

Scenario-driven Innovation Empowered by Digital Intelligence

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Abstract

Advances in digital and intelligent technologies, along with the constant emergence of new application contexts, are fostering a novel innovation paradigm known as scenario-driven innovation. Scenario-driven innovation is one of the emerging research hotspots in recent years. Due to the fuzziness of related concepts, problems such as scattered research results and unclear development direction exist. To clarify the research status of scenario-driven innovation in the digital-intelligent context, this paper elaborates on the theoretical basis related to scenario-driven innovation, uses CiteSpace for bibliometric analysis, describes the knowledge map of scenario-driven innovation research, and refines and analyzes hot topics. Integrating the results of bibliometric analysis and combining with practical cases, a scenario-driven innovation actor network is formed, and a scenario innovation actor network circle layer model is constructed, which can provide reference for the theoretical research and practical development of the scenario-driven innovation actor network.

Keywords

Scenario-Driven Innovation; Digital-Intelligent Empowerment; Innovation Network.

1. Introduction

Currently, human society has entered the digital-intelligent era led by artificial intelligence. The "Next Generation Artificial Intelligence Development Plan" points out that AI has become an important strategy for countries around the world to enhance national competitiveness and maintain national security, a new engine for economic development, and the core driving force of a new round of industrial transformation. Facing the wave upon wave of digital-intelligent impacts, how to use digital-intelligent technology to promote the development of innovation networks and accelerate the optimization process of the national innovation system is a necessary path related to the long-term development of the national innovation cause. According to the "China Scenario Innovation Research Report (2024)", as of June 2024, 65 out of the top 100 cities in China's GDP have carried out scenario innovation, an increase of 25 cities compared to 2023. Each city actively promotes open scene innovation for enterprises, accelerates technological innovation and achievement transformation. In this context, scenarios have become an innovation driving element that cannot be ignored[1]. In the digital-intelligent context, fully exploring the value of concomitant scenarios, giving play to the aggregation advantages of scenarios, developing the scenario technology transformation system, and constructing an innovation network with multi-agent linkage have important practical guiding significance.

From a theoretical perspective, the concept of scenario-driven innovation has gradually gained attention in innovation research in recent years, with a number of leading studies emerging. However, this nascent field of research is still developing and lags behind practical developments. Specifically, scenario-driven innovation refers to using scenarios as a carrier to drive the integration and convergence of innovation elements, break through existing technological bottlenecks, and create new technologies, new products, new markets, and even

new industries. Although current scholars have explored the connotation of scenario-driven innovation, few have explained the mechanism of digital intelligence's role in the scenario-driven innovation process from an empowerment perspective. Furthermore, while existing research has noted significant differences in the practical paths of scenario-driven innovation for different actors such as enterprises and governments, it has failed to view the synergistic driving role of scenarios among heterogeneous actors from a systematic perspective[2]. Therefore, it is extremely necessary to systematically review and analyze the research literature on digital intelligence and scenario-driven innovation, which can not only provide ideas for research on scenario-driven innovation but also offer valuable insights for practice in this field.

To clarify the research progress of scenario-driven innovation in the context of digital intelligence, this paper reviews and analyzes existing literature using a combination of quantitative and qualitative methods. First, it systematically reviews relevant literature to clarify the concepts related to digital intelligence, scenarios, and innovation networks. It uses CiteSpace software for keyword co-occurrence and cluster analysis to map the knowledge structure of research on digital intelligence-empowered scenario-driven innovation, focusing on analyzing hot topics in this field and summarizing exemplary scenarios for different innovation actors in the digital intelligence context. Second, integrating the results of quantitative analysis and qualitative reading, it forms a scenario-driven collaborative innovation actor network based on resource orchestration theory and value co-creation theory, and explains its mechanism using practical cases. Finally, based on the identified hot topics, it constructs a layered model of the scenario-driven innovation actors. In summary, this paper advances research on scenario-driven innovation in five aspects: firstly, presenting a holistic overview of existing research globally based on bibliometric methods; secondly, explaining the mechanism of digital intelligence's role in the scenario-driven innovation process from an empowerment perspective; thirdly, forming a scenario-driven innovation actor network in the digital intelligence context based on theoretical foundations and exploring its practical path through cases; fourthly, integrating previous related research according to a layered context, establishing a layered analysis framework for existing research; fifthly, summarizing the shortcomings of existing research based on the literature review and proposing noteworthy future research directions.

2. Literature Review and Theoretical Analysis

2.1. Concept of Scenario

Clarifying the concept is the prerequisite for research. The development of the concept of scenario is closely related to social changes and the evolution of production tools. It not only reflects the changes in the era's environment but also demonstrates the development process of society. However, due to its broad application space and complex, variable connotations, it has different definitions in different fields. This paper draws on definition: scenario refers to a special complex situation at a specific time. The complex comprehensive challenges, problems, missions, or needs faced by the development or evolution of this situation provide an embedded field for multiple innovation actors to initiate and carry out innovation activities and apply innovation outcomes. This field covers different dimensions such as time and space and is a space where various elements interact[3].

2.2. Scenario-Driven Innovation

Although existing research has noticed differences in the practical paths of scenario-driven innovation among different actors, it has not viewed the synergistic driving role of scenarios among heterogeneous actors from a systematic perspective. Furthermore, although current

scholars have noticed the driving effect of scenario elements on innovation, they have not combined the development trend of IT intelligentization to discuss the specific path of scenario-driven innovation from an empowerment perspective[4]. Therefore, this paper first, based on CiteSpace bibliometric analysis, summarizes exemplary scenarios of different innovation actors in the digital-intelligent context. Then, based on collaborative innovation theory, resource orchestration theory, and value co-creation theory, it explores within the digital-intelligent context how innovation actors, driven by scenarios and based on future trends and vision needs, change the original linear innovation model[5]. By constructing data platforms and establishing intelligent interaction systems, they form a tightly connected innovation network to carry out the collaborative innovation process. Innovation actors integrate resources to meet scenario needs, complete scenario design, form value co-creation, and release scenario value. Finally, it discusses the practical path of the scenario-driven innovation actor network combined with actual cases[6].

3. Bibliometric Analysis of Research on Scenario Driven Innovation Empowered by Digital Intelligence

To ensure the comprehensiveness and validity of the research, this paper utilizes Citespace 6.3.R1 to conduct a detailed search of academic literature related to scenario-driven innovation (the detailed retrieval process and criteria are shown in Table 1). Given that the concept of "digital intellectualization" was proposed in 2015, the time span for the literature search is limited from 2015 to 2023. To eliminate interference from duplicate data, 365 English articles were ultimately obtained after manual screening. Based on this data, keyword clustering analysis is performed, laying the foundation for the logical framework.

Table 1. Retrieval Process

Search time	April 10, 2024				
Data source	Web of Science(WoS)				
Search situation	Search keywords	search terms	search conditions	search results	valid data
	Scenario*And Innovate*	Topic	SSCI	570	365
time span	From January 1, 2015 to December 31, 2023				

3.1. Co-citation Analysis

Figure 1 shows the timezone view of the literature co-citation network. In the figure, documents from the same cluster are placed on the same horizontal line, the publication years of the documents are placed at the top of the view, with more recent publications positioned farther to the right. It displays a timeline visualization dividing the network into different co-citation clusters. Below each timeline, the labels of the most frequently cited references are the largest. The timezone view provides a clearer display of the number of documents in each cluster and the duration of their activity.

In Figure 1, clusters are numbered starting from 0, meaning cluster #0 Dynamic Capability is the largest cluster. As the timeline overview shows, the persistence of the 11 clusters varies. Some clusters have long activity durations but did not continue to the present, while other clusters, despite having shorter durations, are still active. Among them, the citations for #3 Learning Organization have the earliest start date, echoing the citations of #6 Knowledge. Scenarios can influence organizational learning, promoting the creation and transformation of knowledge outcomes through exploratory and exploitative innovation in different contexts.

Barao et al., based on changes in organizational scenarios, used data analysis methods to identify the efficiency of knowledge transformation and value benefit within organizations, studying the impact mechanism on organizational learning networks. The #Dynamic Capability cluster has the longest duration, continuing to the present, indicating a close connection between scenarios and the formation of enterprise dynamic capabilities. Teece DJ believes that dynamic capabilities, as strategic resources, should be analyzed within specific scenarios when considering their impact on corporate behavioral decisions. To adapt to the complex, changing, and ambiguous characteristics of the innovation environment in the digital economy era, it emphasizes shifting from core competencies in traditional competitive fields to dynamic capabilities in the digital age, i.e., how enterprises form dynamic capabilities through digital practices in the context of industrial digitalization, revealing the internal mechanism of scenario-driven innovation.

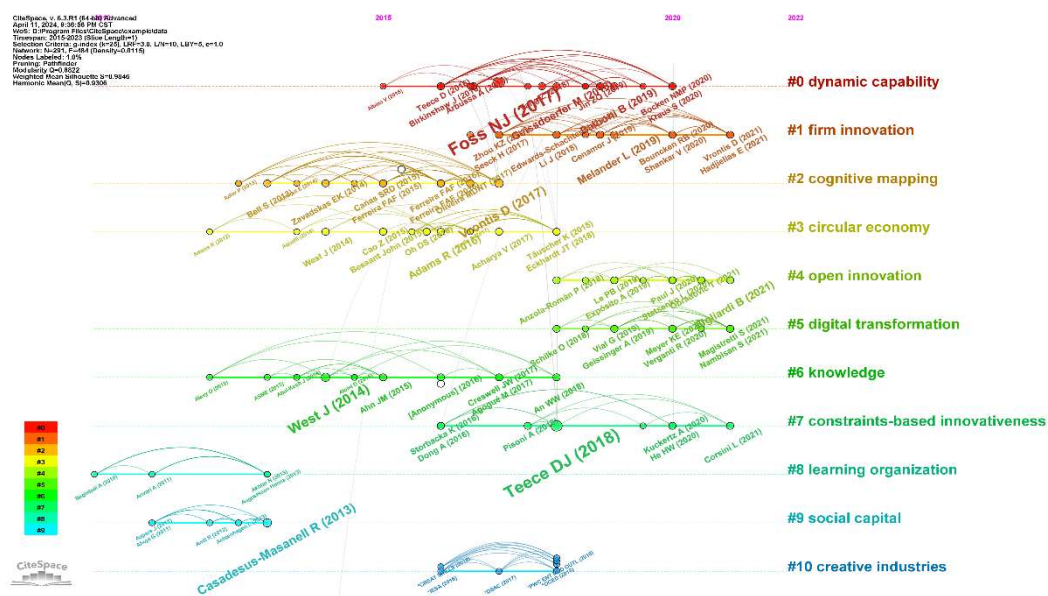


Figure 1. Keyword Clustering Network for Scene Innovation Research

Literature with high co-citation frequency have larger labels, constituting the knowledge base of scenario innovation research. They possess characteristics of citation bursts and function as turning points in connections, wielding significant influence. Analyzing the co-cited literature on scenario innovation helps clarify the knowledge structure of this research field and better grasp the research hotspots. Table 2 lists the top 10 key node literatures by co-citation frequency.

In Table 2, Foss, Nicolaij summarized existing research on BMI into four areas: BMI conceptualization, BMI's impact on organizational change processes, BMI's impact on organizational performance, and contextualized BMI. Contextualized BMI often involves business model innovation in specific industries, such as electric vehicles, tourism, and aviation. Finally, it was found that these four research directions seldom cross-reference and are largely relatively isolated, calling for scholars to conduct cross-disciplinary research. Enterprise dynamic capabilities can generate and enable efficient business model innovation. Business model innovation relies more on scenarios. With the development of new-generation information technology, new business models may emerge. Conversely, the dynamic capabilities of enterprises help identify viable business models in a changing environment. Overall, the highly cited literature in scenario innovation research mostly focuses on BMI, primarily relying on digital technology to deconstruct and integrate the scenario elements and business model elements of enterprises, helping them achieve business model innovation.

Table 2. The top 10 cited literature in total

serial number	Number of citations	centrality	author	title
1	9	0.32	Foss NJ(2017)	Fifteen Years of Research on Business Model Innovation: How Far Have We Come, and Where Should We Go?
2	8	0.18	Teece DJ(2018)	Business models and dynamic capabilities
3	5	0.03	Anderson N(2014)	Innovation and Creativity in Organizations: A State-of-the-Science Review, Prospective Commentary, and Guiding Framework
4	5	0.07	West J(2014)	Leveraging External Sources of Innovation: A Review of Research on Open Innovation
5	4	0	Casadesus-Masanell R(2013)	Business model innovation and competitive imitation: The case of sponsor-based business models
6	4	0.13	Vrontis D(2017)	Ambidexterity, external knowledge and performance in knowledge-intensive firms
7	3	0.12	Adams R(2016)	Sustainability-oriented Innovation: A Systematic Review
8	3	0.05	Balboni B(2019)	Business model evolution, contextual ambidexterity and the growth performance of high-tech start-ups
9	3	0	Bigliardi B(2021)	The past, present and future of open innovation
10	3	0.02	Geissdoerfer M(2018)	Sustainable business model innovation: A review

3.2. Keyword Analysis

Keywords are the condensation and generalization of the article's overall content. Through the analysis of keywords, we can understand the related hotspots and evolution trends of scenario research under the digital-intelligent background.

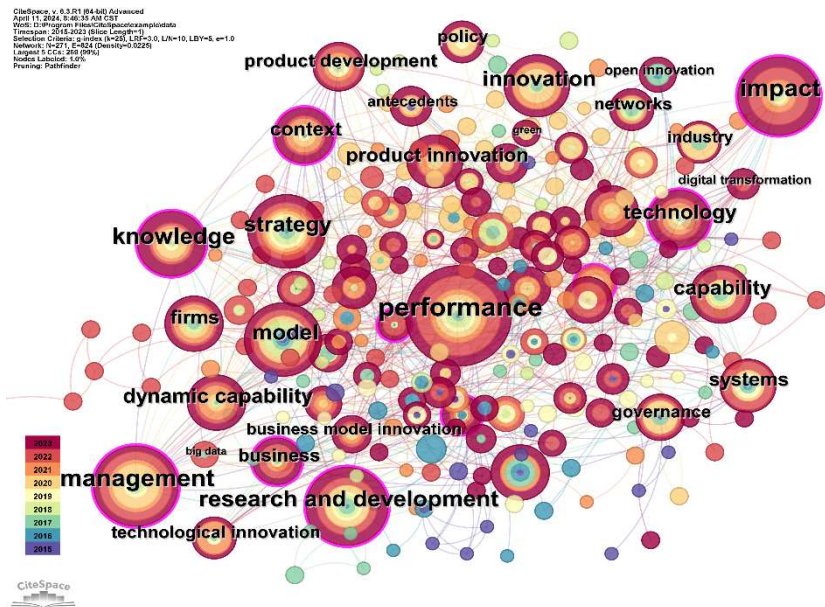


Figure 2. Scene driven innovation research keyword co-occurrence network

From the keyword co-occurrence network (Figure 2), it can be seen that, on the one hand, keywords such as contextualization, application scenario, and scenario marketing have high co-occurrence frequencies and have formed many connecting paths with other keywords. This indicates that the issue of scenario utilization has received much attention and is an important information hub in the field of scenario research, with scholars attempting to use scenario elements for innovation. On the other hand, the appearance of keywords such as artificial

intelligence, Internet of Things, and big data indicates that digital-intelligent technology has a high degree of attention in the field of scenario research and plays an important bridging role in the knowledge network for enhancing scenario application capabilities, which aligns with this paper's research theme of digital intelligence empowering scenario-driven innovation.

3.3. Summary of Research Hotspots in Scenario-Driven Innovation

Combining the above analysis, it is found that digital-intelligent technology, through its intelligent empowerment at the algorithm and governance levels, has spawned a large number of emerging scenarios in various fields. While this provides opportunities, it also increases the difficulty of scenario application. Moreover, there are significant differences in the scenario design and value release methods among different innovation actors. Therefore, this paper, based on the frequency of domestic and international keywords, summarizes exemplary scenarios for different innovation actors, paving the way for subsequently exploring the differentiated paths and practical mechanisms of digital-intelligence-empowered scenario-driven innovation and constructing the scenario-driven innovation actor network.

Based on the summarized research hotspots and keyword co-occurrence results, combined with qualitative reading of the literature, research on digital-intelligence-empowered scenario-driven innovation can be divided into five research themes: the impact of digital intelligence on the scenario-driven innovation process, the scenario-driven innovation actor network, the pathways of digital-intelligence-empowered scenario-driven innovation, the value release of the scenario-driven innovation actor network, and finally, based on these, constructing a layered model of the scenario-driven innovation actor network system.

4. Theme Analysis of Innovative Research on Scenarios Empowered by Digital Intelligence

4.1. The Impact of Digital Intelligence on the Scenario-Driven Innovation Process

(1) Digital intelligence precision drives scenario construction. Scenario identification is the beginning of scenario-driven innovation. Creating highly exemplary scenarios is conducive to promoting innovation development. However, scenarios contain numerous elements, and ordinary technologies may have difficulty accurately identifying key scenarios[7]. On one hand, compared to digital technology, digital-intelligent technology possesses intelligent thinking and is more intelligent at the algorithm level. Emerging digital-intelligent technologies such as big data, artificial intelligence, and the Internet of Things concretize and visualize scenario elements that are traditionally difficult to measure, such as time, space, events, status, and demands, solving the accuracy problem of scenario identification and construction. On the other hand, the precision of digital intelligence is reflected in the enhancement of analytical capabilities, which helps innovation actors deconstruct, reshape, and even subvert scenarios, greatly reducing the cost of technological innovation and achievement transformation. Governments and other innovation actors can use digital-intelligent technology to achieve scenario construction and scenario value release with low cost and high speed.

(2) Digital intelligence openness is the basic condition for the establishment of the scenario-driven innovation actor network. First, digital intelligence openness refers to the interconnection and resource integration of various innovation actors through management systems and data platforms to improve scenario design schemes and enhance scenario application efficiency[8]. For scenario schemes that cannot be carried out with existing technologies, innovation actors need to integrate the basic research advantages of universities and research institutes to form new technologies through original innovation accumulation. Based on digital-intelligent connections and under the traction of major scenarios, the

innovation process of actors shifts from a linear supply chain model to a network model, forming a scenario-driven innovation actor network relationship that transcends spatial constraints. Each innovation actor is not only a service target but also a participant in the scenario-driven innovation process. Second, the enhancement at the algorithm level of digital-intelligent technology provides innovation actors with broader connection platforms, allowing the innovation process to unfold in a non-linear manner across time and space. This attracts more actors to participate in the scenario-driven innovation process, blurs organizational boundaries, expands new fields, new tracks, and new application scenarios, accelerates the technological iteration and technology precipitation of innovation actors, promotes the matching of scenario design schemes with service targets, enables rapid transformation of scientific and technological achievements, brings greater scale benefits, and guides the generation of the scenario-driven innovation actor network.

(3) Digital intelligence interaction forms digital intelligence connection. On one hand, digital-intelligent technology interacts with the external environment through carriers and forms connections with users to exchange data[9]. For example, Himalaya FM can use algorithms to establish different connections with a large number of content-creating users simultaneously, thereby generating massive real-time data convenient for refining scenarios. On the other hand, it emphasizes building data platforms to connect stakeholders, accurately match scenario design schemes, improve one's own touchpoint adaptation capability, and form a rapid-response scenario-driven system.

(4) Digital intelligence generativity enables innovation actors to create new scenarios. With the development of digital-intelligent technology lowering the interaction threshold, enterprises will proactively develop interaction systems[10], integrate one-stop data covering customer demand, R&D, procurement, manufacturing, marketing, and service, perceive differences, and observe user value demands in real-time to design scenarios. Secondly, during the process of users using digital-intelligent technologies such as artificial intelligence, language models, and virtual scenarios, data is continuously generated. Its potential value guides relevant stakeholders to mine the scenarios within, reconstructing products and service models.

4.2. The Value Release of Scenario Driven Innovation Subject Network

As a new innovation paradigm, scenario-driven innovation not only provides an environment and opportunities for the development of new technologies, models, and business formats but also promotes the transformation of scientific and technological achievements. Depending on the differences in problems and demands within actual situations, the paths for innovation actors to release value vary, consequently leading to different levels of output.

From the user level, based on digital-intelligent empowerment, the home large-item logistics industry can accurately profile users and their expectations. By integrating scenario elements into the deconstructed business model, the business model ecosystem is reshaped. During this user experience, the user's value proposition is expressed. From the enterprise level, the scenario-driven process is deconstructed into "scenario penetration" and "scenario coverage." Enterprises, based on these two dimensions, develop more potential scenarios to gain more opportunities. Through "demand identification-technology integration-service operation and maintenance," they develop scenario-based solutions, completing scenario value release. From the government level, scenario-driven transformation of scientific and technological achievements can promote the cultivation of new quality productive forces. Furthermore, this process leverages resource advantages from different fields for technology integration, accelerates technological breakthroughs in major strategic scenarios, and promotes technological innovation and industrial upgrading to open up new scenario tracks. Value outputs at different levels also promote overall societal value creation and economic development in various forms. For example, QuantumCTek, with policy support, constructed a

quantum communication scenario, developed quantum technology, and addressed national quantum security needs through technological iteration. In summary, scenarios are the core grasp for innovation actors to achieve value co-creation. Various innovation actors fully release scenario value by promoting the cyclical process of "scenario construction, scenario-based technological innovation, scenario value release, and scenario expansion."

5. Conclusion and Prospects

5.1. Research Conclusion

Scenario-driven innovation has gained attention in various fields in recent years, with a number of leading studies emerging. However, this burgeoning research area is still in its early stages and lags behind practical developments. This paper sorted out the relevant concepts of digital intelligence and scenarios, used CiteSpace software to identify research hotspots of scenario-driven innovation in the context of digital intelligence, and summarized five research themes based on the keyword knowledge map. It found that digital intellectualization, building upon digitalization, has generated new characteristics, empowering innovation actors to conduct collaborative innovation. Under the traction of scenarios, the innovation process has transformed from a linear supply chain model to a network model, forming an innovation actor network. Combining practical cases, a framework for the scenario-driven innovation actor network was formed. According to the different practical paths of different innovation actors within the scenario-driven innovation actor network, value outputs at different levels were enumerated. Finally, based on the preceding analysis, a layered model of the scenario-driven innovation actor network was constructed to depict existing research, providing specific guidance for the practice of digital-intelligence-empowered scenario-driven innovation.

5.2. Research Limitations and Prospects

This paper conducted relevant discussions on the realization mechanism of digital-intelligence-empowered scenario-driven innovation. Future research in the fields of digital intellectualization and scenarios can be carried out from the following aspects: First, conduct scenario case studies based on local application contexts. On one hand, as a number of local manufacturing companies, such as Conch and Ma Steel, undergo scenario-based transformation, they provide rich case material for scenario application research, which is conducive to building a Chinese scenario application research system. On the other hand, in the digital-intelligent context, scenario-driven innovation often involves knowledge and technology from multiple fields. Existing research needs to fully utilize the extensibility advantage of scenarios to break disciplinary boundaries. Cross-domain integration and collaborative research will become an important direction for future research. Second, strengthen demand management and let opportunities lead innovation iteration. The essence of scenario-driven innovation is the precise satisfaction of scenario demands. Demand insight is the starting point for innovation actors' scenario construction and innovation iteration. More new scenarios that benefit the country and the people can be expanded by mining pain points and difficulties and through resource orchestration. Third: Policy and regulation research. With the in-depth development of research on digital-intelligence-empowered scenarios, related policy and regulatory issues are becoming increasingly prominent. Future research needs to focus on how to formulate reasonable policies and regulations to support data and scenario access and promote the full utilization of scenario element value.

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