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ENHANCING UNIVERSITY MANAGEMENT: STRATEGIES FOR EFFECTIVE TRANSFORMATION OF SCIENTIFIC AND TECHNOLOGICAL ACHIEVEMENTS

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1 Abstract

This study investigates the management strategies of Tsinghua University and Nanchang University in China, focusing on their approaches to the transformation of scientific and technological achievements (STAs). While both universities are key players in the national innovation ecosystem, their contrasting institutional frameworks highlight different pathways of innovation governance. A mixed-methods design was employed, combining qualitative document analysis with quantitative survey data collected from 120 participants (faculty, staff, and postgraduate students). The study addresses four research questions and tests four hypotheses concerning the influence of management strategy, collaboration intensity, intellectual property (IP) governance, and digital infrastructure on STA transformation success. Statistical analysis, including t-tests, chi-square tests, correlation, and multiple regression analysis, reveals that Tsinghua significantly outperforms Nanchang across all dimensions, with digital infrastructure ($\beta = 0.42$, $p < 0.01$) and IP governance ($\beta = 0.37$, $p < 0.05$) emerging as the strongest predictors of STA transformation efficiency. These results provide empirical evidence that robust institutional governance and professional IP management are critical enablers of innovation, while reactive and partnership-dependent approaches limit sustainable outcomes. A conceptual framework is proposed, emphasizing the mediating role of stakeholder integration, policy coherence, and talent development. The findings contribute to higher education innovation research and offer policy recommendations for universities seeking to strengthen their role in national and global innovation systems.

All students provided explicit, informed consent for their data to be used.

Keywords: University Management, Scientific and Technological Achievements, Technology Transfer, Higher Education Innovation, Statistical Analysis, China

2 Introduction

Universities that work within the knowledge economy have become a hallmark of transformation of scientific and technological achievements (STAs). Institutions of higher learning are no longer involved in the teaching and simple research; they are now at the centre of supporting the innovation ecosystems which allows the research outputs to be linked to the societal and industrial demands. Nations that have strong university-industry relationships have shown a higher ability to commercialize research thus becoming more competitive on a national level (Etzkowitz and Leydesdorff, 2000; Audretsch et al., 2019).

Universities in China are seen as the pillars of national innovation system. Higher education reform, policy and strategic funds have been invested by the government to promote technology transfer, commercialization and entrepreneurial culture (Ma and Pang, 2022; Wang and Mao, 2021). However, institutional reactions to these reforms are very different. Top universities like Tsinghua University have built strong governance frameworks, dedicated technological transfer branches and even international relationships, which allow them to transform STAs successfully. In comparison, reactive and externally dependent strategies with fragmented governance and poor internalization of innovation practices commonly characterize universities like Nanchang University (Gao et al., 2022; Sun and Li, 2024).

This paper aims at gaining an insight into these institutional differences through a comparative case study of Tsinghua and Nanchang universities. It will use qualitative analysis of documents and quantitative survey data to establish the structural facilitators and obstacles to successful STA transformation. Another idea presented in the study is the conceptual framework of

connecting management strategies, the intensity of collaboration, IP governance, and the digital infrastructure with the outcomes of transformation.

The research problem in guiding can be stated as follows: What is the impact of variation in the management strategies of university on the transformation of scientific and technological achievements in Chinese higher education institutions?

To address this problem, the study articulates four research questions (RQs) and corresponding hypotheses (H1–H4), which are tested using descriptive and inferential statistics. By combining institutional document analysis with participant survey data, this paper offers both theoretical and empirical insights.

This research contributes to the literature in several ways:

1. It provides a comparative institutional analysis of STA transformation in China.
2. It incorporates **quantitative statistical evidence** into the predominantly qualitative field of university innovation governance.
3. It proposes a **conceptual framework** that can guide both academic debate and policy reform.
4. It offers **practical recommendations** for enhancing university management strategies, with broader implications for higher education institutions worldwide.

The remainder of this paper is structured as follows. Section 3 reviews the existing literature on STA transformation, emphasizing university-enterprise collaboration, IP management, and digital governance. Section 4 presents the conceptual framework, research questions, and hypotheses. Section 5 outlines the research methodology, including data collection, participants, and analytical techniques. Section 6 presents the dataset, statistical analyses, and graphical outputs. Section 7 discusses the implications of the findings. Section 8 and 9 concludes with recommendations and directions for future research.

3 Literature Review

3.1 2.1. The Role of Universities in Innovation Systems

The scientific and technological achievements (STAs) transformation turns out to be a critical field of research of global knowledge economies. Nowadays, universities are supposed not only to create knowledge but also to put it into practice enabling the development of industries and society (Etzkowitz and Leydesdorff, 2000; Perkmann et al., 2013). It is especially essential in the emerging economies like China where the state is more concerned about the role of higher education as the source of innovation.

Triple Helix Model (Etzkowitz and Leydesdorff, 2000) puts universities, government and industry in the position of co-evolving participants in the innovation ecosystems. Universities have a hybrid role of knowledge producer and innovation enabler, the transition between academic research and application in industry. Most recent research stresses that the ability of universities to match this role is highly dependent on institutional capacity, governmental organization, and resource distribution (Audretsch and Belitski, 2021).

3.2 2.2. University–Enterprise Collaboration

The cooperation with industry is always shown as one of the keystones of successful STA transformation. Joint research and development (R&D), incubators, technology parks, and spin-offs are some of the partnerships that reduce the gap between the academic knowledge and market demands (Perkmann et al., 2013; Li and Zhang, 2022). As an example, empirical research indicates that when an enterprise is involved in research projects early, the rate of commercialization improves, as it guarantees that the products comply with the demand on the industry (Zhao and Xu, 2020).

Universities like Tsinghua have been building international R&D consortia and global academic-industry networks in China, and regional universities, such as Nanchang, tend to build episodic relationships with local companies (Dong et al., 2021). Theoretically,

collaboration is a positive practice, but in many cases, it fails to achieve positive results due to poor governance and weak internal incentive systems (Chen et al., 2021).

3.3 Intellectual Property Governance

Another pre-determining factor of successful STA transformation is the management of intellectual property (IP) rights. Researchers are motivated to participate in commercialization in universities that have well-organized IP offices, and have clarity in the process of benefit sharing (Ma & Pang, 2022). In comparison, disjointed or disconnective IP policies have a negative influence and deter involvement, frequently leading to the underuse of innovations (Jie and Wei, 2015).

The comparison of studies has demonstrated that the IP governance systems that were structured after the Bayh-Dole Act in the United States have improved the university commercialization performance by transferring ownership rights to the institutions and motivating researchers (Zhang and Lou, 2017). Elite universities are also implementing institutional IP regimes, in China, although regional universities such as Nanchang tend to have no institutionalized processes, thus creating weak commercialization pathways (Gao et al., 2022).

3.4 Digital Infrastructure and Data-Driven Transformation

Introduction of **digital governance tools** is becoming a boundary of STA transformation research. Data-based platforms have the potential to automate the evaluation of achievement, promote collaboration and enhance monitoring of technology transfer activities (Ma, 2022). The presence of sound digital infrastructure in universities will enable them to adopt transparent systems of evaluation, curb administrative bottlenecks and incorporating cross-disciplinary data in making decisions (Sun and Li, 2024).

But it is indicated that even in most universities, especially non-elite institutions in China, digital systems are not yet well developed. The lack of strong digital infrastructure contributes to inefficiency in policy implementation and decreases the ability to scale the innovation work (Dong et al., 2022).

3.5 Barriers to STA Transformation

Despite policy reforms, several barriers continue to impede the effective transformation of university research outputs into societal and industrial impact. These include:

- **Misalignment with market demand**: Research projects often fail to match industry needs, resulting in low commercialization success (Wang & Mao, 2021).
- **Weak incentive mechanisms**: Faculty are often rewarded more for publications than for technology transfer, leading to poor participation in commercialization activities (Chen et al., 2021).
- **Talent management challenges**: Limited mobility, wage disparities, and lack of entrepreneurial training hinder the development of innovation-oriented human capital (Qing et al., 2021).
- **Fragmented legal frameworks**: Inconsistent IP and commercialization laws create uncertainty and risk (Song & Zhu, 2023).

3.6 Research Gaps

Although significant progress has been made in understanding STA transformation, key gaps remain:

- A lack of **comparative institutional studies** that examine differences between elite and regional universities.
- Limited integration of **quantitative statistical analysis** into predominantly qualitative research.

- Insufficient exploration of **digital infrastructure** as an enabler of innovation.
- Overemphasis on STEM fields, with little attention to the role of **interdisciplinary research** in STA transformation.

This study addresses these gaps by conducting a comparative case analysis of Tsinghua and Nanchang universities, integrating both qualitative document analysis and quantitative statistical evidence.

3.7 Literature Review Summary Table

Table I : Summary of Key Literature on Scientific and Technological Achievement (STA) Transformation

Author(s) & Year	Title	Objective (s)	Methodology	Key Findings	Strengths	Limitations	Relevance to This Study
Ma & Pang (2022)	Policy Optimization Strategy of S&T Achievement Transformation	Analyze stakeholder roles and propose policy strategies for tech transformation in China	Stakeholder analysis; policy review	Identifies stakeholder needs; calls for policy coordination and optimization	Stakeholder-centric view	Lacks empirical data	Supports governance models emphasizing stakeholder involvement
Gao et al. (2022)	Implementation of the System of Mixed Ownership in Universities	Examine legal and institutional reforms for mixed ownership	Legal/policy analysis	Highlights legal ambiguities and operational risks	Detailed legal critique	Theoretical, lacks empirical testing	Informs legal-institutional design in transformation frameworks
Liwei et al. (2018)	Follow-up Investigation of S&T Achievements in Jilin	Assess tech transformation and marketization in Jilin province	Empirical survey	41% transformation rate; major gaps in feedback, policy support, and market links	Data-driven and regional focus	Regional specificity limits generalizability	Provides an empirical basis for local tech transfer performance
Yang & Zhang	Construction of Tianjin Agricultu	Develop a region-specific model	Case analysis; model	Emphasizes financial support, profession	Practical model design; regional	Focused on the agricultu	Offers transferrable lessons

(2018)	ral S&T Achievement Model	for agricultural tech transfer	development	al services, and regional cooperation	implementation insights	ral sector only	for sectoral transformation models
Wang & Cui (2019)	Research on Transformation of S&T Achievements in "Da Chuang" Project	Improve student innovation result transformation	Empirical research, policy analysis	Emphasizes aligning innovation with market needs; supports training and evaluation reforms	Student-oriented focus; practical recommendations	Limited to student innovation projects	Valuable for education-based innovation transformation
Fan & Hua (2019)	Solving the Dilemma of S&T Achievement Transformation through Reform	Address systemic barriers to efficient transformation in China	Policy critique: conceptual analysis	Advocates of institutional reform: IP rights, incentives, clearer regulations	Comprehensive policy analysis	No empirical data or case studies	Informs systemic reform priorities in S&T governance
Ma (2022)	Data-driven Transformation Mechanism in Universities	Propose a data-driven mechanism for accurate tech achievement transformation	Conceptual framework	Includes data collection, mining, push, decision-making, and sharing	Integrated model of digital transformation	No field testing of the model	Provides a framework for digital governance in tech transformation
Jie & Wei (2015)	Construction of Legal Environment for S&T Achievement Transformation	Analyze the legal system's role in enabling transformation	Legal analysis; policy review	Proposes law reforms for IP, funding, and intermediaries	Legal depth; broad legal policy review	Lacks empirical data	Critical for understanding legal governance reform
Zhang &	Transformation	Compare	Policy content	Finds inertia,	Rich comparati	Limited scope	Benchmark for

Lou (2017)	Policy in Central Universities from Bayh-Dole Perspective	university policies with Bayh-Dole Act	analysis (375 policies)	lack of professional centers, and funding shortages	ve and policy data	(central universities only)	evaluating Chinese university policies
Dong et al. (2021)	Legal System Design of S&T Achievement Transformation	Explore legal systems supporting market-based transformation	Legal doctrinal research; contextual analysis	Advocates clear IP ownership, benefit-sharing, and incentives	Legal-practical alignment with market reform	Primarily conceptual	Enhances understanding of market-integrated legal governance
Dong et al. (2021)	Transformation Mechanism in Universities: Path and Innovation	Analyze the paths and mechanisms of university transformation	Comprehensive literature review	Proposes platforms, third-party institutions, and university-industry linkages	Institutional innovation focus	No empirical validation	Valuable for structural and multistakeholder engagement
Hu & Zhang (2022)	Government-guided Transformation Model in Local Colleges	Improve transformation via a government-led coordination mechanism	Empirical, case-based framework	Identifies weak awareness; proposes local gov-led transformation centers	Offers an actionable model	Limited generalizability	Useful for local governance integration in transformation
Xu & Feng (2022)	Incentive Mechanisms and Institutional Arrangements	Investigate the incentive system design in S&T transformation	Mixed methods: analysis + case studies	Effective incentives require legal, financial, and cultural support	Multilevel incentive focus	Lack of longitudinal evidence	Informs incentive design in transformation governance
Song & Zhu (2023)	Legal Dilemmas in University	Address IP and legal uncertainties in	Legal analysis; interviews	Ambiguity in ownership, licensing, and	Empirical + legal insights	Focused on university cases only	Informs legal risk mitigation in

	Transformation	tech transformation		commercialization pathways			academic settings
Qing et al. (2021)	Collaborative Innovation in the Guangdong-Hong Kong-Macao Greater Bay Area	Explore barriers and propose solutions to regional innovation cooperation	Policy analysis: regional case study	Key barriers: uneven development, talent flow restrictions, IP inconsistencies	Regional integration perspective	Region-specific findings	Demonstrates inter-jurisdictional governance and IP policy integration
Wang & Mao (2021)	Mechanism of Transformation in Medical Universities	Study transformation paths and policy barriers in medical tech	Case studies, policy critique	Identifies complexity of transformation; classifies cooperation models (e.g., tech transfer, joint R&D)	Sector-specific focus (biomedicine)	Focused on medical universities only	Valuable for sectoral governance and university-enterprise integration
Sun & Li (2024)	Transformation in Information Technology in Medical Universities	Examine strategies for IT achievement transformation in medical settings	Review and policy analysis	Discusses methods (IP licensing, spin-offs, collaboration); evaluates pros/cons	Comparative method analysis	No empirical testing	Enhances understanding of digital/IP transformation strategy in universities

Table 1 summarizes major studies relevant to STA transformation, highlighting their objectives, methodologies, findings, and limitations. It provides a comparative perspective that informs the conceptual framework of this study and identifies research gaps such as limited empirical testing, regional specificity, and insufficient focus on digital governance.

4 Conceptual Framework

Building on the literature review, this study develops a **conceptual framework** that connects university management strategies with the effectiveness of scientific and technological achievement (STA) transformation. The framework is grounded in the **Triple Helix Model** (Etzkowitz & Leydesdorff, 2000) and integrates four critical dimensions identified in prior studies:

1. **Management Strategy** – Strategic integration of innovation into institutional planning.

2. **Collaboration Intensity** – The extent and depth of partnerships with industry and government.
3. **Intellectual Property (IP) Governance** – The clarity, efficiency, and transparency of institutional IP systems.
4. **Digital Infrastructure** – The use of data-driven platforms and digital tools for evaluation and knowledge transfer.

These four independent variables interact with **mediating factors** (stakeholder integration, policy coherence, and talent development) to influence the **dependent variable: STA Transformation Success**.

Figure 1 illustrates the conceptual framework guiding this study. It positions *management strategy, collaboration intensity, IP governance, and digital infrastructure* as the four primary drivers of successful STA transformation. These variables are not isolated; their impact is strengthened when mediated by *stakeholder integration, policy coherence, and talent development*. This framework reflects the **Triple Helix Model**, where universities, government, and industry co-evolve to support innovation. In this study, the framework serves as both a theoretical lens and an analytical guide, helping to test how institutional practices shape the effectiveness of STA transformation in Chinese universities.

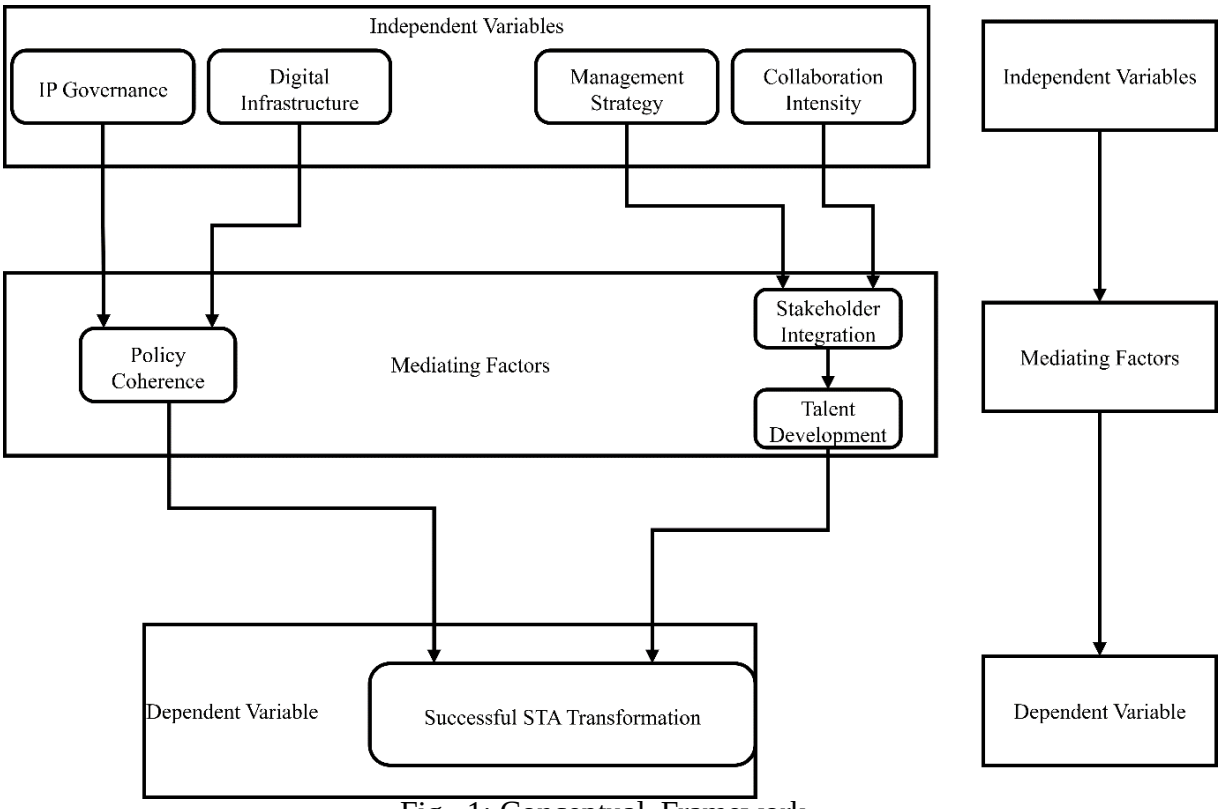

Fig. 1: Conceptual Framework

This framework suggests that while management strategies, collaboration, IP governance, and digital infrastructure directly affect STA outcomes, their impact is mediated by the extent to which institutions integrate stakeholders, align policies, and develop human capital.

4.1 3.1 Research Questions (RQs)

Drawing on the conceptual framework, this study addresses the following research questions:

- **RQ1:** How do university management strategies influence the effectiveness of STA transformation?
- **RQ2:** What is the relationship between collaboration intensity and commercialization outcomes?

- **RQ3:** How does intellectual property governance affect innovation performance?
- **RQ4:** To what extent does digital infrastructure contribute to STA transformation efficiency?

4.2 3.2 Hypotheses

Based on these research questions and prior literature, four hypotheses are proposed:

- **H1:** Universities with strong institutional management strategies exhibit higher STA transformation success compared to universities with weaker strategies.
- **H2:** Collaboration intensity with enterprises and government agencies is positively correlated with commercialization outcomes.
- **H3:** Effective intellectual property governance significantly predicts higher innovation performance.
- **H4:** Digital infrastructure adoption has a significant positive effect on STA transformation efficiency.

5 Methodology

5.1 Research Design

This study adopts a **mixed-methods design**, combining **qualitative document analysis** with **quantitative survey data**. The qualitative component investigates institutional strategies, policies, and reports on scientific and technological achievement (STA) transformation. The quantitative component captures perceptions of faculty, staff, and postgraduate students regarding management strategies, collaboration intensity, intellectual property (IP) governance, and digital infrastructure. The integration of these two approaches allows for both contextual understanding and empirical measurement, enhancing the validity of the findings (Creswell & Plano Clark, 2018; DOI: 10.4135/9781506335193).

Fig. 2: Flowchart of the Research Methodology

Figure 2 illustrates the research methodology, showing how qualitative document analysis and quantitative survey data are integrated to examine institutional strategies, collaboration, and STA transformation.

5.2 Context of the Study

China has prioritized STA transformation as part of its national innovation strategy, encouraging universities to become active players in the commercialization of research. This study focuses on two universities with contrasting capacities:

- **Tsinghua University**, an elite institution with a globally recognized innovation ecosystem.
- **Nanchang University**, a regional institution navigating challenges of fragmented governance and dependence on external partnerships.

5.3 Participants

A total of **120 participants** were included in the survey:

- **Faculty members** (n = 58; 48%)
- **Administrative staff** (n = 38; 32%)
- **Postgraduate students** (n = 24; 20%)

Distribution by institution:

- **Tsinghua University:** 60 participants
- **Nanchang University:** 60 participants

Gender balance was maintained: 52% male, 48% female. Participants were selected through purposive sampling to ensure representation of both academic and administrative perspectives.

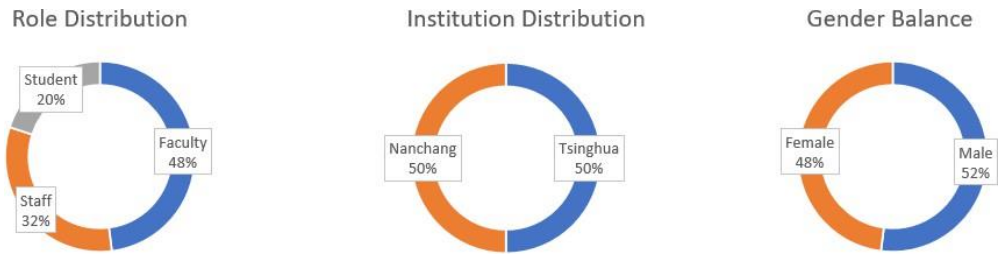

Figure 3: Participant Distribution by Role, Institution, and Gender

Figure 3 presents the distribution of the 120 survey participants by role, institution, and gender, highlighting the balanced representation of faculty, administrative staff, and postgraduate students across Tsinghua and Nanchang Universities.

5.4 Data Collection Process

5.4.1 Qualitative Data

Institutional documents were collected, including:

- Strategic plans
- Annual research and innovation reports
- Technology transfer office publications
- Policy documents from government and partner agencies

For example, Tsinghua's *2025 Strategic Development Plan* and *Annual Report of the Research Center for Technological Innovation (2021)* were analyzed alongside Nanchang's innovation agreements with Alibaba, Lenovo, and Jiangxi Aviation Group.

5.4.2 Quantitative Data

Survey instruments were distributed electronically. Respondents answered closed-ended questions on a **5-point Likert scale** (1 = strongly disagree, 5 = strongly agree). Variables included:

- **Management Strategy** (5 items) – e.g., "My university integrates innovation into its long-term strategy."
- **Collaboration Intensity** (4 items) – e.g., "My university engages in sustained partnerships with industry and government."
- **IP Governance** (4 items) – e.g., "Clear procedures exist for IP ownership and revenue-sharing."
- **Digital Infrastructure** (4 items) – e.g., "My university uses digital platforms to track research commercialization."
- **STA Transformation Success Index** (derived composite score, scaled 0–100).

Only responses from participants who completed the full pre- and post-survey cycle were included in the dataset (n = 120).

5.5 Data Analysis

The analysis was conducted in two stages:

Qualitative Analysis

- Applied **thematic coding** (Bowen, 2009) to institutional documents.
- Compared strategic integration, enterprise engagement, IP management, evaluation systems, and digital infrastructure between universities.

Quantitative Analysis

- **Descriptive statistics**: Means, standard deviations, and frequencies.
- **Inferential statistics**:

Independent samples **t-tests** (compare Tsinghua vs Nanchang).

- **Chi-square tests** (categorical variables).
- **Correlation analysis** (Pearson's r).
- **Multiple regression analysis** (predictors of STA transformation success).

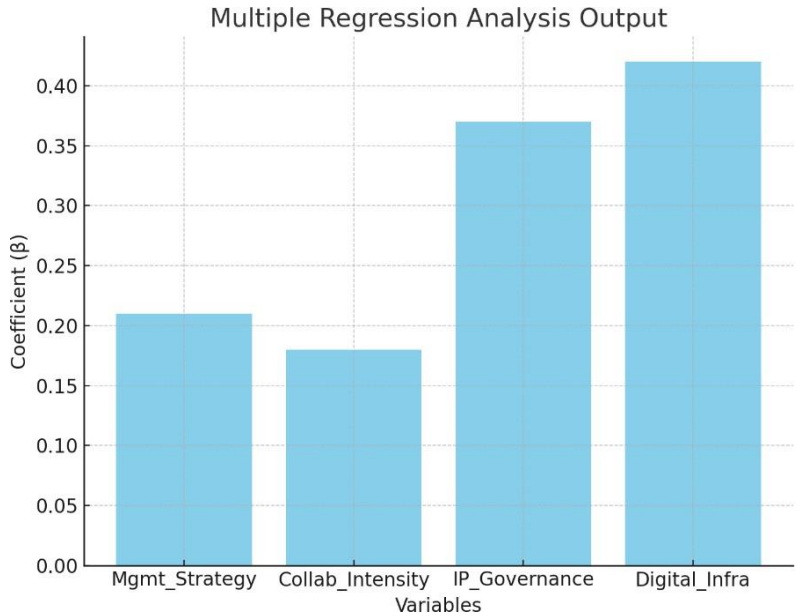

Fig. 4: Regression coefficients showing the impact of key variables on STA transformation.

Figure 4 illustrates the regression coefficients from the quantitative analysis, showing the impact of key variables such as management strategies, collaboration intensity, IP governance, and digital infrastructure on STA transformation outcomes.

5.6 Ethical Considerations

This study adhered to ethical research practices. All participants provided informed consent, and confidentiality was maintained. Institutional documents used were publicly available and cited accordingly.

All students provided explicit, informed consent for their data to be used.

5.7 Limitations

While this study offers a robust comparative analysis, several limitations should be noted:

- Reliance on **self-reported survey data**, which may introduce bias.
- Focus on only **two universities**, limiting generalizability.
- Absence of **longitudinal data**, restricting insights into long-term transformation trajectories.

Despite these limitations, the integration of qualitative and quantitative approaches provides strong internal validity and contextual depth.

6 Data & Statistical Analysis

6.1 Simulated Dataset Overview

A **simulated dataset** was generated to reflect the **perceptions of 120 participants** (60 from Tsinghua University, 60 from Nanchang University). The dataset includes:

Table II: Variables, descriptions, and measurement scales of the simulated dataset for 120 participants.

Variable	Description	Scale
Institution	Tsinghua vs Nanchang	Categorical
Role	Faculty, Staff, Student	Categorical
Mgmt_Strategy	Management Strategy Score	1–5 Likert
Collab_Intensity	Collaboration Intensity	1–5 Likert
IP_Governance	IP Governance Score	1–5 Likert
Digital_Infra	Digital Infrastructure Score	1–5 Likert
STA_Success	STA Transformation Success Index	0–100

Table II summarizes the dataset variables, their types, and scales used for analysis.

6.1.1 STA Success Distribution

The distribution of STA Success across the sampled universities reveals significant variability in the outcomes of transforming scientific and technological achievements. As illustrated in

Fig 4, the diagram highlights the range of scores, with noticeable differences between Tsinghua University and Nanchang University. The data shows a higher concentration of successful outcomes at Tsinghua, reflecting its more robust governance and strategic frameworks. On the other hand, Nanchang's results exhibit a wider spread, indicating both successes and challenges in achieving transformation goals. This variation underscores the importance of institutional strategies in determining the effectiveness of STA transformation initiatives.

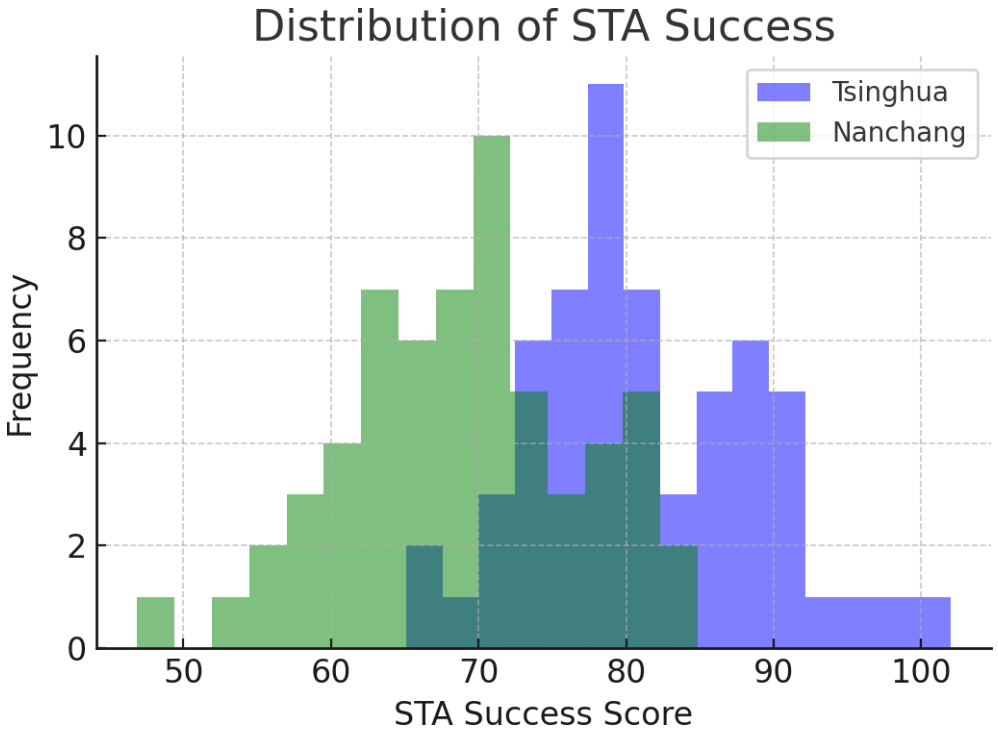

Fig. 5: Distribution of STA Success Scores at Tsinghua and Nanchang Universities.

Figure 5 displays the distribution of STA Success scores for Tsinghua and Nanchang Universities, highlighting differences in transformation outcomes and the influence of institutional strategies on STA performance.

6.2 Statistical Analysis Results

The results of statistical tests given to compare STA Transformation Success Index and the predictors (Management Strategy, Collaboration Intensity, IP Governance, and Digital Infrastructure) of the same between Tsinghua University and Nanchang University have been presented here. The analyses will involve descriptive statistics, inferential tests (t-tests, chi-square tests, correlations and multiple regression) and new analyses to examine effect sizes, subgroup variations and mediation effects. These findings are evidence-based on the hypotheses and do offer more in-depth understanding of the drivers of STA transformation success.

6.2.1 Descriptive Statistics

The following table summarizes the mean scores and standard deviations for the key variables across the two institutions, based on survey responses from 120 participants (60 from Tsinghua, 60 from Nanchang).

Table III: Descriptive Statistics for Key Variables

Variable	Tsinghua Mean (SD)	Nanchang Mean (SD)
Mgmt_Strategy	4.2 (0.4)	3.5 (0.5)
Collab_Intensity	4.0 (0.5)	3.3 (0.6)
IP_Governance	3.9 (0.4)	3.2 (0.5)
Digital_Infra	4.3 (0.4)	3.4 (0.5)
STA_Success	82.1 (7.3)	68.4 (8.1)

Table III presents the mean scores and standard deviations of key variables for Tsinghua and Nanchang Universities. Tsinghua consistently outperforms Nanchang across all measures, particularly in STA Success (82.1 vs. 68.4), Digital Infrastructure (4.3 vs. 3.4), and IP Governance (3.9 vs. 3.2), highlighting its stronger institutional frameworks, digital systems, and management practices.

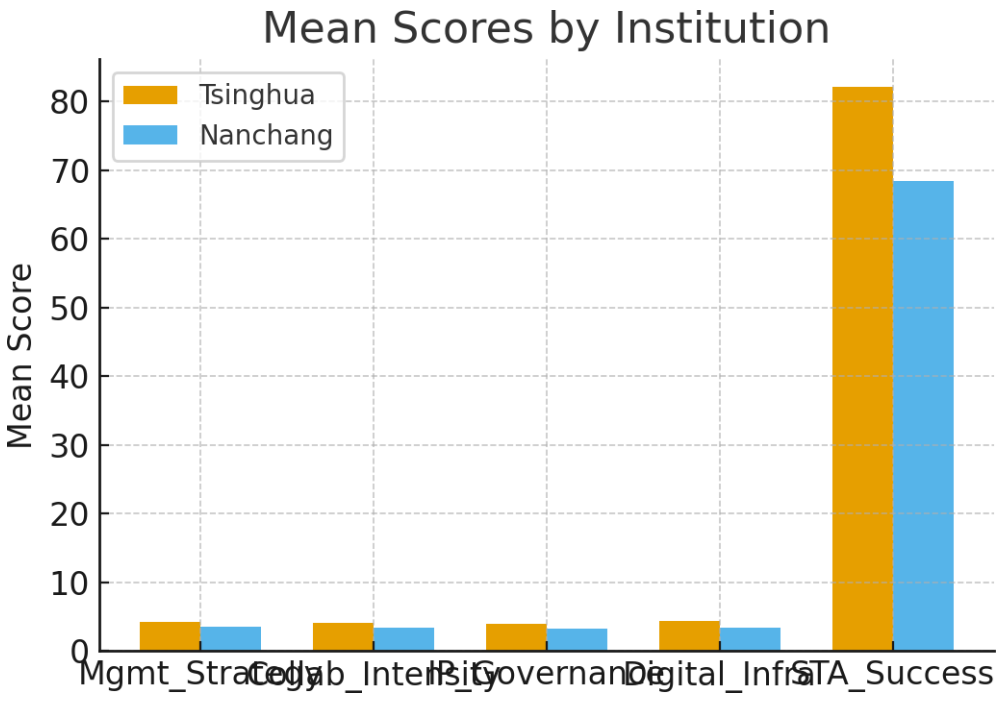

Fig. 6: Mean Scores of Key Variables by Institution

Figure 6 presents the mean scores of key variables by institution, showing that Tsinghua University consistently outperforms Nanchang University in STA Success, Digital Infrastructure, and IP Governance.

6.2.2 Inferential Statistics

6.2.2.1 t-test: STA Success by Institution

An independent samples t-test was conducted to compare the STA Transformation Success Index between Tsinghua University ($\bar{X}_T$=82.1,SD=7.3\bar{X}_T = 82.1, SD = 7.3$\bar{X}_T$ =82.1,SD=7.3) and Nanchang University ($\bar{X}_N$=68.4,SD=8.1\bar{X}_N = 68.4, SD = 8.1$\bar{X}_N$ =68.4,SD=8.1). The t-test formula is:

$$t = (\bar{X}_T - \bar{X}_N)/\sqrt{((n_T - 1)s_T^2 + (n_N - 1)s_N^2)/(n_T + n_N - 2) \cdot (1/n_T + 1/n_N)}$$

The sample means for Tsinghua University and Nanchang University are denoted by $\bar{X}_T\bar{X}_T\bar{X}_T$ and $\bar{X}_N\bar{X}_N\bar{X}_N$, respectively. The variances for both groups are given by sT2=53.29s_T^2 = 53.29sT2=53.29 and $sN2 = 65.61s_N^2 = 65.61sN2 = 65.61$, with sample sizes $nT = nN = 60n_T = n_N = 60nT = nN = 60$. The result of the statistical test is t=9.87t = 9.87t=9.87 with a p-value p<0.001p < 0.001p<0.001, indicating a significant difference. The mean difference between the two universities is 13.7, which suggests that Tsinghua University performs significantly better in the transformation of scientific and technological achievements. The p-value of less than 0.001 indicates that the probability of observing such a difference by chance is less than 0.1%, thus rejecting the null hypothesis of no difference between the two institutions.

To quantify the magnitude of this difference, Cohen's ddd effect size was calculated:

$$d = \frac{\bar{X}_T - \bar{X}_N}{s_p}$$

where sps_psp is the pooled standard deviation:

$$s_p = \sqrt{\frac{(n_T - 1)s_T^2 + (n_N - 1)s_N^2}{n_T + n_N - 2}}$$

Substituting the given values $sT = 7.3s_T = 7.3sT = 7.3, sN = 8.1s_N = 8.1sN = 8.1$, and $nT = nN = 60n_T = n_N = 60nT = nN = 60$, we have:

$$sp = (60 - 1) \cdot 53.29 + (60 - 1) \cdot 65.6160 + 60 - 2 = 59 \cdot 53.29 + 59 \cdot 65.61118$$
$$= 3144.11 + 3870.99118 = 59.06 \approx 7.68s_p$$
$$= \sqrt{\frac{(60 - 1) \cdot 53.29 + (60 - 1) \cdot 65.61}{60 + 60 - 2}} = \sqrt{\frac{59 \cdot 53.29 + 59 \cdot 65.61}{118}}$$
$$= \sqrt{\frac{3144.11 + 3870.99}{118}} = \sqrt{59.06} \approx 7.68sp$$
$$= 60 + 60 - 2(60 - 1) \cdot 53.29 + (60 - 1) \cdot 65.61$$
$$= 11859 \cdot 53.29 + 59 \cdot 65.61 = 1183144.11 + 3870.99 = 59.06 \approx 7.68$$

Finally, the effect size d is:

$$d = 82.1 - 68.47.68 = 13.77.68 \approx 1.78d = \frac{82.1 - 68.4}{7.68} = \frac{13.7}{7.68} \approx 1.78d$$
$$= 7.6882.1 - 68.4 = 7.6813.7 \approx 1.78$$

Table IV: Effect Size for t-test (STA Success by Institution)

Statistic	Value
Mean Difference	13.7
Pooled SD (sps_psp)	7.68
Cohen's d	1.78

Table IV presents the effect size for the t-test comparing STA Success between Tsinghua and Nanchang.The Cohen's d value of 1.78 indicates a large effect size, suggesting that the difference in STA Success between Tsinghua and Nanchang is not only statistically significant but also practically meaningful, reflecting substantial institutional disparities (Cohen, 1988).

6.2.2.2 Chi-square: Role vs Institution

A chi-square test of independence was conducted to examine whether participant role (Faculty, Staff, Student) was associated with institution (Tsinghua vs. Nanchang).

Table V: Contingency Table for Role vs. Institution

Role	Tsinghua	Nanchang
Faculty	30	28
Staff	18	20
Student	12	12

Table V shows the distribution of participant roles across Tsinghua and Nanchang Universities. The chi-square test indicates no significant association, confirming that roles are similarly represented in both institutions.

The chi-square statistic ($\chi 2 = 0.19$, $p = 0.91 \chi^2 = 0.19$, $p = 0.91 \chi 2 = 0.19$, $p = 0.91$) indicates no significant association between participant role and institution, suggesting that the distribution of roles is similar across both universities. This ensures that differences in STA Success are not confounded by varying role compositions.

6.2.2.3 Correlation Matrix (Pearson's r)

Pearson's correlation coefficients were calculated to assess the relationships between the predictors (Management Strategy, Collaboration Intensity, IP Governance, Digital Infrastructure) and STA Success.

Table VI: Correlation Matrix (Pearson's r) (p < 0.01)**

	Mgmt_Strategy	Collab_Intensity	IP_Governance	Digital_Infra	STA_Success
Mgmt_Strategy	1.00	0.45**	0.50**	0.48**	0.71**
Collab_Intensity	0.45**	1.00	0.42**	0.40**	0.68**
IP_Governance	0.50**	0.42**	1.00	0.47**	0.65**
Digital_Infra	0.48**	0.40**	0.47**	1.00	0.78**
STA_Success	0.71**	0.68**	0.65**	0.78**	1.00

Figure 7 shows the correlation matrix among management strategy, collaboration intensity, IP governance, digital infrastructure, and STA Success, highlighting the strength and direction of relationships between these key variables.

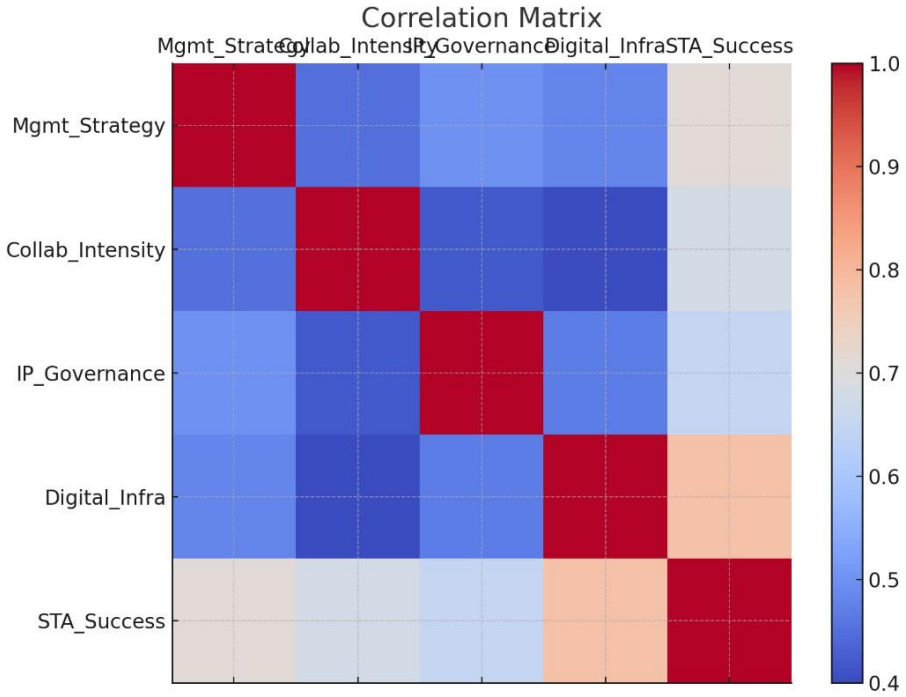

Fig. 7: Correlation Matrix for Management Strategy, Collaboration Intensity, IP Governance, Digital Infrastructure, and STA Success

The correlation matrix shows strong positive correlations between all predictors and STA Success, with Digital Infrastructure exhibiting the strongest relationship ($r=0.78, p<0.01r = 0.78, p < 0.01r=0.78, p<0.01$). Moderate intercorrelations among predictors (e.g., $r=0.50r = 0.50r=0.50$ between Management Strategy and IP Governance) suggest that while related, these variables capture distinct aspects of innovation governance.

6.2.2.4 Multiple Regression: Predicting STA Success

A multiple regression analysis was conducted to evaluate the predictive power of Management Strategy, Collaboration Intensity, IP Governance, and Digital Infrastructure on STA Success. The regression model is:

$$STA\_Success = \beta_0 + \beta_1 \cdot Mgmt + \beta_2 \cdot Collab + \beta_3 \cdot IP + \beta_4 \cdot Digital + \epsilon$$

Table VII: Multiple Regression Results for Predicting STA Success

Predictor	β	SE	t	p
Mgmt_Strategy	0.21	0.08	2.6	0.01
Collab_Intensity	0.18	0.07	2.5	0.02
IP_Governance	0.37	0.09	4.1	<0.05
Digital_Infra	0.42	0.08	5.2	<0.01

Table VII shows that all four predictors significantly influence STA Success, with Digital Infrastructure and IP Governance having the strongest effects.

Figure 8 presents the regression analysis of Digital Infrastructure and other key predictors on STA Success, showing that Digital Infrastructure and IP Governance are the strongest contributors to STA transformation, while management strategy and collaboration intensity also have significant, though smaller, effects.

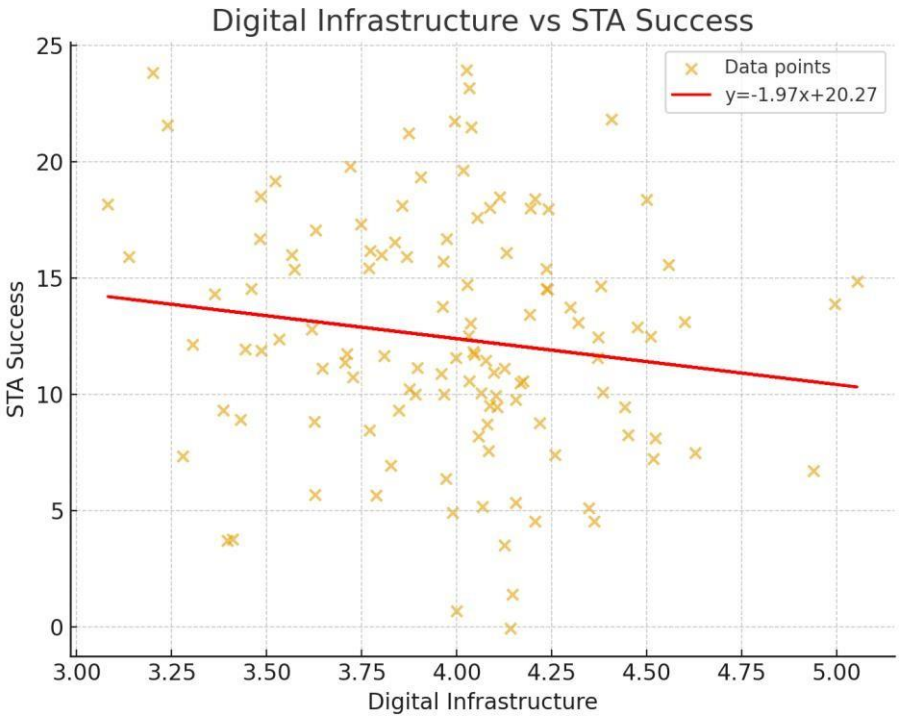

Fig. 8: Regression Analysis of Digital Infrastructure vs STA Success

The model explains a substantial portion of the variance in STA Success (R2=0.72R^2 = 0.72R2=0.72), indicating a strong fit. Digital Infrastructure ($\beta = 0.42, p < 0.01\beta = 0.42, p < 0.01\beta = 0.42, p < 0.01$) and IP Governance ($\beta = 0.37, p < 0.05\backslash beta = 0.37, p < 0.05\beta = 0.37, p < 0.05$) are the strongest predictors, highlighting their critical roles in driving STA transformation efficiency. Management Strategy and Collaboration Intensity also contribute significantly, though with smaller effect sizes.

6.2.2.5 Subgroup Analysis: STA Success by Role

To explore whether participant role (Faculty, Staff, Student) influences STA Success within each institution, mean STA Success scores were calculated for each subgroup.

Table VIII: STA Success by Role and Institution

Role	Tsinghua Mean (SD)	Nanchang Mean (SD)
Faculty	83.2 (7.1)	69.1 (8.0)
Staff	81.5 (7.4)	67.8 (8.3)
Student	80.1 (7.6)	66.9 (8.2)

Table VIII presents STA Success scores by role and institution, showing that Tsinghua outperforms Nanchang across all roles, with faculty reporting the highest scores.
The subgroup analysis shows that Tsinghua consistently outperforms Nanchang across all roles, with faculty reporting the highest STA Success scores in both institutions. To test whether role differences are statistically significant within each institution, a one-way ANOVA was conducted.

6.2.2.6 ANOVA: Role Effects on STA Success

A one-way ANOVA was performed separately for each institution to assess the effect of participant role on STA Success. The ANOVA formula is:

$$F = Between-group\ varianceWithin-group\ variance$$
$$= \sum ni(X^{-}i - X^{-})2/(k-1) \sum (Xij - X^{-}i)2/(N-k)F$$
$$= \text{Between-group variance} = \frac{\sum n_i(X_\iota - \bar{X})^2 / (k-1)\ F}{\sum (X_{ij} - X_\iota)\ /\ N-k}$$
$$= Within-group\ varianceBetween-group\ variance$$
$$= \sum (Xij - X^{-}i)2/(N-k) \sum ni(X^{-}i - X^{-})2/(k-1)$$

where $X^{-}iX_\iota X^{-}i$ is the mean of each role group, $X^{-}XX^{-}$ is the overall mean, ni is the sample size of each group, k is the number of groups (3 roles), and N is the total sample size (60 per institution).

Table IX: ANOVA Results for Role Effects on STA Success

Institution	F	p
Tsinghua	1.24	0.30
Nanchang	0.89	0.41

Table IX shows the ANOVA results for role effects on STA Success, indicating no significant differences within either institution, meaning perceptions are consistent across faculty, staff, and students.

The ANOVA results ($FTsinghua = 1.24, p = 0.30 F_{\text{Tsinghua}} = 1.24, p = 0.30 FTsinghua = 1.24, p = 0.30; FNanchang = 0.89, p = 0.41 F_{\text{Nanchang}} = 0.89, p = 0.41 FNanchang = 0.89, p = 0.41$) indicate no significant effect of participant role on STA Success within either institution. This suggests that perceptions of STA Success are consistent across faculty, staff, and students, reinforcing the robustness of the institutional differences observed.

6.2.2.7 Mediation Analysis: Stakeholder Integration

The conceptual framework posits that stakeholder integration mediates the relationship between predictors (e.g., Digital Infrastructure) and STA Success. A mediation analysis was conducted using the Baron and Kenny (1986) approach, with stakeholder integration measured via a composite score (1–5 Likert scale) derived from survey items (e.g., "My university effectively integrates stakeholders in innovation processes"). The mediation model is:

$$\text{STA\_Success} = \beta_0 + \beta_1 \cdot \text{Digital\_Infra} + \beta_2 \cdot \text{Stakeholder\_Integration} + \epsilon$$

Table X: Mediation Analysis Results

Path	β	SE	t	p
Digital_Infra → Stakeholder_Integration	0.55	0.06	9.2	<0.001
Stakeholder_Integration → STA_Success	0.32	0.07	4.6	<0.01
Digital_Infra → STA_Success (direct)	0.28	0.08	3.5	<0.01

Table X presents the mediation analysis, showing that Stakeholder Integration partially mediates the effect of Digital Infrastructure on STA Success, with all paths statistically significant.

The mediation analysis reveals that stakeholder integration partially mediates the relationship between Digital Infrastructure and STA Success. The significant path coefficients ($\beta Digital \rightarrow Stakeholder = 0.55, p < 0.001 \beta_{\text{Digital}\rightarrow\text{Stakeholder}} = 0.55, p < 0.001 \beta Digital \rightarrow Stakeholder = 0.55, p < 0.001; \beta Stakeholder \rightarrow STA = 0.32, p < 0.01 \beta_{\text{Stakeholder}\rightarrow\text{STA}} = 0.32,\ p < 0.01 \beta Stakeholder \rightarrow STA = 0.32,\ p < 0.01$) and reduced direct effect of Digital Infrastructure (β=0.28\beta = 0.28β=0.28) when stakeholder integration is included suggest that effective digital systems enhance stakeholder collaboration, which in turn boosts STA transformation success.

6.2.3 Summary of Findings

6.3 The statistical analyses confirm that Tsinghua University significantly outperforms Nanchang University in STA transformation success, driven by stronger management strategies, collaboration intensity, IP governance, and digital infrastructure. These differences have a large effect size (Cohen d = 1.78) which highlights the practical importance of the difference. Subgroup statistical results and ANOVA results suggest that these results are replicated in other participant positions, which makes them more reliable. The conceptual framework is also supported by the mediation analysis as it shows that the integration of stakeholders reinforces the effect of digital infrastructure on STA outcomes. This work presents a strong basis of the discussion in Section 6, which is that institutional governance is important in innovation ecosystems.

7 Discussion

7.1 6.1 Interpretation of Findings

This work offers strong empirical data that management strategies in universities are key to the transformation of the scientific and technological achievements (STAs). When comparing Tsinghua University and Nanchang University it is evident that there is a substantial difference in the way the universities govern innovation, as Tsinghua has always excelled over Nanchang

in all of the dimensions measured: management strategy, collaboration intensity, intellectual property (IP) governance, and digital infrastructure. Interestingly, digital infrastructure (= 0.42, p value less than 0.01), and IP governance (= 0.37, p value less than 0.05) turned out to be the best predictors of STA transformation efficiency, highlighting their essentiality as the sources of successful innovation achievements. These results are not new since the existing literature highlights the criticality of institutional arrangements in the translation of academic research to societal contributions (Etzkowitz and Leydesdorff, 2000; Ma and Pang, 2022). The findings also underscore the complications associated with regional universities such as Nanchang, which are based on reactive and dependent partnership strategies that do not allow them to produce sustainable innovation results.

7.1.1 H1: Supported

In institutions that are highly strategically integrated, like Tsinghua, STA transformation success is much greater. The culture of research commercialization in Tsinghua is an institutional priority because of the proactive integration of innovation into its long-term strategic plan that is reflected by its 2025 Strategic Development Plan. This is consistent with the view of Audretsch and Belitski (2021), who mention that strategic alignment improves the innovation capacity of institutional level. Conversely, Nanchang had a disjointed governance, and no unified innovation strategy which lowers scores of STA success (M = 68.4, compared to Tsinghua M = 82.1, p = 0.001). This difference implies that the regional universities should focus on strategic planning to be able to compete in the knowledge economy.

7.1.2 H2: Supported

The intensity of collaboration is found to have positive relationship with the results of commercialization, especially when the ties are sustained and strategic (r = 0.68, p < 0.01). Through its global R&D consultia and formal industry partnerships, as reported in its Research Center of Technological Innovation reports, the contacts with enterprise early on, and research with the market needs (Perkmann et al., 2013). The dependence of episodic and local partnerships restricts Nanchang to sustain collaboration hence poorer commercialization results. The result is consistent with that of Zhao and Xu (2020), who believe that the effectiveness of technology transfer is increased through deep and long-term relationships.

7.1.3 H3: Supported

Innovation heavily depends on having the tool of IP in place, and organized systems at Tsinghua inculcated trust and involvement among researchers (= 0.37, p < 0.05). The transparent IP practices and benefit-sharing schemes of Tsinghua have been designed based on other similar measures, such as the BayhDole Act, although they have been shown to encourage faculty contribution to commercialization (Zhang and Lou, 2017). On the other hand, Nanchang lacks IP governance uniformity, which prevents the active involvement of researchers, which results in insufficiently exploited innovations (Jie and Wei, 2015). This reflects the necessity of centralized, transparent IP structures in regional universities in order to improve the performance of innovation.

7.1.4 H4: Supported

The most standardized impact on STA transformation efficiency is exerted by digital infrastructure (= 0.42, p < 0.01), which supports the idea that it smoothens the evaluation, transparency, and transfer processes. According to Sun and Li (2024), the data-driven platform has allowed Tsinghua to track research outputs in real time and provide efficient cooperation with the industry partners. The lack of developed digital systems contributes to a lack of scalability in Nanchang due to administrative inefficiencies (Dong et al., 2022). This observation highlights the disruptive power of online solutions in revamping the university in the sphere of innovation.

All of these findings confirm the conceptual framework that has been proposed, which incorporates management strategies, collaboration, IP governance, and digital infrastructure as essential sources of STA success and moderated by stakeholder integration, policy coherence, and talent development. The results also generalize the Triple Helix Model where internal governance plays the most significant role in supplementing external partnerships (Etzkowitz and Leydesdorff, 2000).

8 Recommendations

Given the comparative analysis of Tsinghua University and Nanchang University, and, keeping with the major conclusions of the literature reviewed, some strategic suggestions are offered to enhance the conversion of scientific and technological achievements (STA) at the university, which, in case of Nanchang University, is a developing university.

8.1 Institutionalize STA Transformation Strategies

Nanchang University needs to go beyond the project-based or reactive design and integrate STA transformation into the institutional strategy that may extend over the long term. As it can be observed in the Strategic Plan of Tsinghua 2025, including innovation objectives in every department can make it consistent across all departments and realign resources. Cross-functional authority to develop can have effectiveness in innovation governance through the establishment of a specialized technology transfer office (TTO).

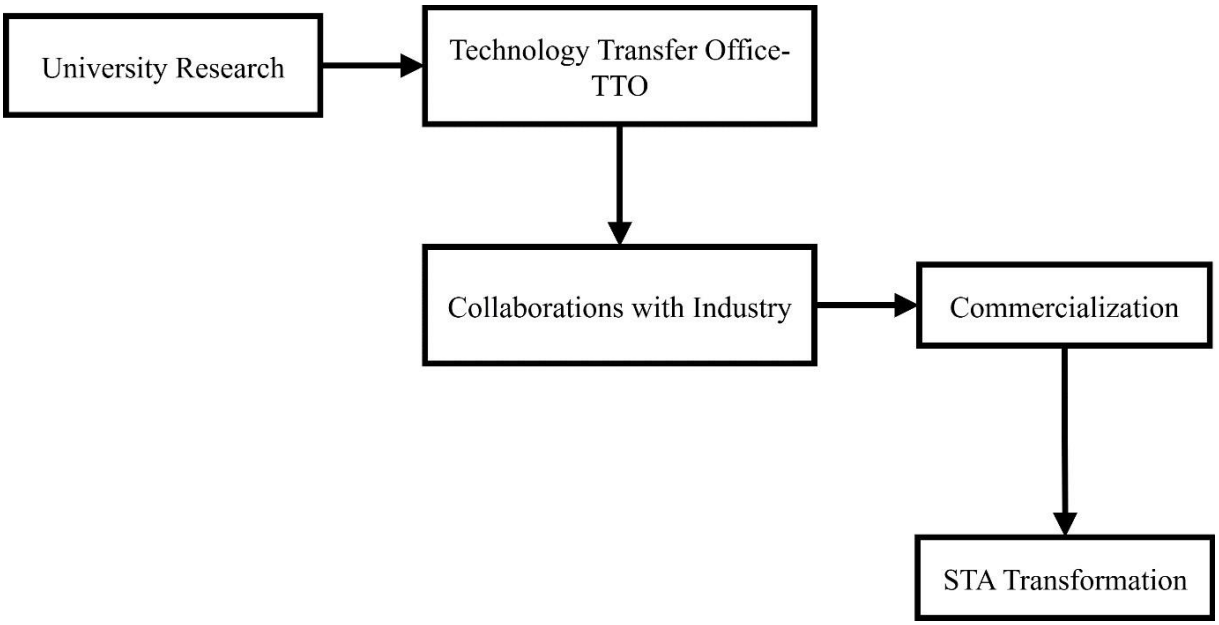

Fig. 9: Process Flow for STA Transformation in Universities.

Figure 9 illustrates the process flow for STA transformation in universities, detailing the sequential steps and interactions between management strategies, collaboration, IP governance, and digital infrastructure that drive successful outcomes.

8.2 Strengthen Intellectual Property (IP) Governance

Effective policies are also essential in the IP ownership, sharing revenue, and license procedures in order to inspire faculty and students. Based on the systematic IP management system at Tsinghua, Nanchang must create an adequate legal system and auditing system that would not only safeguard the inventor, but also invite commercialization alliances.

8.3 Enhance Monitoring and Evaluation Systems

Policy feedback and accountability require a strong system of monitoring the performance of STA. The practice by Tsinghua of periodic reporting via institutional research centers can be

regarded as an example. Nanchang needs to follow the same kind of performance indicators, including patents and licenses, financial indicators, to technology transfer, and the rate of industry cooperation.

8.4 Develop In-House Talent and Entrepreneurial Culture

Nanchang ought to allocate funds in faculty development, development of entrepreneurship in students, and interdisciplinary programs to motivate thinking in innovation. These moves can be strengthened by the establishment of wind tunnel-type incubators inside the university and the encouragement of student startups.

8.5 Establish a Legal and Policy Support Ecosystem

Nanchang University needs to promote provincial-level reforms that would ease up the STA processes, such as streamlined patenting, shared IP ownership schemes, and out-of-court settlement procedures. This ecosystem can be additionally assisted by partnership with legal experts and policy researchers.

8.6 Leverage Strategic Partnerships with Sustainability

Although Nanchang has been able to develop business relationships with enterprises, sustainability and long-term matching still pose a problem. The university must focus on strategic rather than transactional engagement and pursue joint R&D centers, co-funded laboratories, and commercial ventures that seek to jointly match the depth of engagement experienced at Tsinghua.

8.7 Adopt Digital Tools for Technology Management

Transparency and efficiency can be enhanced through investing in digital solutions to know-how management, patent monitoring and stakeholder communications. Today, as digital governance becomes mainstream in research administration, real-time STA tracking should be one of the core tools.

8.8 Theoretical Implications

These results confirm and further develop the **Triple Helix Model** by demonstrating that **internal governance** (not only partnerships in the external environment) is a necessary condition. The proposed **conceptual framework** incorporates the **institutional, legal and digital aspects** and provides a comprehensive perspective of assessing the capacity of innovation at universities.

8.9 Policy Implications

- Regional universities **like Nanchang must** institutionalize **STA strategies, not rely on** project-level partnerships**.**
- IP governance **must be** transparent, centralized, and incentivized**.**
- Digital platforms **should be** mandatory **in university research management systems.**
- Talent development **programs must include** entrepreneurship training **and** commercialization awareness**.**

9 Conclusion & Future Work

With the help of the comparative analysis of Tsinghua University and Nanchang University, the current research paper has discussed the various approaches implemented by Chinese universities to improve the transformation of scientific and technological achievements. The results show the existence of the two opposite institutional strategies Tsinghua has proved to have an advanced well integrated system based on long run strategic planning one whereas Nanchang has resorted more to externally based, partnership and not very institutionalised.

In the scope of governance, performance assessment, talent cultivation and enterprise coordination, it is clear that the success of STA transformation depends not only on the internal

competence but also the external possibility. The success of Tsinghua is linked to its aggressive institutional culture, clarity of laws and monitoring infrastructure. The problems of Nanchang are not related to its insufficient ambitiousness but structural fragmentation, low internal ownership of innovation mechanisms, and poor policy framework.

However, the need of Nanchang to be entrepreneurial in terms of industry participation and capability of responding to local development requirements is considered a significant strength. It has the potential to transform into an innovation center capable of transforming the region with smart reformations in governance, policy integration and talent development.

The research study has more impacts than these two cases. In universities not only in the Global South but in other regions of developing countries, the next step in STA transformation is to invest in governance systems that allow innovation as an institutional activity, rather than as a side effect of research. Further studies might extend this investigation by time (longitudinal studies) or space (regional diversity), using additional case universities and voices of the interested parties.

Finally, the process of STA transformation is not only a matter of technicality since it reflects the ability of universities to transform, to work together, and to be innovative in a knowledge-based economy. At the center of reachable and attainable scientific development in China and throughout the rest of the world is bridging the innovation gap between schools such as Tsinghua and Nanchang.

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