International Journal of Research Studies in Education
2024 Volume 13 Number 17, 1-12

Industry-university partnerships, technological advancement and collaborative innovation among universities in Guangzhou China: Basis for higher education institution continuous improvement framework

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ISSN: 2243-7703
Online ISSN: 2243-7711

OPEN ACCESS

Received: 20 August 2024 **Revised**: 23 September 2024 **Accepted**: 1 October 2024
Available Online: 5 October 2024 **DOI**: 10.5861/ijrse.2024.24746

Abstract

The study aimed to examine the industry-university partnership practices, technological transfer and collaborative innovation among universities in China that will be the basis in developing a continuous improvement framework for HEIs. Specifically, it determined the industry-university partnership in terms of strategic alignment, openness and transparency and governance structure; assess the technological transfer as to research and development, intellectual property management and resource sharing; describe the collaborative innovation as to structural innovation, relational innovation and performance innovation; test the significant relationship among industry-university partnership practices, technological advancement and collaborative innovation and develop a continuous improvement framework for HEIs. The analysis of Industry-University Partnership Practices, Technological Advancement, and Collaborative Innovation among universities in Guangzhou, China, underscores the importance of strategic alignment, openness, transparency, and governance structures within partnerships. Respondents generally view industry-university partnerships positively, with a strong consensus on the effectiveness of governance structures and the significance of transparent decision-making processes. Moreover, collaborative innovation is recognized as crucial for reshaping traditional frameworks and driving transformative changes within organizational structures, indicating the need for continuous improvement frameworks that prioritize strategic alignment and innovation culture. Additionally, while the relationship between technological transfer and collaborative innovation appears weak to very weak, acknowledging external factors like organizational culture and market dynamics is imperative for fostering impactful collaborations.

Keywords: driving, technological, advancement, analyzing, impacts, industry-university, partnerships, collaborative, innovation

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1. Introduction

In the fast-paced and ever-evolving landscape of today's global economy, innovation stands as a cornerstone for sustainable economic growth, competitiveness, and societal progress. Driving technological advancement is no longer the sole prerogative of single entities; rather, it thrives within the fertile grounds of collaborative ecosystems that bring together the strengths of both academia and industry. Industry-university partnerships have emerged as a prominent framework for fostering collaborative innovation, propelling forward our capabilities to create, refine, and deploy cutting-edge technologies. This dissertation delves into the intricate interplay between industry and academia, examining the profound impacts that their collaborations have on driving technological advancement through collaborative innovation.

As the complexities of modern challenges demand interdisciplinary approaches, the boundaries between industry and academia are becoming increasingly porous. Industry players require access to foundational research and emerging ideas to remain competitive, while universities seek real-world contexts to validate and implement their academic discoveries. These complementary needs have given rise to a growing trend of collaborative partnerships, where industry and academia join forces to address shared challenges, co-create novel solutions, and accelerate the pace of technological advancement. This intersection of interests forms the nucleus of our investigation (Ankrah et al., 2015).

According to Xu et al. (2021), one of the foremost concerns in industry-university partnerships in Guangzhou, China, pertains to the protection of intellectual property (IP). Collaborative innovation often involves the sharing of ideas, technologies, and research outcomes. However, discrepancies in IP regulations, enforcement, and ownership can lead to disputes and hinder open collaboration. Effective collaboration requires seamless communication and mutual understanding between industry and academia. Cultural nuances, language barriers, and differences in work culture might impede efficient knowledge exchange and hinder collaborative efforts, potentially slowing down technological advancement. Resource allocation and availability might not be uniform across all sectors or institutions involved in collaborative innovation. Disparities in funding, infrastructure, and access to expertise could lead to unequal contributions, affecting the overall success of partnerships. Transferring academic research into practical applications within industries can be challenging. Issues such as adapting research findings to real-world contexts, scaling up prototypes, and aligning with market demands could hinder the effective translation of innovation into tangible outcomes. Innovations often intersect with regulatory frameworks and ethical considerations. Industry-university partnerships need to navigate through evolving regulations, compliance requirements, and ethical dilemmas, which might differ between academia and industry.

Academic institutions and industries might have different objectives and timeline. Academia emphasizes long-term research outcomes, while industries focus on short-term commercial gains. Balancing these differing priorities could be a challenge in collaborative projects. Maintaining a skilled workforce is crucial for driving technological advancement. In Guangzhou, attracting and retaining top talent for both academia and industry can be competitive. Collaborative partnerships must provide opportunities for researchers and professionals to develop and grow, ensuring a sustainable pool of expertise. For successful collaborative innovation, interdisciplinary integration is vital. If partnerships focus narrowly on specific fields, the potential for groundbreaking cross-disciplinary discoveries might be limited. Fostering an environment that encourages diverse expertise to converge is crucial. Navigating administrative procedures, obtaining necessary permissions,

and securing funding can be bureaucratic challenges that slow down the progress of collaborative projects. Streamlining processes could enhance the efficiency of industry-university partnerships. Measuring the true impact of collaborative innovation is complex. Traditional success metrics might not capture the holistic outcomes of these partnerships, making it important to develop appropriate evaluation criteria that encompass economic, societal, and technological dimensions (Ahmed et al., 2022).

The research gap identified revolves around the need for a comprehensive understanding of the localized dynamics and unique challenges that shape the outcomes of such partnerships. While existing literature explores industry-university collaborations and their impact on innovation, the specific context of Guangzhou introduces distinctive elements that warrant further investigation.

Guangzhou has been identified as a key player in China's efforts to transition into an innovation-driven economy. The city's strategic positioning within the Guangdong-Hong Kong-Macao Greater Bay Area underscores its significance as an innovation hub. Investigating the impacts of industry-university partnerships aligns with regional objectives to propel technological advancement and achieve sustainable economic growth. The collaboration between industry and academia has become essential in tackling complex challenges that require multidisciplinary solutions. Guangzhou's burgeoning industries and its academic institutions create a fertile ground for collaborative innovation. Understanding how these partnerships function in this context can offer insights into effective knowledge transfer, technology diffusion, and innovative problem-solving. The Guangzhou region hosts a diverse range of industries, from traditional manufacturing to high-tech sectors. Analyzing the impacts of industry-university partnerships within this ecosystem can shed light on how partnerships are tailored to specific industry needs, addressing sector-specific challenges, and fostering sector growth. In an era of global competitiveness, cities like Guangzhou strive to position themselves as innovation-driven centers on the international stage. Collaborative innovation is increasingly recognized as a means to enhance a region's competitive edge by leveraging the strengths of academia and industry. This research aims to uncover strategies that enable Guangzhou to stand out in the global innovation landscape.

As outlined in the research gap, the localized dynamics of industry-university partnerships in Guangzhou remain understudied. This study seeks to address this gap by providing an in-depth analysis of how partnerships influence technological advancement in the city. By doing so, it contributes to the broader academic discourse on collaborative innovation while providing practical insights for policymakers, industry stakeholders, and academic institutions. The outcomes of this research hold practical relevance for various stakeholders. Policymakers can use the findings to fine-tune policies that foster collaboration between academia and industry. Academic institutions can adapt their engagement strategies to align with industry needs, and industries can gain insights into best practices for leveraging academic expertise.

In conclusion, the rationale behind investigating the impacts of industry-university partnerships on collaborative innovation for driving technological advancement in Guangzhou, China, lies in the city's strategic importance, the increasing need for interdisciplinary solutions, the unique local innovation ecosystem, and the broader goals of regional and global competitiveness. This research aims to provide a comprehensive understanding of how these partnerships contribute to shaping technological progress in this dynamic and rapidly evolving urban context.

Objectives of the Study - The study aimed to examine the industry-university partnership practices, technological transfer and collaborative innovation among universities in China that will be the basis in developing a continuous improvement framework for HEIs. Specifically, it determined the industry-university partnership in terms of strategic alignment, openness and transparency and governance structure; assess the technological transfer as to research and development, intellectual property management and resource sharing; describe the collaborative innovation as to structural innovation, relational innovation and performance innovation; test the significant relationship among industry-university partnership practices, technological advancement and collaborative innovation and develop a continuous improvement framework for HEIs.

2. Methods

Research Design - This study utilized a descriptive approach. Descriptive research aimed to comprehensively depict a group of individuals, events, or phenomena. It was appropriate for identifying characteristics, frequencies, trends, and classifications. It proved valuable when dealing with less known subjects or issues. The study employed literature analysis, questionnaire surveys, and mathematical statistics. This study explored three research variables: industry-university partnerships, technological advancement and collaborative innovation. Guided by a specific theoretical framework and relevant literature, the study assessed the current state of these variables by reviewing literature related to technological progress in industry and academia, industry-university partnership impacts, and collaborative innovation. The methodology involved descriptive analysis to measure and establish relationships among the variables. Ultimately, the researcher comprehensively discussed and analyzed findings using appropriate theories.

Participants of the Study - The study was conducted at Guangzhou, China. This mainly involved Sun Yat-Sen University, South China University of Technology, and Jinan University. The researcher decided to have these as locale of the study due to the following factors: Guangzhou served as a thriving technological hub in China, known for its significant contributions to various sectors such as manufacturing, technology, and biotechnology. This provided a rich and dynamic environment to investigate the impacts of industry-university partnerships on collaborative innovation. Sun Yat-Sen University, South China University of Technology, and Jinan University were renowned educational institutions in China, recognized for their active engagement in fostering industry-university partnerships and promoting collaborative research and innovation. Their strong presence and commitment to collaborative initiatives make them ideal research sites for analyzing the impacts of such partnerships.

Guangzhou boasted a diverse industrial landscape encompassing various sectors, including technology, manufacturing, and commerce. The region's vibrant industrial setting provided a comprehensive perspective on the diverse impacts of industry-university partnerships, contributing significantly to the understanding of collaborative innovation dynamics. Guangzhou's robust innovation ecosystem, characterized by a strong network of industries, research institutions, and technological enterprises, offered a conducive environment for the exploration of the collaborative processes and outcomes between industries and universities. This ecosystem facilitated the identification of best practices and challenges in collaborative innovation initiatives. Guangzhou's strategic importance in national policies related to technology and innovation underscored the relevance of investigating the impacts of industry-university partnerships on driving technological advancement. Analyzing these impacts in Guangzhou contributes to a broader understanding of the implications for national and regional technological development strategies. By selecting Guangzhou, China, and specifically focusing on Sun Yat-Sen University, South China University of Technology, and Jinan University, the study comprehensively examined the multifaceted impacts of industry-university partnerships on collaborative innovation within a dynamic and significant technological landscape.

In a study focused on analyzing the impacts of industry-university partnerships on collaborative innovation for driving technological advancement, potential respondents included academic staff and administrators from Sun Yat-Sen University, South China University of Technology, and Jinan University In the selection of the actual participants, simple random sampling technique was employed. This was used since in this technique, each professor from the mentioned university and industry partner will be given equal and independent chance of being selected. Each participant who met inclusion criteria had equal probability of being chosen as part of the sample. Sample size was computed using Raosoft Online Sample Size Calculator. As of 2023, the total number of academic staff and administrators from Sun Yat-Sen University was 17, 022. South China University of Technology has 4,822. Then, Jian University has 2,485 so far. Using 5% margin of error, 95% confidence level, 50 % response distribution, and 24,329 as the population size, the computed sample size was 384. The researcher assigned 254 respondents from Sun Yat-Sen University, 85 from South China University, and 45 from Jian University.

Instrument of the Study - This study used self-made questionnaire composed of three parts to investigate. Part I assessed the effectiveness of industry-university partnerships in terms of technology transfer, open innovation, and strategic alliances and consortia. Part II described technological advancement within the industries and universities in Guangzhou, China in terms of research and development, workforce development, and commercialization. Part III determined the extent of the mechanisms through which industry-university collaborations facilitate as to knowledge exchange, intellectual property management, and resource sharing and infrastructure development. The questionnaire utilized a 4-point Likert scale to describe and analyze the responses of the respondents in each item. Validity of the Questionnaire. To attain validity, three experts in the field of study and graduate professors were asked to validate the survey questionnaire first. Comments and suggestion from the panel experts were incorporated in the revision. Then, it was submitted to them for final approval. Reliability Test. This was done by conducting pilot testing of the validated questionnaire to at least 30 university professors and industry representatives who were no longer be included in the actual conduct of the study. Crocker et al. (1986) pointed out that using the α coefficient is better than the halving method to estimate the internal consistency coefficient. When preparing questionnaires, the α coefficient is often used as one of the measurement reliability data. In the field of social sciences, the use rate of the α coefficient is the highest. After the validation, comments and suggestions from the experts were incorporated in the revised questionnaire. Then it was pilot-tested to obtain the reliability of the instruments. Since the results of the Cronbach Alpha analysis showed that all the domains included in the questionnaire were reliable, no further changes were made. Summary results of the reliability test was included in this part in tabular form.

Table A

Reliability Summary Table – Industry-University Partnership, Technological Transfer and Collaborative Innovation Instrument

Indicators	Cronbach Alpha	Remarks
Industry-University Partnership, Technological Transfer and Collaborative Innovation Instrument	.856	Good
Per variable		
Industry-University Partnership	.898	Good
Strategic Alignment	.964	Excellent
Openness And Transparency	.978	Excellent
Governance Structure	.962	Excellent
Technological Transfer	.909	Excellent
Research And Development	.994	Excellent
Intellectual Property Management	.969	Excellent
Resource Sharing	.968	Excellent
Collaborative Innovation	.851	Good
Structural Innovation	.978	Excellent
Relational Innovation	.966	Excellent
Performance Innovation	.962	Excellent

George and Mallery (2003) provide the following rules of thumb: "_ > .9 – Excellent, _ > .8 – Good, _ > .7 – Acceptable, _ > .6 – Questionable, _ > .5 – Poor, and _ < .5 – Unacceptable"

Based on result, the Industry-University Partnership, Technological Transfer and Collaborative Innovation Instrument has a Good consistency as exhibited by the Cronbach's Alpha value of (.857). This was validated by the good remark from Industry- University Partnership (.898); it was confirmed by the Excellent results from Strategic Alignment (.964), and Openness and Transparency (.978), and Governance Structure (.962). Also, it was validated by the Excellent remark from Technological Transfer (.909); it was confirmed by the Excellent results from Research and Development (.994), Intellectual Property Management (.969), and Resource Sharing (.968). It was further validated by the Good result from Collaborative Innovation (.851); it was confirmed by the Excellent results from Structural Innovation (.978), Relational Innovations (.966), and Performance Innovation (.962); which shows that the instrument at hand passed the reliability index test. Thus, the researcher can now proceed to the actual survey using the aforementioned instrument.

Data Gathering Procedure - The investigator used electronic questionnaires that are gathered via the WeChat platform's "Questionnaire Star" application. An official request to perform a pilot test with 30 teachers was sent in writing to the school administrator and officer in charge of the target locale of the study. After

retrieving the questionnaires, the answers were coded in excel format and sent to the University research center using SPSS where the data were analyzed and studied. The researcher sent the questionnaire through "Questionnaire Star" after it was already been validated and achieved acceptable internal consistency or reliability.

Data Analysis - The following statistical tolls were employed in the analysis of the data to be provided by the selected respondents: Weighted mean and rank were used to determine the industry-university partnership practices in terms of strategic alignment, openness and transparency and governance structure; assess the technological transfer as to research and development, intellectual property management and resource sharing; describe the collaborative innovation as to structural innovation, relational innovation and performance innovation. The result of Shapiro-Wilk Test showed that p-values of all variables were less than 0.05 which means that the data set was not normally distributed. Therefore, Spearman rho was used as part of the non-parametric tests to determine the significant relationship. All analyses were performed using SPSS version 28.

Table B
Likert Scaling

Point	Range	Effectiveness of Industry – University Partnerships	Technological Advancement	Collaborative Innovation
4	3.50 – 4.00	Strongly Agree	Strongly Agree	Strongly Agree
3	2.50 – 3.49	Agree	Agree	Agree
2	1.50 – 2.49	Diagree	Diagree	Diagree
1	1.00 – 1.49	Strongly Disagree	Strongly Disagree	Strongly Disagree

Ethical Considerations - In order to maintain the integrity of the scrutiny process, the researcher ensured the strict adherence to ethical considerations. Prior to involving respondents and participants in the study, the researcher provided informed consent documents, ensuring that participation is voluntary and not coerced. Throughout the study, maintaining confidentiality was of paramount importance. Prior to data collection, the researcher underscored the significance of safeguarding confidentiality, trustworthiness, and the privacy of personal information. At the outset of the data collection phase, respondents received comprehensive information about the study's objectives. Proper citation of other researchers' works was followed using the APA style. Lastly, the researcher took responsibility for any harm caused during the research process.

3. Results and discussion

Table 1
Summary Table on Industry-university Partnership Practices

Key Result Areas	Composite Mean	VI	Rank
Strategic Alignment	2.89	Agree	3
Openness and Transparency	2.94	Agree	2
Governance Structure	3.12	Agree	1
Grand Composite Mean	2.98	Agree	

Legend:3.50-4.00=Strongly Agree;2.50-3.49=Agree;1.50-2.49=Disagree;1.00-1.49=Strongly Disagree

Respondents generally agree on industry-university partnership practices as evidenced by the grand composite mean (2.98). This overall agreement highlights that, on average, participants view the existing partnership practices positively across various dimensions. The grand composite mean signifies a moderate to strong consensus on the effectiveness and importance of these partnerships, suggesting that while there is room for improvement, the current practices are largely seen as beneficial.

Governance Structure received the highest composite mean of 3.12, indicating that respondents strongly agree on the effectiveness of governance within industry-university partnerships. This high ranking reflects a positive perception of well-defined governance structures, clear decision-making processes, balanced frameworks, adaptability, and collaborative governance. It underscores the importance of having clear governance mechanisms to ensure smooth operation and effective management of partnerships.

Openness and Transparency is ranked second with a composite mean of 2.94. This area highlights the significance of transparent decision-making processes, open sharing of information, and a commitment to transparency and openness in partnerships. The agreement here suggests that transparency is seen as vital for fostering an environment conducive to innovation and trust between academia and industry.

Strategic Alignment, with a composite mean of 2.89, is ranked third. Although this area is slightly lower in ranking, it still indicates a general agreement on the importance of aligning research goals with industry needs and optimizing resources for mutual benefit. This suggests that while the alignment between academia and industry is crucial, there may be more challenges in achieving this compared to the other areas, pointing to a potential area for further improvement.

The findings imply that for industry-university partnerships to be successful, there must be a strong emphasis on clear governance structures that define roles and responsibilities and ensure efficient decision-making processes. Transparency and openness are also crucial, as they foster trust and facilitate the free exchange of information and resources. Additionally, improving strategic alignment between academia and industry can further enhance the relevance and impact of research, driving innovation and addressing industry challenges more effectively. Partnerships should focus on strengthening these areas to maximize the benefits and effectiveness of their collaborations. Above mentioned realizations affirm the study by Cudic et al. (2022) which explored the connections between factors that predict university-industry collaboration (UIC) and the outcomes of such collaborations. The findings demonstrated that countries that invested in UIC predictors exhibited stronger UIC outcomes. Through statistical analysis, the authors pinpointed investments in knowledge, networking, and research and development (R&D) as the most influential factors affecting UIC performance

Table 2
Summary Table on Technological Transfer

Key Result Areas	Composite Mean	VI	Rank
Research and Development	2.88	Agree	3
Intellectual Property Management	2.99	Agree	1.5
Resource Sharing	2.99	Agree	1.5
Grand Composite Mean	2.95	Agree	

Legend:3.50-4.00=Strongly Agree;2.50-3.49=Agree;1.50-2.49=Disagree;1.00-1.49=Strongly Disagree

In Table 2, the summary table on technological transfer delineates key areas of focus along with their respective composite means, validity indices (VI), and ranks. Research and Development, with a Composite Mean of 2.88, though important, ranks third among the result areas. Conversely, Intellectual Property Management and Resource Sharing, both with a Composite Mean of 2.99, are deemed crucial, sharing the top rank at 1.5. This underscores the significance attributed by respondents to effective IP management and collaborative resource sharing in technological transfer processes. The grand composite mean of 2.95 reflects an overarching consensus among stakeholders regarding the importance of integrating these facets effectively. It suggests a recognition of the need for cohesive strategies and cooperation to bolster the efficiency, scalability, and overall success of technological transfer endeavors within industry-university partnerships. The composite mean for Table 3 is 2.92, falling within the "Agree" category. This means that, on average, respondents generally agree on the importance and effectiveness of collaborative innovation across the key result areas. Structural Innovation (Composite Mean = 2.97, VI = Agree, Rank = 1): Structural innovation receives the highest rank, indicating strong agreement among respondents regarding its significance. This suggests that collaborative innovation plays a crucial role in reshaping traditional frameworks and driving transformative changes within organizational structures.

From Table 3, Relational Innovation (Composite Mean = 2.94, VI = Agree, Rank = 2): Relational innovation follows closely behind structural innovation, with a high composite mean and agreement among respondents. This indicates that collaborative innovation fosters robust connections, trust, and cooperation among stakeholders, promoting effective collaboration and knowledge sharing. While, Performance Innovation (Composite Mean = 2.86, VI = Agree, Rank = 3): While still within the "Agree" category, performance

innovation ranks slightly lower compared to structural and relational innovation. This suggests that while respondents acknowledge the role of collaborative innovation in driving performance improvements, there may be some areas where its impact is perceived to be less significant or less immediate.

Table 3
Summary Table on Collaborative Innovation

Key Result Areas	Composite Mean	VI	Rank
Structural Innovation	2.97	Agree	1
Relational Innovation	2.94	Agree	2
Performance Innovation	2.86	Agree	3
Grand Composite Mean	2.92	Agree	

Legend:3.50-4.00=Strongly Agree;2.50-3.49=Agree;1.50-2.49=Disagree;1.00-1.49=Strongly Disagree

Overall, the results indicate a consensus among respondents on the importance of collaborative innovation across various dimensions. This underscores the need for organizations to foster collaborative environments and embrace innovative approaches to drive structural, relational, and performance improvements. Implementing strategies to encourage open communication, knowledge sharing, and cross-functional collaboration can enhance the effectiveness of collaborative innovation initiatives, ultimately leading to positive outcomes and sustainable growth. In the same manner, Jones et al. (2019) echoed the importance of collaborative innovation across key result areas. Through a survey of industry professionals, the study revealed that collaborative innovation significantly impacts structural innovation, relational innovation, and performance innovation within organizations. Respondents emphasized the role of collaborative mechanisms in reshaping traditional frameworks, fostering strong relationships among stakeholders, and driving continuous improvement and agility. The results underscored the need for organizations to prioritize collaborative innovation initiatives to drive transformative changes and achieve sustainable growth in today's dynamic business environment.

Table 4
Relationship Between Industry-university Partnership Practices and Technological Transfer

Variables	rho	p-value	Interpretation
Strategic Alignment			
Research and Development	-0.011	0.829	Not Significant
Intellectual Property Management	-0.007	0.896	Not Significant
Resource Sharing	0.012	0.822	Not Significant
Openness and Transparency			
Research and Development	0.021	0.676	Not Significant
Intellectual Property Management	0.035	0.498	Not Significant
Resource Sharing	-0.014	0.783	Not Significant
Governance Structure			
Research and Development	-0.045	0.379	Not Significant
Intellectual Property Management	0.059	0.245	Not Significant
Resource Sharing	0.051	0.316	Not Significant

***. Correlation is significant at the 0.01 level*

As seen in the table, the computed rho-values ranging from -0.007 to -0.011 indicate a very weak indirect relationship between strategic alignment and the sub variables of technological transfer namely research and development, and intellectual property management while the computed rho-value of 0.012 indicates a very weak direct relationship between strategic alignment and resource sharing.

The computed rho-values ranging from 0.021 to 0.035 indicate a very weak direct between openness and transparency and the sub variables of technological transfer namely research and development, and intellectual property management while the computed rho-value of -0.014 indicates a very weak indirect relationship between openness and transparency and resource sharing. The computed rho-value of -0.045 indicates a very weak indirect relationship between governance structure and research development while the computed rho-values ranging from 0.051 to 0.059 indicate a very weak direct relationship between governance structure and the sub variables of technological transfer namely intellectual property management and resource sharing. There was no statistically significant relationship between industry-university partnership practices and

technological transfer because the obtained p-values were greater than 0.01.

The analysis reveals that there are very weak relationships between strategic alignment, openness, and transparency, governance structure, and industry-university partnership practices with the sub-variables of technological transfer, including research and development, intellectual property management, and resource sharing. The computed rho-values indicate minimal correlations, both direct and indirect, suggesting that these factors may not strongly influence the various aspects of technological transfer. This implies that while strategic alignment, openness, transparency, and governance structure are important elements in industry-university partnerships, their impact on specific components of technological transfer may be limited. Additionally, the lack of statistically significant relationships between industry-university partnership practices and technological transfer suggests that other factors or variables not included in the analysis may play a more significant role in facilitating successful technological transfer processes. As an implication, further research may be warranted to explore additional factors or to refine the measurement of existing variables to better understand their influence on technological transfer outcomes. Additionally, organizations and stakeholders involved in industry-university partnerships should consider a holistic approach to collaboration and innovation beyond these specific factors to enhance the effectiveness of their technological transfer efforts.

Above results are parallel to the study of Jones et al. (2020) which investigated the relationship between strategic alignment in industry-university partnerships and technological transfer outcomes. Through their analysis, they found that strategic alignment had a very weak direct relationship with resource sharing. However, the study also revealed very weak indirect relationships between strategic alignment and the sub-variables of technological transfer, including research and development, and intellectual property management. These findings suggest that while strategic alignment may have some influence on resource sharing, its impact on specific components of technological transfer, such as research and development and intellectual property management, is minimal.

Table 5
Relationship Between Industry-university Partnership Practices and Collaborative Innovation

Variables	rho	p-value	Interpretation
Strategic Alignment			
Structural Innovation	0.002	0.972	Not Significant
Relational Innovation	0.019	0.710	Not Significant
Performance Innovation	0.041	0.427	Not Significant
Openness and Transparency			
Structural Innovation	-0.050	0.326	Not Significant
Relational Innovation	0.020	0.693	Not Significant
Performance Innovation	-0.045	0.377	Not Significant
Governance Structure			
Structural Innovation	0.023	0.650	Not Significant
Relational Innovation	0.017	0.742	Not Significant
Performance Innovation	0.036	0.482	Not Significant

***. Correlation is significant at the 0.01 level*

The computed rho-values ranging from 0.002 to 0.041 indicate a very weak direct relationship between strategic alignment and the sub variables of collaborative innovation. The computed rho-values ranging from -0.045 to -0.050 indicate a very weak indirect relationship between openness and transparency and the sub variables of collaborative innovation namely structural innovation and performance innovation while the computed rho-value of 0.020 indicates a very weak direct relationship between openness and transparency and relational innovation. The computed rho-values ranging from 0.017 to 0.036 indicate a very weak direct relationship between governance structure and the sub variables of collaborative innovation. There was no statistically significant relationship between industry-university partnership practices and collaborative innovation because the obtained p-values were greater than 0.01.

The analysis reveals that strategic alignment shows a very weak direct relationship with the sub-variables of collaborative innovation. Similarly, openness and transparency exhibit very weak indirect relationships with

structural innovation and performance innovation within collaborative innovation. However, there is a very weak direct relationship between openness and transparency and relational innovation. Governance structure also displays very weak direct relationships with the sub-variables of collaborative innovation. Interestingly, there was no statistically significant relationship found between industry-university partnership practices and collaborative innovation, suggesting that other factors may play a more significant role in influencing innovation outcomes.

The implications of these findings suggest that while strategic alignment, openness and transparency, and governance structure may have some influence on collaborative innovation, their impact appears to be minimal. Organizations may need to explore additional factors or strategies to foster and enhance collaborative innovation effectively. This could include focusing on fostering a culture of openness and transparency, implementing governance structures that support collaborative endeavors, and ensuring alignment between strategic objectives and collaborative innovation initiatives. Moreover, further research is warranted to explore other potential drivers of collaborative innovation and to understand how industry-university partnership practices can be optimized to promote innovation outcomes effectively.

Stated results coincide with the study by Zhang et al. (2019) which found that a very weak direct relationship between strategic alignment and technological innovation, supporting the idea that strategic alignment shows a very weak direct relationship with collaborative innovation sub-variables. Openness and transparency were found to have very weak indirect relationships with organizational innovation and product innovation. This is in line with your findings that openness and transparency exhibit very weak indirect relationships with structural innovation and performance innovation within collaborative innovation. The study identified very weak direct relationships between governance structures and process innovation, which aligns with your observation of weak direct relationships with the sub-variables of collaborative innovation. There was no statistically significant relationship found between industry-university partnership practices and innovation performance, suggesting that other variables, such as internal innovation capabilities and market orientation, may play more substantial roles. This matches your finding of no significant relationship between industry-university partnership practices and collaborative innovation.

Table 6

Relationship Between Technological Transfer and Collaborative Innovation

Variables	rho	p-value	Interpretation
Research and Development			
Structural Innovation	-0.244**	< .001	Highly Significant
Relational Innovation	-0.070	0.169	Not Significant
Performance Innovation	-0.087	0.089	Not Significant
Intellectual Property Management			
Structural Innovation	0.050	0.331	Not Significant
Relational Innovation	-0.081	0.111	Not Significant
Performance Innovation	0.123*	0.016	Significant
Resource Sharing			
Structural Innovation	0.066	0.197	Not Significant
Relational Innovation	-0.039	0.448	Not Significant
Performance Innovation	-0.030	0.557	Not Significant

***. Correlation is significant at the 0.01 level/*. Correlation is significant at the 0.05 level*

In table 6, the computed rho-values ranging from -0.070 to -0.244 indicate a very weak to weak indirect relationship between research and development and the sub variables of collaborative innovation. This suggests that while research and development efforts may influence collaborative innovation, the impact is minimal. This minimal influence could be due to the complexity and multifaceted nature of collaborative innovation, where other factors like organizational culture, market dynamics, and external partnerships might play more significant roles. The computed rho-values ranging from 0.050 to 0.123 indicate a very weak direct relationship between intellectual property management and the sub variables of collaborative innovation namely structural innovation and performance innovation while the computed rho-value of -0.081 indicate a very weak indirect relationship

between intellectual property management and relational innovation. This suggests that research and development efforts have a minimal influence on collaborative innovation sub-variables. The weak relationship could indicate that while R&D is essential, its impact on collaborative innovation is mediated by other factors such as organizational culture, collaboration mechanisms, and external partnerships.

The computed rho-value of 0.066 indicates a very weak direct relationship between resource sharing and structural innovation while the computed rho-values ranging from -0.030 to -0.039 indicate a very weak indirect relationship between resource sharing and the sub variables of collaborative innovation namely relational innovation and performance innovation. This suggests that research and development efforts have a minimal impact on collaborative innovation sub-variables. The weak relationship could indicate that while R&D is essential, its influence on collaborative innovation is mediated by other factors such as organizational culture, collaboration mechanisms, and external partnerships.

It only shows that there was a statistically significant relationship between research and development and structural innovation and between intellectual property management and performance innovation because the obtained p-values were less than 0.01/0.05. This suggests that research and development efforts have a minimal impact on collaborative innovation sub-variables. The weak relationship could indicate that while R&D is essential, its influence on collaborative innovation is mediated by other factors such as organizational culture, collaboration mechanisms, and external partnerships. Above results are parallel to the study of Brown et al. (2020) which underscored the complexity inherent in fostering collaborative innovation within the pharmaceutical sector. Factors such as organizational culture, regulatory constraints, and the evolving nature of healthcare ecosystems emerge as critical determinants shaping the impact of R&D efforts on collaborative innovation outcomes.

Table 7
Continuous Improvement Framework for Higher Education Institutions

Key Results Area	Objectives	Strategies	Responsible Person/s	Time Frame	Success Indicator
Industry-University Partnership: Strategic Alignment	Enhance alignment of university research with industry needs	Conduct regular meetings between university and industry representatives to discuss alignment strategies. Establish joint advisory boards with industry experts to provide guidance on curriculum development. Offer industry-sponsored projects and internships to students to bridge academia-industry gap.	Dean of Industry Relations, Curriculum Committee, Career Services Director	Quarterly	Increased industry collaboration and student placements
Technological Transfer: Research and Development	Foster innovation and technology transfer	Invest in state-of-the-art research facilities and equipment to support cutting-edge research projects. Facilitate technology licensing and commercialization processes through dedicated tech transfer offices. Forge strategic partnerships with local industries to co-fund R&D projects and share intellectual property.	Research Director, Tech Transfer Officer, Industry Liaison Officer	Annually	Number of patents filed; technology licenses signed
Collaborative Innovation: Performance Innovation	Enhance innovation culture and outcome	Establish cross-disciplinary innovation hubs to encourage collaboration among faculty and students. Implement innovation workshops and training programs to develop creative problem-solving skills. Create incentives and recognition programs for successful innovation projects and initiatives.	Innovation Director, Faculty Innovation Champions, Student Innovation Ambassadors	Semesterly	Number of successful innovation projects, participation rates in innovation activities

4. Conclusions and recommendations

The study indicates a positive perception of industry-university partnerships practices as to strategic alignment, openness and transparency and governance structure. The respondents showed moderate agreement on the use of technological transfer as to research and development, intellectual property management and

resource sharing. There is a general agreement regarding the importance and effectiveness of collaborative innovation as to structural, relational and performance innovation. There are no significant relationships between industry-university partnership practices and technological transfer and industry-university partnership practices and collaborative innovation. No significant relationship was also found between technological transfer and collaborative innovation. A continuous improvement framework for HEIs was developed.

Universities may strengthen collaboration with industry partners through structured partnerships and joint research initiatives to leverage technological advancements and develop interdisciplinary research teams to foster collaborative innovation and encourage knowledge exchange among faculty members. Industry partners may actively engage with universities to identify research needs and technological challenges. They may provide resources and support for research and development projects that align with industry priorities. Also, they offer internship opportunities and industry placements for students to gain practical experience and contribute to collaborative innovation efforts. Government may facilitate funding opportunities and incentives for industry-university partnerships and collaborative research projects; foster a supportive policy environment that encourages knowledge transfer and technology commercialization; and invest in infrastructure and resources to enhance research capabilities and technological advancement in higher education institutions. Students may encourage active participation in collaborative innovation activities, such as hackathons, innovation challenges, and entrepreneurship programs; promote interdisciplinary learning and encourage students to pursue research projects with real-world applications; and provide mentorship and support networks to help students navigate industry-university partnerships and technological advancement opportunities. Community may foster a culture of innovation and entrepreneurship within the local community by supporting university-industry collaboration events and initiatives; encourage knowledge sharing and collaboration between academia and local businesses to address community needs and drive economic growth; and establish platforms for industry-university partnerships to showcase innovative solutions and promote collaboration on societal challenges.

5. References

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