THE DEVELOPMENT MODELS OF CHINA'S NEW ENERGY VEHICLE INNOVATION CONSORTIUMS: CASE ANALYSES OF CHANGAN

TianChen Yang
Shanghai University of Engineering Science, Shanghai 201620, China.

Abstract: Against the strategic backdrop of the "dual carbon" goals, the new energy vehicle (NEV) industry has become a core sector driving energy transition and low-carbon development in the transportation sector. Innovation consortia, as collaborative innovation organizations integrating enterprises, universities, research institutes, and government resources, are of great significance for breaking through key generic technologies and enhancing industrial innovation capabilities. This study selects Changan Automobile as a case study, comprehensively employing case analysis and evolutionary game models to systematically investigate the internal and external challenges it faces in the process of building an NEV innovation consortium, the cooperation mechanisms it adopts, and its game strategies. By constructing a two-party game model between the enterprise and research institutions, the analysis focuses on the impact of key parameters such as total cooperation benefits and profit distribution ratios on the stability of bilateral cooperation. The findings reveal that: the increase in cooperation benefits and the fairness of the distribution mechanism are core elements for the stable operation of innovation consortia; the technology integration and resource coordination capabilities of leading enterprises play a dominant role in the consortium's effectiveness; and the design of systematic cooperation mechanisms (including benefit distribution, risk sharing, breach penalties, and communication and coordination mechanisms) constitutes an important foundation for ensuring the long-term development and sustained innovation capability of the consortium. Accordingly, this paper proposes managerial recommendations such as establishing a reasonable benefit distribution mechanism, increasing government investment in R&D, and accelerating the formation of innovation consortia, aiming to provide theoretical support and practical references for the collaborative innovation and high-quality development of China's NEV industry.
Keywords: Innovation consortium; Industry-university-research collaboration; Evolutionary game theory; Collaborative innovation

1 INTRODUCTION

Against the strategic backdrop of the "dual carbon" goals (carbon peaking and carbon neutrality), the new energy vehicle (NEV) industry has become a core sector driving global energy transition and low-carbon development in transportation. The Chinese government has clearly proposed establishing a green, low-carbon, and circular economic system [1]. As a strategic emerging industry, technological breakthroughs and industrial upgrading in NEVs are not only a key path to achieving emission reductions in the transportation sector but also crucial to national energy security and industrial competitiveness [2]. In this process, innovation consortia—collaborative innovation organizations integrating enterprises, universities, research institutes, and government entities—have increasingly become important carriers for tackling key generic technologies, accelerating the transformation of scientific and technological achievements, and enhancing the overall innovation capacity of the industry [3]. However, significant differences exist among enterprises in terms of resource endowments, organizational structures, and cooperation mechanisms, leading to diverse models for the establishment and operation of their innovation consortia [4]. Against this backdrop, an in-depth analysis of the innovation consortium practices of typical enterprises and a summary of their successful experiences and common laws hold important theoretical and practical significance for promoting the high-quality and sustainable development of China's NEV industry [5].

This study selects Changan, a representative enterprise in China's new energy vehicle industry, as the case study object. As a large state-owned automotive group, Changan actively explores collaborative innovation in new energy vehicles while pursuing a parallel path of joint ventures and independent development [6]. Through case analysis and game model analysis, this study aims to systematically reveal the key influencing factors in the formation, operation, and governance of innovation consortia within the enterprise, and to refine scalable development models and mechanism designs, providing references for relevant policy formulation and corporate practice.

This study focuses on the following questions:
(1) What internal and external challenges does Changan face in the process of building a new energy vehicle innovation consortium?
(2) What cooperative game strategies and mechanism designs has Changan adopted to address these challenges?
(3) How should different stakeholders, including the government, enterprises, and academic research institutions, collaborate and interact within the innovation consortium to achieve stable cooperation and maximize benefits?

To address these questions, this paper comprehensively employs case analysis and game modeling methods, combining quantitative and qualitative analysis to deeply explore core mechanisms such as benefit distribution, risk sharing, and policy guidance within innovation consortia. The aim is to provide theoretical support and practical insights for the collaborative innovation and systematic development of China's new energy vehicle industry.

2 LITERATURE REVIEW

As a cross-organizational collaborative innovation model, innovation consortiums have garnered significant attention in academic circles both domestically and internationally. Existing research has primarily explored this topic from the following dimensions.

Firstly, regarding the theoretical connotation and organizational forms of innovation consortiums, scholars generally agree that an innovation consortium is a long-term collaborative network led by enterprises and involving universities, research institutions, governments, and upstream and downstream entities in the industry chain. It is built around the research and development of common technologies and their industrial application [7]. The organizational forms of innovation consortiums are diverse, including joint laboratories, industrial technology innovation strategic alliances, and research and development collaboration platforms. Their core objectives are to reduce R&D risks, share innovation resources, and accelerate technology iteration [8]. Some scholars further categorize them into contractual, equity-based, and hybrid innovation consortiums from a governance structure perspective, emphasizing that their success depends on resource complementarity, goal alignment, and institutional adaptability [9]. In recent years, with the development of open innovation and ecosystem theory, innovation consortiums have increasingly been regarded as key hubs within innovation ecosystems, serving functions such as knowledge flow, resource sharing, and value co-creation [10].

Secondly, in the study of the collaboration mechanisms and governance structures of innovation consortiums, game theory has been widely applied to analyze strategic interactions and stability issues in collaboration. Many scholars have constructed multi-party game models to examine the impact of profit-sharing mechanisms, risk-sharing ratios, breach penalty mechanisms, as well as government subsidies and regulatory policies on collaboration willingness and effectiveness [11-14]. Research indicates that reasonable benefit distribution and effective contract design are key to maintaining collaboration stability, while the government plays an irreplaceable role in guiding resource allocation and standardizing collaborative behavior. Further studies have also focused on the roles of trust mechanisms, knowledge-sharing mechanisms, and coordination mechanisms in the operation of consortiums, highlighting the significance of dynamic contracts and adaptive governance in addressing innovation uncertainties [15]. In recent years, with the advancement of digitalization, technologies such as blockchain-based smart contracts and data-sharing platforms have been incorporated into the governance framework of innovation consortiums to enhance collaboration transparency and execution efficiency [16].

In the practical research on innovation consortiums in the new energy vehicle industry, scholars both domestically and internationally have focused on comparing cases from different countries and enterprises. For example, Germany's "Automotive Industry Cluster" model emphasizes the deep integration of industry, academia, and research, as well as the promotion of standardization [17]. Japanese automobile companies, on the other hand, achieve technological collaboration through a "keiretsu" supply chain system [18]. In the United States, cross-sector R&D alliances are driven by government projects such as those led by DARPA [19]. Domestic research has largely centered on descriptive analyses of innovation consortiums involving specific enterprises or regions, such as the collaborative network of CATL in the field of power batteries and the construction experience of the new energy vehicle industry-academia-research platform in Shanghai [20, 21]. Additionally, the open innovation and user collaboration practices of emerging companies like Tesla, NIO, and XPeng have gradually attracted attention [22]. However, existing research still rarely provides a systematic comparison and model-based explanation of the behavioral logic and model differences between state-owned enterprises and private enterprises in innovation consortiums from the perspectives of game theory and mechanism design.

In terms of research methodologies and theoretical perspectives, beyond game theory, an increasing number of studies in recent years have employed methods such as social network analysis, comparative case studies, and simulation modeling to explore the structural characteristics, evolutionary pathways, and performance-influencing factors of innovation consortiums [23-25]. Theoretical frameworks like ecosystem theory, resource dependence theory, and institutional theory have also been applied to explain the underlying drivers of consortium formation and development [26]. Despite the growing diversity of methodologies, systematic research that addresses the multi-level, multi-stage, and multi-agent interactions within the technology-intensive and policy-driven new energy vehicle industry remains relatively scarce.

In summary, while existing literature has made certain progress in the theoretical construction, mechanism analysis, and case description of innovation consortia, the following research gaps remain: In terms of research methods, qualitative analyses are predominant, while empirical studies combining game models with mechanism simulation and strategy deduction are relatively scarce. Furthermore, the dynamic regulatory role of the government in innovation consortia and the effectiveness of its policy tools have not been thoroughly discussed. Therefore, this study takes Changan as a case study by constructing and analyzing a game model involving enterprises, academic research institutions, and the government. It aims to address the aforementioned research gaps and provide a new analytical perspective and empirical basis for understanding the development logic of innovation consortia in China's new energy vehicle industry.

3 CASE INTRODUCTION: CHANGAN NEW ENERGY VEHICLE INNOVATION CONSORTIUM

Led by Changan New Energy Automobile Technology Co., Ltd., the Changan New Energy Vehicle Industry Innovation Consortium conducts research to tackle key technical challenges in the new energy vehicle (NEV) sector. These include "in-depth integrated R&D of electric drives" "battery integration + battery management" and "development of an integrated underbody platform" aiming to address common technical bottlenecks hindering the large-scale industrialization of current NEVs.

The consortium collaborates with upstream and downstream industrial chain enterprises such as Changan Automobile and Qingshan Industry, as well as numerous research institutions including Chongqing University and Chongqing University of Technology. Together, they develop a new generation of highly integrated electric drive systems, master core technologies in electric drives, and promote the in-depth integrated unification of multiple functions such as motors, controllers, and reducers. This effort has resulted in fully independent intellectual property rights (IPR) in three core areas: the technical capabilities, products, and development systems for integrated electric drive systems; the technical capabilities, products, and development systems for cloud-based BMS (Battery Management System); and the core technical capabilities, products, and development systems for integrated underbody platforms.

3.1 Company Profile and Developmental Challenges

Amid the wave of nationwide efforts to advance "carbon neutrality," new energy vehicles (NEVs) hold greater long-term economic significance. As a leading brand in the NEV industry, Changan Automobile shoulders the corporate responsibility of achieving carbon neutrality.

After years of exploration, Changan New Energy has successively launched multiple mass-produced models into the market. It has mastered more than 400 core technologies, established a professional R&D team of over 160 members for hybrid systems—including returned overseas experts and senior talents—and fostered a core R&D talent pool for NEVs featuring high academic qualifications, strong professional competence, and excellent overall quality.

3.2 Insufficient Brand Profitability

Insufficient profitability is a chronic issue plaguing China's domestic auto brands, and Changan Automobile is no exception. However, the reasons behind Changan's profit struggles differ from those of most domestic counterparts.

The main cause of poor profitability among domestic auto brands lies in their lack of ability to create best-selling products. For instance, as previously analyzed by *Caijing Eleven*, BYD's sales and profitability have fluctuated drastically due to its failure to develop hit models consistently.

Changan Automobile, though, stands out with an impressive track record in crafting popular models. In the SUV segment—where domestic brands hold a dominant position—the Changan CS75 ranked second in sales among all models from January to September 2021. Changan was also the only domestic brand with two models in the top 15 sales rankings. Yet, a comparison between CS75's sales volume and Changan's net profit during the same period reveals a disconnect: while the correlation between best-selling models and profits was normal in the first few years after CS75's launch, it ceased to exist from 2019 onward. This indicates that factors beyond the performance of popular models are contributing to Changan's insufficient profitability.

3.3 Imperfect Industrial Organization Structure

State-owned automotive groups such as Changan have mainly pursued a joint venture path, where multinational corporations act as the main players in technological innovation. Their investment in R&D and resources for domestic brands is insufficient, even lagging behind that of private automotive enterprises. In Changan's joint venture model, foreign investors hold the dominant power in technological innovation and exercise strict technical control over joint ventures. They have formed strong technological monopolies in areas such as technology introduction, transfer, and R&D division of labor, while Chinese partners have relatively low participation and remain in a passive position. Multinational corporations impose strict restrictions on core technology R&D through their headquarters; R&D activities in the Chinese market are mainly focused on localized adaptive technology development. Although years of cooperation have indeed helped state-owned automotive groups improve their technical capabilities through talent training and technology spillover from joint ventures, the improvement in core technology R&D and innovation capabilities for Chinese partners has been slow. The development of domestic brands under state-owned automotive groups is still constrained by the lack of core technologies, with insufficient investment in independent R&D and fewer patent applications compared to private automotive enterprises.

R&D in new energy vehicle technologies requires substantial investment, carries high risks, and involves long cycles. Building independent R&D capabilities demands long-term investment and industry-wide cooperation, which calls for active participation from major enterprise groups. From an industrial organization perspective, in developed countries such as the United States, Japan, and Germany, large automotive groups are the main drivers of technological innovation. Governments provide significant financial support, guiding and facilitating collective cooperative R&D across the automotive industry. They compete with automotive industries in other countries through organized and systematic innovation models, achieving high industrial concentration alongside strong inter-enterprise cooperation. China, however, still lags far behind in this regard. Under the current industrial organization structure, the innovation

vitality of large state-owned automotive groups like Changan is constrained by foreign partners. Private automotive enterprises have strong innovation motivation but limited strength overall. As a result, the automotive industry struggles to integrate resources and form a synergistic force for collective cooperative innovation.

3.4 Relatively Low R&D Innovation Capability

In terms of timeline, Changan's large-scale development in the new energy vehicle (NEV) industry spans only about a decade. Compared with multinational automotive groups with decades or even a century of development experience, Changan NEV enterprises have obvious deficiencies in R&D experience and technical accumulation.

R&D of NEV technologies is a comprehensive systematic project. It requires basic research, data accumulation, process control, talent training, and other elements that cannot be easily acquired through introduction or mergers and acquisitions. Enterprises must rely on their own continuous exploration, experience accumulation, and long-term R&D to truly enhance their comprehensive technical level and innovation capabilities.

Compared with competitors, Changan lacks independent control over core NEV technologies. BYD boasts a full-industry-chain layout. Geely has the SEA Architecture, widely recognized as China's top pure electric vehicle platform to date. Great Wall has established a presence in power batteries and hybrid technologies through Honeycomb Energy and Honeycomb Power. GAC has built solid technical reserves in autonomous driving, fast charging, and battery safety. In contrast, Changan has almost no key independent technologies under its control in the critical areas of NEVs and intelligent vehicles.

4 A TWO-PARTY GAME MODEL WITH ACADEMIA/RESEARCH INSTITUTIONS

4.1 Scenario Description and Parameter Setting

Led by Changan New Energy Automobile Technology Co., Ltd., the Changan New Energy Vehicle Industry Innovation Consortium tackles a series of key technical challenges in the new energy vehicle (NEV) sector, including "in-depth integrated R&D of electric drives," "battery integration + battery management," and "development of an integrated underbody platform." It aims to address the common technical bottlenecks restricting the large-scale industrialization of current NEVs.

In collaboration with upstream and downstream industrial chain enterprises such as Changan Automobile and Qingshan Industry, as well as numerous universities and research institutions including Chongqing University and Chongqing University of Technology, the consortium develops a new generation of highly integrated electric drive systems. It masters core technologies for electric drive systems, promotes the in-depth integrated unification of multiple functions such as motors, controllers, and reducers, and establishes: core technical capabilities, products, and development systems for integrated electric drive systems with full independent intellectual property rights (IPR); technical capabilities, products, and development systems for cloud-based BMS (Battery Management System) with full independent IPR; and core technical capabilities, products, and development systems for integrated underbody platforms with full independent IPR.

Within the aforementioned innovation consortium, both Changan New Energy and the universities/research institutions possess certain independent innovation capabilities. If the two parties fail to establish a collaborative relationship (both choose the non-cooperation strategy), each will achieve different benefits. When they form a collaborative relationship (both choose the cooperation strategy), the establishment of the innovation consortium will increase the total benefit of the collaborative innovation system by 150,000 yuan. This additional benefit is distributed between the two parties, with Changan New Energy receiving a 40% share (distribution rate: 0.4) and the universities/research institutions receiving a 60% share (distribution rate: 0.6).

In addition, building and maintaining the collaborative relationship incurs certain costs: the initial setup cost is 25,000 yuan, and the maintenance cost is 15,000 yuan. During the strategy selection process, either party may abandon the collaborative cooperation for other interests, which will cause economic losses to the collaborative innovation system and the other cooperating party. The party that abandons cooperation must pay compensation to the other party, with the amount linked to the total collaborative benefit and a compensation coefficient of 0.3. Furthermore, the party that gives up collaborative cooperation will gain additional benefits from other sources—50,000 yuan for Changan New Energy and 50,000 yuan for the universities/research institutions.

At the initial stage of the game, the probability of Changan New Energy choosing cooperative cooperation is 0.6, and the probability of choosing non-cooperation is 0.4; the probability of the universities/research institutions choosing cooperative cooperation is 0.5, and the probability of choosing non-cooperation is 0.5.

Based on the above scenario description, a collaborative cooperation model for Changan New Energy's innovation consortium is constructed with the following key parameters, see Table 1:

<div align="center">**Table 1** Main Parameters</div>

Symbol	Name
$R_1^{'} = 5$	A new energy vehicle will receive an additional profit of 50000 yuan from abandoning collaborative cooperation
$R_2^{'} = 5$	The additional income obtained by academic research institutions from abandoning collaborative cooperation is 50000 yuan
$\triangle R = 15$	The total revenue increased by building an innovation consortium is 150000 yuan
$a = 0.4$	The profit distribution rate of Changan new energy vehicles is 0.4
$1 - a = 0.6$	The profit distribution rate of academic research institutions is 0.4
$C_1 = C_2 = 2.5$	The cost of building a collaborative relationship is 25000 yuan
$C_1^{'} = C_2^{'} = 1.5$	The cost of maintaining a collaborative relationship is 15000 yuan
$r = 0.3$	The compensation coefficient is 0.3
$x = 0.6$	The probability of Changan new energy vehicles choosing collaborative cooperation is 0.6
$y = 0.5$	The probability of academic research institutions choosing collaborative cooperation is 0.5

4.2 Model Construction and Payment Matrix

Based on the above scenario description and main parameters, construct the game benefit matrix between Changan New Energy Vehicles and academic research institutions under the two strategies of choosing collaborative cooperation and non-collaborative cooperation, as shown in Table 2.

<div align="center">**Table 2** Game Payment Matrix between New Energy Vehicles and Research Institutions</div>

		Research institutions	
		Collaboration	**Non collaborative cooperation**
Changan New Energy Vehicles	Collaboration	$R_1 + a\triangle R - C_1 - C_1^{'}$ $R_2 + (1-a)\triangle R - C_2 - C_2^{'}$	$R_1 + r\triangle R - C_1 - C_1^{'}$ $R_2 + R_2^{'} - r\triangle R - C_2$
	Non collaborative cooperation	$R_1 + R_1^{'} - r\triangle R - C_1$ $R_2 + r\triangle R - C_2 - C_2^{'}$	$R_1 ; \ R_2$

The dynamic evolution process of industry university research cooperation decision-making under the innovation consortium can be represented by a dynamic replication system composed of the following differential equations:

$$\begin{cases} \dfrac{dx}{dt} = x(1-x)[(a\triangle R - R_1^{'} + C_1)y + r\triangle R - C_1 - C_1^{'}] \\ \dfrac{dy}{dt} = y(1-y)[(\triangle R - aR_1^{'} - R_2^{'} + C_2)x + r\triangle R - C_2 - C_2^{'}] \end{cases}$$

4.3 Numerical Analysis and Findings

By substituting the operational parameters of Changan Innovation Consortium into the function model and conducting case analysis, this study explores the impact of different parameters on the collaborative decision-making of enterprises and research institutions.

As shown in Figure 1, the increase in collaborative benefits has a promoting effect on both enterprises and research institutions in choosing collaborative strategies. Under other constant conditions, increasing the benefits of collaborative cooperation can evolve directly from a state where both parties choose not to cooperate to a state where both parties choose to cooperate, without a transitional state where one party chooses to cooperate while the other gives up. So, in the decision-making process of industry university research cooperation under the innovation consortium, if the prospects of the innovation project are good, the more total benefits it can bring to both parties, the more it can promote the realization of collaborative cooperation between enterprises and research institutions.
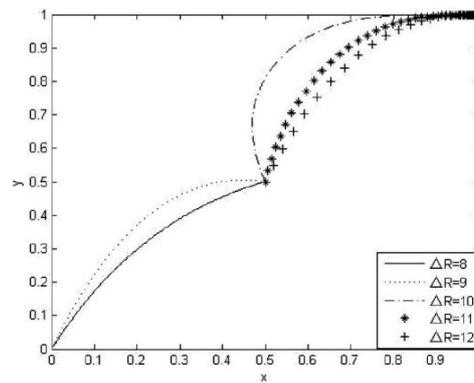
Figure 1 The Impact of the Total Revenue Increased by Constructing an Innovation Consortium on the Decision Results

As shown in Figure 2, the rationality of the profit distribution coefficient has a significant impact on the strategic choices of both enterprises and research institutions. Whether it is a company or a research institution, when distributing the total benefits of collaborative cooperation, a low proportion of income will lead to the party abandoning the collaborative cooperation strategy, which is consistent with the fair distribution of benefits in reality. Therefore, in practical distribution, both parties should attach importance to the fairness of income distribution, and a distribution plan can be formulated based on the resource investment situation of both parties.
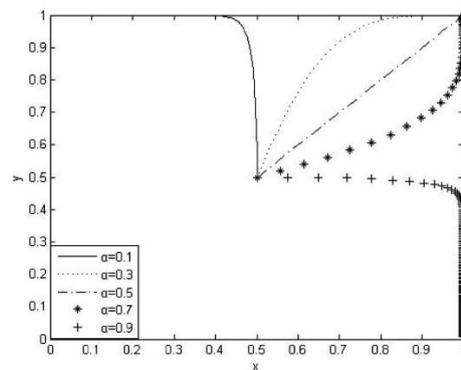

Figure 2 The Influence of Allocation Coefficient on Decision Results

5 CONCLUSION

5.1 Main Findings

Based on the above analysis, this study arrives at the following main findings:

(1) Cooperation benefits and distribution fairness are the core elements for the stable operation of innovation consortia. In the two-party game model of Changan Automobile, increasing the total benefits of collaborative innovation can significantly enhance the willingness of enterprises and academic research institutions to cooperate. Furthermore, the reasonableness of the revenue distribution coefficient directly affects the stability of their cooperation. A fair revenue distribution mechanism is key to maintaining long-term cooperative relationships and stimulating the active participation of all parties.

(2) The leading role of flagship enterprises is indispensable. As a leading enterprise in the industrial chain, Changan Automobile's dominant capabilities in technology integration, resource coordination, and market alignment directly influence the operational efficiency and outcome transformation effectiveness of the innovation consortium.

(3) The success of an innovation consortium relies on the design of a systematic cooperation mechanism. This includes, but is not limited to, a benefit distribution mechanism, a risk-sharing mechanism, a default penalty mechanism, and a communication and coordination mechanism. Together, these mechanisms constitute the institutional foundation of the innovation consortium, affecting its long-term development and sustained innovation capability.

5.2 Managerial Implications

5.2.1 Establish a reasonable benefit distribution mechanism

Fair benefit distribution is key to the stable operation of an innovation consortium. The allocation plan should comprehensively consider the input of elements such as talent, technology, capital, and brand, reflecting the principle of distribution based on contribution. Particularly in the new energy vehicle sector, where technological complexity is high and R&D risks are substantial, a greater share should be appropriately tilted toward partners undertaking core R&D

tasks. This helps stimulate the enthusiasm of all parties and avoids cooperation breakdowns caused by unfair distribution.

5.2.2 Increase government investment in R&D

Independent innovation in the new energy vehicle industry relies on government financial support in areas such as basic research and generic technologies. Government investment helps enterprises spread innovation costs and reduce R&D risks. In light of the relatively weak innovation capacity of China's new energy vehicle enterprises, it is essential to create a policy environment conducive to enterprise-led innovation through instruments such as tax incentives, special subsidies, and innovation awards.

5.2.3 Accelerate the formation of innovation consortia

Given the existing gaps between China and international levels in fields such as energy batteries and electronic technologies, the government should actively guide the establishment of collaborative platforms integrating industry, academia, research, and application. On one hand, financial support should be provided to help enterprises overcome core technological bottlenecks; on the other hand, the formation of innovation consortia should be promoted to facilitate upstream and downstream collaboration in low-carbon technology development and the sharing of achievements.

5.3 Research Prospects

Although this study has conducted preliminary explorations in case analysis and model construction, it still has certain limitations, such as the limited representativeness of samples, the simplified handling of real-world cooperation by game models, and the lack of empirical research with primary data. Future research can be deepened in the following aspects: constructing dynamic evolutionary models more in line with the complexity of innovative cooperation, conducting comparative studies across different enterprise types and industries, performing empirical tests on cooperation mechanisms through field investigations and data collection, and further exploring the dynamic paths and institutional optimization directions of collaborative innovation in the new energy vehicle industry from the perspectives of innovation ecosystems and international experience comparison.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

[1] Ren Qiuzhen, Li Jinkai, Johan Albrecht. Toward circular economy: Implementing circular economy strategies to reduce carbon emissions in Chinese cities. Business Strategy and the Environment, 2025, 34(1): 914-931. DOI: 10.1002/bse.4019.

[2] Bergougui B, Murshed S M, Shahbaz M, et al. Towards secure energy systems: Examining asymmetric impact of energy transition, environmental technology and digitalization on Chinese city-level energy security. Renewable Energy, 2025, 238: 121883. DOI: 10.1016/j.renene.2024.121883.

[3] Mahdad M, Roshani S. The open innovation kaleidoscope: navigating pathways and overcoming failures. Review of Managerial Science, 2025, 19(6): 1637-1668. DOI: 10.1007/s11846-024-00804-7.

[4] Serrano-Ruiz J C, Ferreira J, Jardim-Goncalves R, et al. Relational network of innovation ecosystems generated by digital innovation hubs: a conceptual framework for the interaction processes of DIHs from the perspective of collaboration within and between their relationship levels. Journal of Intelligent Manufacturing, 2025, 36(3): 1505-1545. DOI: 10.1007/s10845-024-02322-5.

[5] Jialin Shen, Zhang Qi, Tian Shuoshuo. Decarbonization pathways analysis and recommendations in the green steel supply chain of a typical steel end user-automotive industry. Applied Energy, 2025, 377: 124711. DOI: 10.1016/j.apenergy.2024.124711.

[6] Godfrey Yeung, Liu Yi. Hybrid governance of joint ventures in transitional economies: The case of Guangzhou Automobile Group in China. Review of International Political Economy, 2023, 30(3): 1177-1201. DOI: 10.1080/09692290.2022.2062033.

[7] Schuhmacher A, Gassmann O, Bieniok D, et al. Open innovation: A paradigm shift in pharma R&D? Drug Discovery Today, 2022, 27(9): 2395-2405. DOI: 10.1016/j.drudis.2022.05.018.

[8] Cheng Qiang, Peng Chun, Wan Huaxin, et al. How to realize digital knowledge innovation through digital technology? A perspective based on knowledge digitization and inter-organizational knowledge sharing. Technology in Society, 2025, 82: 102905. DOI: 10.1016/j.techsoc.2025.102905.

[9] Rahman H A, Karunakaran A, Cameron L D. Taming platform power: Taking accountability into account in the management of platforms. Academy of Management Annals, 2024, 18(1): 251-294. DOI: 10.5465/annals.2022.0090.

[10] Basole R C, Park H, Seuss C D. Complex business ecosystem intelligence using AI-powered visual analytics. Decision Support Systems, 2024, 178: 114133. DOI: 10.1016/j.dss.2023.114133.

[11] Lv L, Zhao A. A Multi-party Evolutionary Game Study of Green Behaviour of Construction Industry Practitioners considering Consumer Preferences. Energy, 2025: 137866. DOI: 10.1016/j.energy.2025.137866.

[12] Zhao Hui, Cheng Xian, Gao Jing, et al. A study on risk sharing of smart city PPP projects based on EW-G1 and TOPSIS-UT: a case study in China. Kybernetes, 2025, 54(3): 1470-1494. DOI: 10.1108/K-05-2023-0824.

[13] Zhu Yuchen. Research on evolutionary game of digital twin data information sharing based on blockchain technology. Measurement and Control, 2025, 58(1): 24-49. DOI: 10.1177/00202940241245035.

[14] Xie Deru, Zhang Huiqin, Zhang Yuxiang, et al. Applications of autonomous driving technology in ride-hailing service platform: based on multi-party evolutionary game analysis. Computers & Industrial Engineering, 2025: 111339. DOI: 10.1016/j.cie.2025.111339.

[15] Hanisch M, Graf-Vlachy L, Haeussler C, et al. Kindred spirits: Cognitive frame similarity and good faith provisions in strategic alliance contracts. Strategic Management Journal, 2025, 46(2): 436-469. DOI: 10.1002/smj.3660.

[16] Song Yu, Chen Bo, Wang Xinyi. Cryptocurrency technology revolution: are Bitcoin prices and terrorist attacks related? Financial innovation, 2023, 9(1): 29. DOI: 10.1186/s40854-022-00445-3.

[17] Micek G, Gwosdz K, Kocaj A, et al. The role of critical conjunctures in regional path creation: a study of Industry 4.0 in the Silesia region. Regional Studies, Regional Science, 2022, 9(1): 23-44. DOI: 10.1080/21681376.2021.2017337.

[18] Nie Shiqi, Cao Xiaojing, Li Zilong, et al. Supply chain digitization in the net-zero era: The impact of digital technology, renewable energy, and infrastructure. Energy Economics, 2025, 144: 108403. DOI: 10.1016/j.eneco.2025.108403.

[19] Tollefson J. What the rise of 'arpa-everything'will mean for science. Nature, 2021, 595: 483-484. DOI: 10.1038/d41586-021-01878-z.

[20] Li Qiang, Ulissi U, Liang Zibin, et al. Progress and Prospect of Industrialization of Sodium-Ion Battery in China. Advanced Energy Materials, 2025: e04877. DOI: 10.1002/aenm.202504877.

[21] Yao Yongzheng, Tan Luyao, Chen Fang, et al. Hydrogen energy industry in China: The current status, safety problems, and pathways for future safe and healthy development. Safety Science, 2025, 186: 106808. DOI: 10.1016/j.ssci.2025.106808.

[22] Marti C L, Liu Huimin, Kour G, et al. Leveraging artificial intelligence in firm-generated online customer communities: a framework and future research agenda. Journal of Service Management, 2024, 35(3): 438-458. DOI: 10.1108/JOSM-10-2023-0443.

[23] Di Kaixiong, Xu Runhan, Liu Zuankuo, et al. How do enterprises' green collaborative innovation network locations affect their green total factor productivity? Empirical analysis based on social network analysis. Journal of Cleaner Production, 2024, 438: 140766. DOI: 10.1016/j.jclepro.2024.140766.

[24] Eisenhardt K M, Graebner M E. Theory building from cases: Opportunities and challenges. Academy of management journal, 2007, 50(1): 25-32. DOI: 10.5465/amj.2007.24160888.

[25] Davis J P, Eisenhardt K M, Bingham C B. Developing theory through simulation methods. Academy of management review, 2007, 32(2): 480-499. DOI: 10.5465/amr.2007.24351453.

[26] Jacobides M G, Cennamo C, Gawer A. Towards a theory of ecosystems. Strategic management journal, 2018, 39(8): 2255-2276. DOI: 10.1002/smj.2904.