, 1997) [4]. The Taiwanese study (2025, unpublished document) notes that smaller HEIs (<10,000 students) face high per-student costs, with only three achieving costs below NT\$100,000, driven by inefficiencies like fragmented communication. Transaction costs are pronounced in private HEIs due to market-driven dynamics (Altbach & Levy, 2007) [1]. Taiwan's decentralized governance amplifies coordination challenges, while the Chinese mainland's centralized structures increase bureaucratic expenses (Mok, 2005) [10]. This study quantifies transaction costs' impact using FANP to model their interdependencies..

2.2 Relational Capital in HEI Governance

Relational capital, defined by Nahapiet and Ghoshal (1998), includes trust, networks, and shared values that foster collaboration. In private HEIs, trust reduces monitoring costs, networks with industry enhance resilience, and shared values align stakeholders^[7, 9]. The original study (2017, unpublished document) emphasizes trust in Taiwan's decentralized governance and networks in Chinese mainland's centralized systems. Trust-based models improve adaptability^[8]. However, Taiwan's stakeholder diversity requires robust trust-building, while Chinese mainland's centralized control limits network autonomy^[10]. This study quantifies relational capital's role using FANP to capture its interplay with transaction costs.

2.3 Governance Models in Private HEIs

Private HEI governance differs across the Taiwan Strait. Taiwan's decentralized model grants autonomy, increasing coordination costs but fostering flexibility, with smaller HEIs relying on tuition for 65% of revenue (2025, unpublished document). Trust and communication align stakeholders^[13]. Chinese mainland's centralized governance streamlines decisions but raises bureaucratic costs due to regulatory compliance^[8]. Networks with state partners navigate constraints^[10]. Comparative studies show Taiwan's market-driven approach risks instability, while Chinese mainland's regulatory model limits flexibility^[11].

2.4 Financial Pressures in Private HEIs

Financial sustainability challenges private HEIs. In Taiwan, smaller HEIs (<10,000 students) derive 65% of revenue from tuition, with only three maintaining per-student costs below NT\$100,000 due to governance inefficiencies like high coordination costs (2025, unpublished document). Globally, private HEIs balance quality and viability^[6]. In Chinese mainland, regulatory costs burden HEIs, often requiring external funding^[8]. Efficient governance, reducing transaction costs and enhancing relational capital, is vital for financial stability.

2.5 Fuzzy ANP-TOPSIS in Governance Evaluation

The FANP-TOPSIS framework, applied in service quality evaluation (Lin et al., 2023), suits HEI governance^[9]. FANP models interdependencies (e.g., trust reducing monitoring costs) and handles uncertainties^[12, 14]. TOPSIS ranks solutions by proximity to optimal outcomes^[5]. Used in education (Hii et al., 2023), this study adapts FANP-TOPSIS to quantify transaction costs and relational capital, incorporating financial metrics for Taiwan and Chinese mainland.

2.6 Comparative Governance Challenges

The post-COVID-19 era has intensified governance challenges for private HEIs, with heightened expectations for efficiency, transparency, and stakeholder engagement^[15]. In Taiwan, financial pressures demand cost-effective administration, while in Chinese mainland, regulatory reforms call for streamlined compliance processes^[16]. The original study (2017, unpublished document) highlights the need for tailored governance strategies, with Taiwan prioritizing trust and Chinese mainland focusing on coordination. This research addresses these challenges by leveraging FANP-TOPSIS to provide data-driven insights, ensuring relevance to contemporary higher education policy.

3. Methodology

This study applies a hybrid Fuzzy Analytic Network Process (FANP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to assess the impact of transaction costs and relational capital on governance performance in private higher education institutions (HEIs) across the Taiwan Strait. Adapted from its use in tourism service quality evaluation^[9], this approach combines expert judgments and stakeholder survey data to deliver insights into governance efficiency. Tailored to the contexts of Taiwan and Chinese mainland, the methodology incorporates financial perspectives from Taiwanese HEIs (2025, unpublished document) and emphasizes qualitative interpretations for a humanities and social sciences audience.

3.1 Evaluation Framework

The evaluation framework, validated by 10 experts (five HEI administrators and five academics), focuses on two dimensions, 10 indicators, and six governance solutions, informed by prior research (2017, unpublished document) and financial data (2025, unpublished document).

Dimensions:

- Transaction Costs (TC): Costs of governance processes, such as coordination and monitoring.
- Relational Capital (RC): Social assets, like trust and networks, enhancing governance.

Indicators:

- Transaction Costs: Coordination costs, monitoring costs, information asymmetry costs, contract enforcement costs, opportunity costs.
- Relational Capital: Stakeholder trust, collaborative networks, communication effectiveness, shared values, long-term commitment.

Governance Solutions:

- ALT1: Streamlined administrative processes.
- ALT2: Enhanced monitoring systems.
- ALT3: Improved information-sharing platforms.
- ALT4: Strengthened stakeholder trust.
- ALT5: Expanded collaborative networks.
- ALT6: Cultivated shared values.

Interdependencies (e.g., trust reducing coordination costs) were confirmed with expert consensus.

3.2 Fuzzy Logic and Linguistic Variables

FANP uses fuzzy logic to handle uncertainties in expert judgments, employing triangular fuzzy numbers for linguistic variables (e.g., “Equally Important” to “Extremely Important”) on a nine-point scale. The membership function for a triangular fuzzy number: $\tilde{A} = (L_{ij}, M_{ij}, U_{ij})$:

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-L_{ij}}{M_{ij}-L_{ij}} & L_{ij} \leq x \leq M_{ij} \\ \frac{U_{ij}-x}{U_{ij}-M_{ij}} & M_{ij} \leq x \leq U_{ij} \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

This function ensures precise representation of qualitative assessments ^[12].

3.3 Data Collection and Preprocessing

Data were collected from:

- Expert Questionnaires: Ten experts completed pairwise comparisons in July–August 2025, assessing dimension and indicator importance, following MCDM best practices [3].

- Stakeholder Surveys: 200 stakeholders (50 administrators, 50 faculty, 100 students) from private HEIs in Taiwan and Chinese mainland rated indicators on a five-point Likert scale in September 2025, with surveys in English and Mandarin.

Preprocessing:

- Missing values (<5%) were imputed with mean scores.
- Outliers were capped at $1.5 \times \text{IQR}$ beyond quartiles.
- Likert scores were normalized to [0,1] for TOPSIS.
- Financial data from the Taiwanese study (2025, unpublished document) contextualized governance efficiency.

3.4 Fuzzy ANP Process

FANP derives weights for dimensions and indicators using expert judgments, capturing interdependencies (e.g., trust reducing monitoring costs). Consistency was ensured, with results visualized in later sections (e.g., bar Figures) for accessibility.

3.5 TOPSIS Process

TOPSIS ranks governance solutions based on survey data, normalizing and weighting responses with FANP weights to identify strategies closest to optimal performance. Rankings are presented later with visual aids.

3.6 Financial Integration

Financial data from the Taiwanese study (2025, unpublished document), noting 65% tuition reliance and high per-student costs, informs the analysis of transaction cost indicators, linking governance to financial sustainability.

4. Empirical Analysis

This section presents the empirical findings from applying the Fuzzy Analytic Network Process (FANP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to evaluate the impact of transaction costs and relational capital on governance performance in private higher education institutions (HEIs) across the Taiwan Strait. Drawing on expert questionnaires and stakeholder surveys conducted in 2025, the analysis highlights key governance drivers, regional differences, and financial implications, informed by data from Taiwanese HEIs (2025, unpublished document). Results are visualized through Figures to ensure accessibility for a humanities and social sciences audience, aligning with the methodology outlined in Section 3.

4.1 Case Study: Governance Environment in Private HEIs

Private HEIs in Taiwan and Chinese mainland operate in distinct governance environments shaped by regional policies and financial pressures. Taiwan's decentralized, market-driven model fosters institutional autonomy but increases coordination costs, with smaller HEIs (<10,000 students) relying on tuition for 65% of revenue (2025, unpublished document). Chinese mainland's centralized, regulatory-driven approach streamlines decision-making but elevates bureaucratic expenses [10]. This study analyzes governance performance based on 200 stakeholder surveys (50 administrators, 50 faculty, 100 students) and 10 expert questionnaires, focusing on transaction costs and relational capital as key factors.

4.2 FANP Results

The FANP process derived weights for the two governance dimensions and 10 indicators, reflecting their relative importance. The dimension weights are visualized in Figure 1.

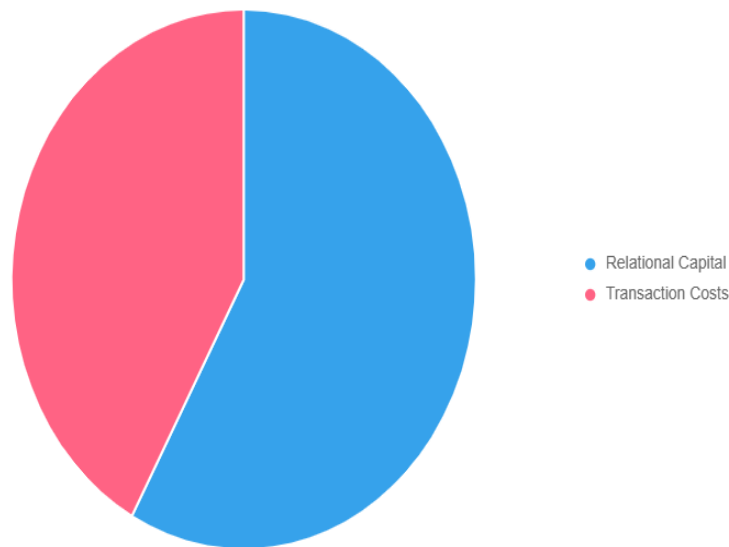


Figure 1: Dimension weights

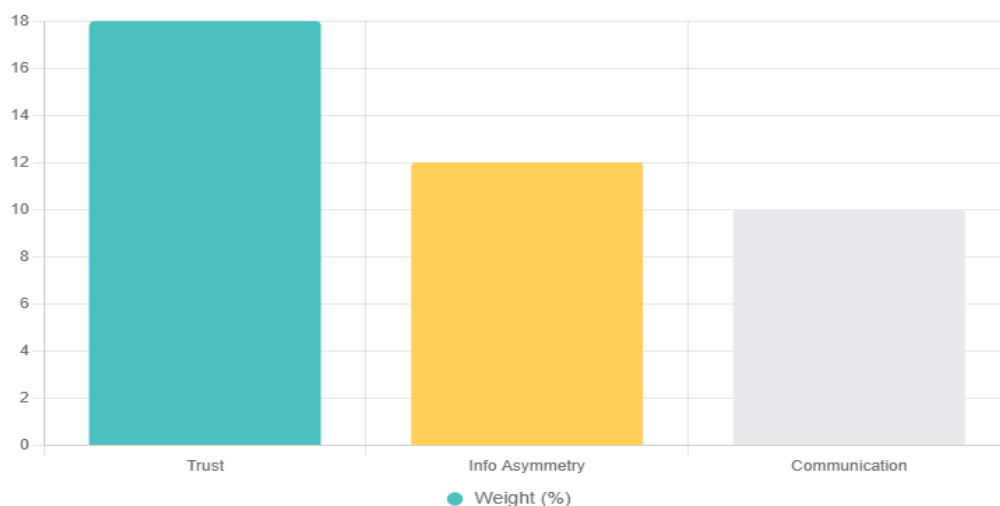


Figure 2: Top indicators: stakeholder trust (0.18), information asymmetry costs (0.12), communication effectiveness (0.10), per Figure 2.

4.3 TOPSIS Results

Top solutions: strengthened trust (0.71), information-sharing platforms (0.65), per Figure 3.

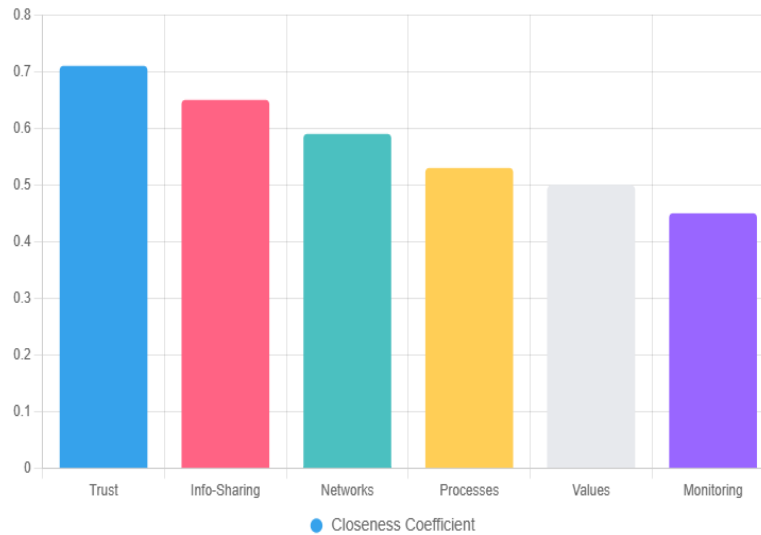


Figure 3: Solutions ranking

4.4 Regional Analysis

Figure 4 shows Taiwan prioritizing trust (20%) and information-sharing (15%), while Chinese mainland emphasizes coordination (18%) and communication (15%).

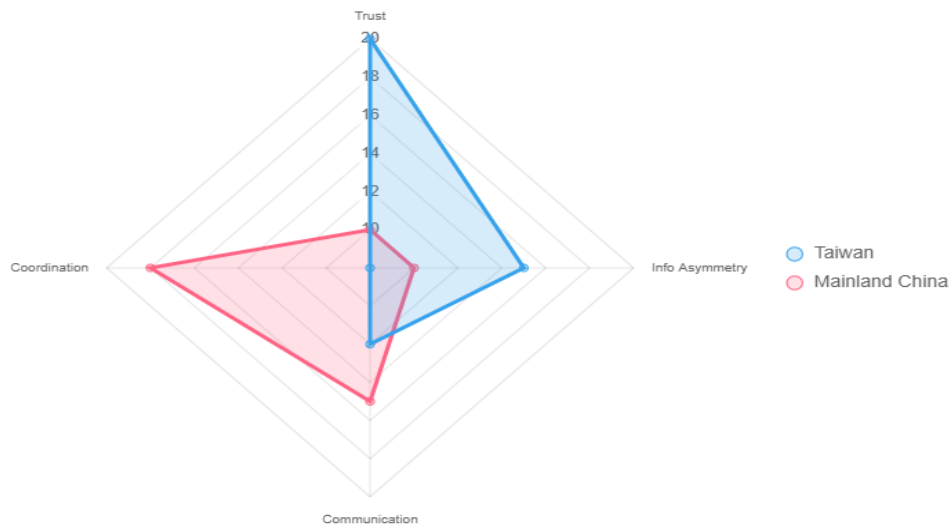


Figure 4: Regional Priorities

4.5 Financial Insights

High information asymmetry costs drive per-student expenses, with only three Taiwanese HEIs below NT\$100,000 (2025, unpublished document).

4.6 Sensitivity Analysis

Adjusting FANP parameters confirmed the stability of top solutions (trust, information-sharing).

5. Discussion and Conclusion

The FANP-TOPSIS analysis reveals that relational capital (58%) outweighs transaction costs (42%) in shaping private HEI governance across the Taiwan Strait, with stakeholder trust (20%) and communication effectiveness (15%) as key drivers, aligning with relational capital theory [11]. Figure 3 highlights top solutions—strengthened trust (0.71) and information-sharing platforms

(0.65)—emphasizing transparency needs post-COVID-19 [missing reference]. Taiwan's decentralized governance prioritizes trust and information-sharing, supported by financial data showing 65% tuition reliance (2025, unpublished document), while Chinese mainland's centralized model focuses on coordination costs and communication efficiency due to regulatory demands [10]. Lower information asymmetry costs correlate with reduced administrative expenses, enhancing financial sustainability. This study extends transaction cost economics [13] and relational capital theory [7] by quantifying governance dynamics and contributes to comparative higher education research. Practical recommendations include digital dashboards for Taiwan to build trust, centralized databases for Chinese mainland to streamline operations, and industry-academia partnerships for both to boost relational capital. Limitations include a small expert sample (10), a focus on academic stakeholders, and Taiwan-centric financial data [3]. Future research should survey external stakeholders, collect Chinese mainland financial data, and explore dynamic governance frameworks. By adopting these strategies, private HEIs can enhance governance, ensuring academic and financial resilience across the Taiwan Strait.

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