

Operational Mechanism of Industrial Technology Innovation Alliance Based on Game Theory: Basis for Strategic Plan

Fan Weijie¹, Arjhel V. Domingo²

^{1,2}Nueva Ecija University of Science and Technology

*arjheldomingoi@gmail.com

Abstract. This study aimed to investigate the operational mechanism of an Industrial Technology Innovation Alliance (ITIA) at Chongqing City Science and Technology College, employing game theory principles. The primary objective was to analyze and comprehend the dynamics of ITIA, focusing on enhancing technological innovation in the industrial sector. The study's specific objectives included describing key components of ITIA, such as membership, organizational structure, governance, innovation initiatives, and strategic collaborations. Additionally, it aimed to elucidate the application of game theory in decision-making processes among ITIA members, especially concerning interdependence, payoffs, incentives, and cooperative models. The study also examined risk decision-making processes within ITIA, including risk identification, assessment, treatment, strategies, negotiation, and resource allocation. Furthermore, it explored factors influencing the implementation of game theory within ITIA, such as organizational culture, resource availability, and information sharing. The research involved a quantitative descriptive design, with the fieldwork conducted at Chongqing City Science and Technology College, involving 130 ITIA members as respondents. The study's key findings revealed that ITIA demonstrated satisfactory engagement with members and stakeholders, supported by an organized structure and robust governance. While actively involved in innovation initiatives, there was room for improvement in strategic collaboration and partnerships. Application of game theory within ITIA was notably effective, particularly in analyzing interdependence, payoffs, and cooperative models. In risk decision-making, game theory proved effective in risk identification, assessment, treatment, strategies, negotiation, and resource allocation. Organizational culture, resource availability, and information sharing significantly supported game theory implementation within ITIA. Significant differences were found in respondents' perceptions of factors affecting game theory implementation, emphasizing the need for tailored strategies. Based on these findings, recommendations included proactive risk mitigation, integration of game theory into planning, training in game theory for negotiation teams, increased financial support, efficient information sharing, educational integration of game theory, funding for relevant research, collaboration with industry partners, and active member engagement.

Keywords: *Industrial Technology Innovation Alliance; Game Theory Application; Technological Innovation; Strategic Collaboration; Risk Decision-Making*

1. Introduction

The current technological landscape is one that is constantly shifting, and as a result, collaboration between industries, research institutions, and academic institutions has become increasingly important to propel innovation and encourage industrial development. Industrial Technology Innovation Alliances, or ITIAs for short, are emerging as dynamic platforms with the goal of fostering synergies among a wide variety of stakeholders in an effort to quicken the pace of technological advancements and fuel economic expansion. This study investigates the workings of an industrial technology innovation alliance (ITIA) housed within Chongqing City Science and Technology College. Particular attention is paid to ITIA's utilization of the principles of game theory in order to encourage technological innovation within the manufacturing sector.

The Chongqing City Science and Technology College has been at the vanguard of efforts to advance technological innovation and industrial growth in the surrounding area. The college recognized the potential benefits of collaborative efforts, and in response, it established an Industrial Technology Innovation Alliance. The purpose of the alliance is to provide a platform for stakeholders from various sectors to pool their resources, expertise, and knowledge in pursuit of common technological objectives. The objective of the alliance is to improve the region's industrial capabilities and raise its level of competition on the international market.

Understanding the complexities of decision-making, strategic interactions, and resource allocation is absolutely necessary in order to ensure effective collaboration and make the most of the impact that technology innovation initiatives can have in an ecosystem that is both complex and highly interconnected, such as an ITIA. Game theory, which is well-known for the usefulness it offers in modeling strategic interactions, provides an important theoretical framework that can be used to analyze and comprehend the dynamics that are present within the ITIA. Through the application of the principles of game theory, the purpose of this study is to provide insights into the ways in which cooperation, competition, and negotiation among alliance members influence the overall performance of the alliance.

While the concept of ITIAs and their potential benefits have gained popularity, it is still necessary to investigate how game theory can effectively guide decision-making and cooperation within such alliances. As game theory offers a systematic method for analyzing strategic interactions, its application in ITIAs has the

potential to improve resource allocation, reduce risks, and foster a more collaborative and competitive atmosphere. Therefore, the purpose of this research is to bridge the gap between theoretical game theory concepts and their practical application in the context of an ITIA.

Despite the increasing interest in ITIAs and the potential contributions of game theory, there is a lack of research on the precise operation mechanism and practical implications of applying game theory to these alliances. Existing research frequently focuses on the application of game theory in more traditional contexts, such as economics and business strategy, leaving room for further exploration of its role in the dynamic and ever-changing landscape of ITIAs.

This research is built upon a solid foundation of existing research and studies that explore the application of game theory in various contexts, as well as the dynamics of industrial technology innovation alliances.

This research seeks to contribute valuable knowledge to the field of industrial technology innovation alliances by drawing on established literature and empirical evidence, while offering practical recommendations for the successful application of game theory principles in the context of the ITIA at Chongqing City Science and Technology College.

2. Methodology

This study used a quantitative descriptive design. This design involved the systematic collection and analysis of numerical data in order to provide a comprehensive overview of the Industrial Technology Innovation Alliance (ITIA) operation mechanism at Chongqing City Science and Technology College. Quantitative descriptive research focuses on describing and summarizing data in order to gain insight into the characteristics and trends of a particular population. In this study, surveys and questionnaires will be used as primary research instruments to collect information from ITIA members and stakeholders. The purpose of these surveys is to collect quantitative data on key ITIA components, the application of game theory in decision-making and risk management, and the factors influencing the alliance's adoption of game theory principles. The collected quantitative data were analyzed using descriptive statistics such as mean to organize and summarize the survey results. This analysis allowed the researcher to recognize patterns, trends, and relationships within the data, yielding valuable insights into the ITIA's operational dynamics. Using a

quantitative descriptive research design, this study aimed to provide a thorough and objective evaluation of the ITIA's operation mechanism and the role of game theory principles in fostering technological innovation in the industrial sector. The findings of this research design contributed to a greater comprehension of how the ITIA operated and how game theory principles could improve collaboration, competitiveness, and overall performance within the alliance.

2.1. Sampling Procedure

The respondents were selected using a method of purposeful sampling to ensure that representatives from each ITIA membership category are included in the study. The inclusion of these 130 ITIA members as respondents provided a comprehensive and holistic understanding of the Industrial Technology Innovation Alliance's operation mechanism based on the principles of game theory at Chongqing City Science and Technology College.

The selection of the respondents for the study required a careful consideration of multiple criteria to ensure the relevance, validity, and reliability of the collected data. The most important selection criterion was respondents' participation in the operations and activities of the Industrial Technology Innovation Alliance (ITIA). This criterion ensures that the selected individuals have direct knowledge and experience of the functioning dynamics, collaborative efforts, and decision-making processes of the alliance.

Another essential criterion for selection was the respondents' knowledge and involvement in technology-related fields. The chosen candidates had relevant knowledge and experience regarding technological advances, research and development projects, and industrial processes. Their active participation in ITIA collaborative technology projects made them valuable sources of information and insight for the study.

In addition, the availability and willingness of respondents to participate in the study were crucial factors. Researchers aim to select individuals who are approachable, cooperative, and easily accessible, thereby enhancing the efficiency and effectiveness of data collection (Domingo, 2023a; Domingo, 2023b; Domingo, 2023c).

2.2. Respondents

The respondents of the study were the 130 ITIA members at the Chongqing City Science and Technology College research site. These ITIA members

represented a variety of entities and organizations affiliated with the Industrial Technology Innovation Alliance.

The ITIA members were categorized into different groups, such as:

- a. Industrial Partners. Representatives from industrial companies and organizations that actively collaborate with the ITIA to achieve technological innovation goals and promote advancements in the industrial sector.
- b. Research Institutions. Faculty members, researchers, and experts from academic and research institutions affiliated with the ITIA. They play a crucial role in sharing knowledge, expertise, and conducting research to support technological advancements.
- c. Government Agencies. Officials and stakeholders from government departments and agencies that engage with the ITIA to support industrial development and promote innovation initiatives.
- d. Academia. Academic professionals, educators, and scholars from Chongqing City Science and Technology College and other educational institutions involved in the ITIA, contributing to research, technology transfer, and knowledge dissemination.
- e. Other Relevant Entities. Other stakeholders, such as entrepreneurs, start-ups, non-profit organizations, and industry associations, that have a shared interest in technological innovation and industrial development within the research locale.

2.2.1 Research Site

China's Chongqing City Science and Technology College was the location of the study's fieldwork. The Industrial Technology Innovation Alliance (ITIA) operates and functions specifically at Chongqing City Science and Technology College. Based on the principles of game theory, the researchers will investigate the ITIA's operation mechanism at this college, which serves as the study's focal point.

The Chongqing City Science and Technology College is a prestigious educational institution known for its emphasis on science, technology, and innovation. The college's location in Chongqing, a major city in southwestern China, contributes significantly to technological progress and industrial growth in the region.

Table 1 *Distribution of Selected Respondents Based on Purposive Sampling*

Respondent Category	Number of Respondents
Industrial Partners	30
Research Institutions	25
Government Agencies	20
Academia	40
Other Relevant Entities	15
Total	130

3. Results and Discussion

3.1. Key components of the ITIA at Chongqing City Science and Technology College

Engagement dimension received a mean rating of 3.23, indicating a satisfactory level. This suggests that the ITIA has a reasonable level of engagement with its members and stakeholders, fostering collaboration and involvement within the alliance. The Organizational Structure dimension achieved a mean of 3.19, signifying a satisfactory status. This implies that the ITIA at Chongqing City Science and Technology College has an organized structure in place, facilitating its operations and objectives effectively. Governance was rated at 3.21, indicating a satisfactory level. This suggests that the governance structure within the ITIA is robust, enabling effective decision-making and oversight to support the alliance's mission and goals. The dimension of Innovation Initiatives received a mean score of 3.23, indicating a satisfactory performance. This suggests that the ITIA is actively involved in innovation initiatives, encouraging creativity and advancements in the field of information technology. The dimension of Strategic Collaboration and Partnerships received a mean score of 3.08, implying a satisfactory but slightly lower level. This indicates that while collaboration and partnerships are part of the ITIA, there is potential for improvement in the strategic aspect of these endeavors.

The overall mean for all dimensions of the ITIA was 3.19, categorizing the alliance's performance as satisfactory. This suggests that the ITIA at Chongqing City Science and Technology College is effectively engaging its members and stakeholders, maintaining an organized structure, ensuring robust governance, actively promoting innovation initiatives, and engaging in collaborations and partnerships. However, there is room for enhancement, particularly in strategic

collaboration and partnerships, to further bolster the overall effectiveness and comprehensiveness of the ITIA. Additionally, findings align with the broader organizational behavior literature stressing the significance of balanced structures and proactive governance for sustained success (Jairak & Praneetpolgrang, 2013).

3.2. Application of game theory in the decision-making processes of the ITIA members

The dimension of Interdependence received a mean rating of 3.15, categorizing it as effective. This suggests that the application of game theory to analyze interdependence among decision-makers within the ITIA is a reasonably effective approach. It emphasizes the importance of considering the decisions and actions of others while making strategic choices.

Payoffs and Incentives dimension also received a mean of 3.15, indicating effectiveness. This implies that the application of game theory in assessing payoffs and incentives related to various decisions within the ITIA provides valuable insights. Considering the potential gains and losses helps in formulating informed strategies.

The dimension of the Cooperative Model achieved a mean score of 3.19, indicating effectiveness. This suggests that employing game theory to model cooperative behavior and strategies within the ITIA is an effective approach. It emphasizes collaboration and cooperative strategies to achieve collective goals.

The overall mean for all dimensions evaluating the application of game theory in the decision-making processes of the ITIA member was 3.17, which categorizes the application as effective. This implies that utilizing game theory to understand interdependence, assess payoffs and incentives, and model cooperative behavior is beneficial and contributes to effective decision-making within the ITIA. It encourages a strategic approach that takes into account the actions and motivations of others, ultimately leading to better outcomes and cooperation among the members. Studies (Axelsson, 2019; Fang et al. 2021) highlight the relevance of game theory in understanding strategic interactions and decision outcomes. The positive responses align with the notion that game theory provides a framework for rational decision-making in situations involving multiple actors with competing interests.

3.3. Risk in decision-making processes using the game theory of ITIA members

Risk Identification, Assessment and Treatment dimension received a mean of 3.19, categorizing it as effective. It indicates that employing game theory to identify, assess, and treat risks in technology innovation projects is a beneficial approach within the ITIA. This enables a structured and comprehensive evaluation of potential risks, aiding in effective risk management.

The Strategies dimension achieved a mean rating of 3.26, classifying it as highly effective. This suggests that employing game theory in strategy formulation for risk management is highly beneficial within the ITIA. It provides a structured and effective approach to strategize and navigate the complexities associated with technological risks.

The Negotiation dimension achieved a mean score of 3.16, indicating effectiveness. It implies that employing game theory in negotiation processes concerning risk management is effective. It facilitates a strategic and rational negotiation approach, aligning decisions with the ITIA's objectives and encouraging optimal outcomes.

Resource Allocation received a mean rating of 3.22, categorizing it as effective. This suggests that employing game theory to allocate resources for risk management within the ITIA is effective. It ensures efficient resource allocation, optimizing risk management efforts and supporting the successful execution of technology innovation projects.

The overall mean for all dimensions evaluating the risk decision-making processes using game theory within the ITIA members was 3.21, categorizing the process as effective. This implies that utilizing game theory in risk identification, assessment, strategy formulation, negotiation, and resource allocation supports effective risk management. It encourages a structured approach to handle risks associated with technology innovation, fostering the overall effectiveness of risk management processes within the ITIA. This resonates with various scholars, including Koster (2013) and Grzyl et al. (2019), who have underscored the strategic and optimization capabilities of game theory in decision-making under uncertainty and interdependence, validating the positive perception within the ITIA.

3.4. Factors that affect the implementation of game theory of ITIA members

The mean rating for Organizational Culture is 3.23, categorizing it as "Supports." This suggests that the existing organizational culture within the ITIA provides a supportive environment for the implementation of game theory. A conducive culture encourages the integration and utilization of game theory principles in decision-making processes.

The mean rating for Resource Availability is 3.22, also categorized as "Supports." This indicates that the availability of resources, including financial, human, and technological, supports the successful implementation of game theory. Adequate resources are crucial in effectively applying game theory in various aspects of the ITIA's functioning.

The mean rating for Information Sharing is 3.24, reflecting that the practice of effective information sharing supports the implementation of game theory within the ITIA. Transparency and efficient sharing of relevant data and insights aid in aligning decisions with game theory objectives, promoting a collaborative and informed decision-making environment.

The overall mean for all dimensions evaluating the factors affecting the implementation of game theory within the ITIA members was 3.23, indicating "Supports." This implies that the organizational culture, resource availability, and information sharing mechanisms within the ITIA collectively support the effective integration and application of game theory. A supportive organizational culture, coupled with the availability and effective sharing of resources and information, enhances the successful implementation of game theory. The positive responses align with various scholars, such as Amah & Nwuche (2013) and Annan (2022), who have emphasized the role of organizational culture and resource availability in the effective implementation of strategic methodologies.

3.5. Difference on the respondents' perception of the factors that affect the implementation of game theory of ITIA members

The significant F-ratio (12.887) with a p-value of less than 0.001 indicated that there were significant differences in the perception of respondents regarding the factors affecting the implementation of game theory within ITIA members. The within groups analysis (variability within each group) and between groups analysis (variability among different groups) further support this, suggesting that the factors influencing the perception of game theory implementation vary significantly among different groups, highlighting potential areas of focus for better understanding and utilization of game theory within ITIA.

3.6. Proposed Game Theory–Inspired Strategic Plan for ITIA based on the findings of the study.

The findings showed the significance of the multifaceted dimensions critical to the success of the ITIA in leveraging game theory for effective decision-making and risk management. Addressing risks through proactive measures like workshops and risk quantification models is pivotal. Integration of game theory strategies into planning and resource allocation optimizes outcomes, emphasizing strategic resource distribution. The importance of a cooperative and informed negotiation approach is highlighted through training in game theory. A supportive organizational culture, advocating risk-taking and embracing innovation, emerges as a cornerstone. Ensuring adequate resource availability and fostering seamless information sharing further enhance the ITIA's ability to foster innovation and industrial growth.

4. Conclusions

The ITIA at Chongqing City Science and Technology College demonstrates commendable functionality across various dimensions, albeit with identifiable areas for enhancement, particularly in strategic collaboration and partnerships. The application of game theory emerges as a valuable and effective tool in decision-making processes, both for strategic collaboration and risk management within ITIA. This approach fosters interdependence, considers payoffs and incentives, and encourages cooperative behavior, contributing to overall effectiveness. The successful application of game theory is facilitated by a conducive environment within the ITIA, characterized by a supportive organizational culture, ample resource availability, and effective information sharing. However, variations in the perception of game theory implementation among ITIA members suggest the need for a more uniform understanding. The proposed game theory–inspired strategic plan underscores the significance of proactive risk management, strategic resource allocation, informed negotiation, a supportive organizational culture, and adequate resource availability, aiming to cultivate innovation and propel industrial growth within the alliance.

References

- Annan, F. (2022). Misconduct and reputation under imperfect information. Available at SSRN 3691376.
- Amah, E., & Nwuche, C. A. (2013). The influence of size on corporate culture and organizational effectiveness in the Nigerian banking industry. *International Journal of Business Administration*, 4(5), 15.
- Axelsson, J. (2019). Game theory applications in systems-of-systems engineering: A literature review and synthesis. *Procedia Computer Science*, 153, 154–165.
- Domingo, A. (2023). Economic appraisal and strategic analysis of the onion industry in the Philippines. *International Journal of ADVANCED AND APPLIED SCIENCES*, 10(8), 78–90. <https://doi.org/10.21833/ijaas.2023.08.009>
- Domingo, A. (2023). The plight of the onion industry in the onion capital of the Philippines: Basis for intervention strategies. *Asian Journal of Agriculture and Rural Development*, 13(1), 66–74. <https://doi.org/10.55493/5005.v13i1.4766>
- Domingo, A. (2023). Mung bean production as a source of livelihood among farmers in a municipality in the Philippines: Challenges and opportunities. *Asian Journal of Agriculture and Rural Development*, 13(2), 130–137. <https://doi.org/10.55493/5005.v13i2.4779>
- Fang, F., Liu, S., Basak, A., Zhu, Q., Kiekintveld, C. D., & Kamhoua, C. A. (2021). Introduction to game theory. *Game Theory and Machine Learning for Cyber Security*, 21–46.
- Grzyl, B., Apollo, M., & Kristowski, A. (2019). Application of game theory to conflict management in a construction contract. *Sustainability*, 11(7), 1983.
- Jairak, K., & Praneetpolgrang, P. (2013). Applying IT governance balanced scorecard and importance–performance analysis for providing IT governance strategy in university. *Information Management & Computer Security*, 21(4), 228–249.
- Koster, R. (2013). *Theory of fun for game design*. " O'Reilly Media, Inc."