

Article

A Review of Policy Framework Research on Promoting Sustainable Transformation of Digital Innovation

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Abstract: With the increasing demand for digital innovation scenarios, it is important to complement and improve the policy system for the governance of digital innovation activities. Combining the previous research results on the analysis of antecedent variables, basic effects and potential mechanisms of digital innovation, and based on the citation analysis of digital innovation topics based on the Citespace method, we find that in the past two decades, the topic of digital innovation policy research has gradually shifted from focusing on “constraining policies to control negative impacts” to focusing on “constructive policies to expand positive impacts”. The digital transformation has brought about multidimensional and profound impacts on the governance of innovation activities, and it is necessary to accelerate the theoretical research on policy frameworks for the new areas of technology socialization effects. Summarizing some of the important progresses, we propose a policy framework covering three aspects: policy needs for sustainable transformation of digital innovation, policy orientation and policy dimensions for sustainable transformation of digital innovation, creating R&D opportunities, optimizing R&D organization, building ecological advantages, improving R&D governance, knowledge creation, enabling applications, collaborative promotion, standardizing management, national digital innovation system, digital innovation foundation, data governance capacity, digital security and other aspects of the conceptual framework of the basic policies for sustainable transformation of digital innovation. The research viewpoints and conclusions are of theoretical reference value for further research on key policy conditions for digital innovation, major policy impact effects and digital innovation governance mechanisms.

Keywords: digital innovation; policy framework; digital transformation; sustainable innovation; literature review



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1. Introduction

Digitalization promotes continuous changes in the participants, processes, results and environment of innovation activities and poses challenges to the basic assumptions of the analysis of innovation governance boundaries, institutional functions and related social impacts (Nambisan et al., 2017) [1]. It has become a new way to open up theoretical space in the field of innovation management. At present, digital platforms, systems and models are becoming an important carrier for major developed countries to deploy independent research and development resources, and digital innovation has also played an important role in the transformation of manufacturing industries in important developing countries (Liu et al., 2021) [2]. In this context, although the antecedent variables, basic effects and potential mechanism analysis of digital innovation have been widely discussed by scholars in recent years, except for some achievements, they have focused on the policy construction of digital innovation such as industrial coordination, institutional foundation and ecological construction. In addition to the key points, there is still a lack of special and systematic research on policy issues that promote the sustainable transformation

of digital innovation. Therefore, this study conducts research on the policy framework for the sustainable transformation of digital innovation from three aspects: the policy requirements for the sustainable transformation of digital innovation, the policy orientation and policy dimensions to promote the sustainable transformation of digital innovation, by means of literature review. The research results can further play the role of value co-creation of various actors such as government agencies at all levels, scientific research departments, universities and enterprises: optimize the allocation of innovative production factors and resources, accelerate the overcoming of key technologies in important fields, break through industrial bottlenecks and contribute to digital transformation. In the new era, the main body of digital innovation activities can effectively grasp the initiative of innovation and development. In turn, it can effectively support governments and digital innovation organizations to analyze the key policy conditions of digital innovation, study and judge the main policy impact effects and promote the policy development of sustainable transformation of digital innovation, while it can provide valuable references for governments and digital innovation organizations to formulate more effective sustainable transformation policies.

Digital innovation refers to the change or creation of products and innovation processes resulting from new combinations of digital and physical components enabled by digital technologies (Liu et al., 2021) [2]. Some typical cases and related research in key areas have found that digitalization of innovation is a revolutionary R&D process change. Digital technology can use R&D multi-subjects and the whole process on the basis of building R&D platforms, virtual verification capabilities and data feedback models. The data flow can shorten the research and development cycle, reduce the cost and double the market value (Kohli and Melville, 2019) [3]. These previous studies provide a direction for promoting the update of digital innovation policy. First, the collaborative R&D platform can promote the internal and external collaboration of the R&D subject, and is the co-construction carrier of the agile development mechanism, which will promote digital technology to play an important role in transforming the relationship between organizations and innovation, and constitute the openness, affordability and generation of digital innovation (Nambisan et al., 2019) [4], emphasizing the importance of digital innovation infrastructure construction and development. Second, virtual reality can obtain the optimal model in reality in a virtual way, breaking the limitations of physical space and time and reducing one-time development costs. Digital twins can greatly reduce the number of tests of physical prototypes by taking advantage of their strong reproducibility capabilities. To ensure the traceability, system and economy of product design (Gao et al., 2022) [5], the proliferation and adoption of emerging technologies and models provide new drivers for the transformation of the innovation ecosystem and the development of the industrial economy, emphasizing the importance of digital innovation system construction and R&D data governance importance. Third, data feedback on the cloud mainly uses the value and supplementary information created by back-end data analysis to feed back the front-end, and promotes business model innovation, reflecting various changes at the business and social levels caused by the use of digital innovation technologies and concepts (Van Veldhoven and Vanthienen, 2022) [6], emphasizing the importance of digital innovation enabling scene mining.

Digital innovation is leading the transformation of innovation policy from “following” following imitation to “leading” with independent innovation. Through literature review, we found that the research topic of digital innovation policy has gradually shifted from restrictive policy to constructive policy change. At present, the relevant policy dimensions have been initially formed around the driving basis, system application and social impact of digital innovation. The diversity of research perspectives and the complexity of research points on digital innovation policy indicate that digital transformation has brought multi-dimensional and deep-seated impacts on the governance of innovation activities. Although many regions actively promote digital technological innovation and intelligent product design, accelerate the construction of supporting policy systems for technological independent innovation, and continue to promote the upgrading of regional R&D capabilities, the

initial construction is based on “digital divide”, “digital economy” and “social media”. In the digital context of the research direction, explore the important foundation of innovation activity governance policies and at the same time rely on the support of digital technology for innovation activities, improve the management efficiency and market value of digital innovation organizations in innovation activities and then promote innovation activities from the traditional departmental hierarchy. The transformation of division of labor to network sharing and intelligent applications has greatly enhanced the value of scenario empowerment for innovation activities and formed a digital innovation governance system in key areas such as manufacturing [7], agriculture [8] and new materials [9]. However, the existing progress pays little attention to the changes in the governance scope, demand and orientation of innovation activities in the process of digital transformation, and there is still a lack of integrated research results on relevant policy frameworks and change trends. Moreover, the current digital innovation system and governance policy construction are still unbalanced and uncoordinated, the main role of social innovation is limited, and the potential mechanism and institutional conditions for profiting from digital innovation are still unclear. Especially for the social and economic background of regions, industries, or technologies, follow-up research needs to continue to improve the affordability of innovative digital-related technological services (Liu et al., 2023) [7], enhance the multiplier role of R&D data in digital scenarios (Sgroi and Marino, 2022) [8] and enhance the normativeness of open science paradigm construction (Lyytinen, 2022) [9], in order to promote the coordinated development of digital innovation and digital economy.

Based on the above analysis and considering that there are no direct research results on the digital innovation policy framework, this study combines the previous research results of digital innovation antecedent variables, basic effects and potential mechanism analysis, focusing on the policy background of digital innovation transformation. This study uses the Citespace method to sort out the overall research progress, research trends and orientation of the current innovation digitalization policy and further summarizes the policy orientation of the sustainable transformation of innovation digitalization. Combined with the construction needs of the national digital innovation system, digital innovation infrastructure, R&D data governance system and innovation digital security guarantee, this study proposes important policy dimensions to promote the construction of the digital innovation system. Under the condition that the demand for digital innovation scenarios is increasingly abundant, this research summarizes and puts forward the policy requirements, formulation orientation and main dimensions of the policy system construction content for the digital transformation of innovation activities, supplements the policy path for digitalization to support the transformation of innovative organizations, and clarifies the digital innovation. The main points of system construction and policy improvement strategies have improved the content of innovation governance institutions to continuously promote the digital transformation of innovation activities and build a digital innovation system. It provides theoretical reference value for further research on key policy conditions of digital innovation, main policy influence effects and digital innovation governance mechanism.

2. Co-Citation Analysis of Documents Based on Citespace

2.1. Overall Research Progress

The sample literature of this paper comes from the Web of Science database, with “innovation”, OR “scientific research”, AND “digital (digitization)”, AND “policy” and related synonyms as the main inscriptions, searching for SCI and SSCI retrieval journal articles published in the category of “management or business” since 2000 (the data collection time is 31 December 2022), and 2225 valid citation data were obtained. Each query document covers the following contents: author, title, keywords, abstract and complete citations. The CiteSpace 6.1 software is used to process the retrieved citation data, and the first eight clusters with the highest citation frequency are selected as the analysis object. After the stable analysis results are obtained from the citation network layout, the digital

innovation policy research map based on literature co-citation timeline shown in Figure 1 is obtained by keyword clustering time map analysis.

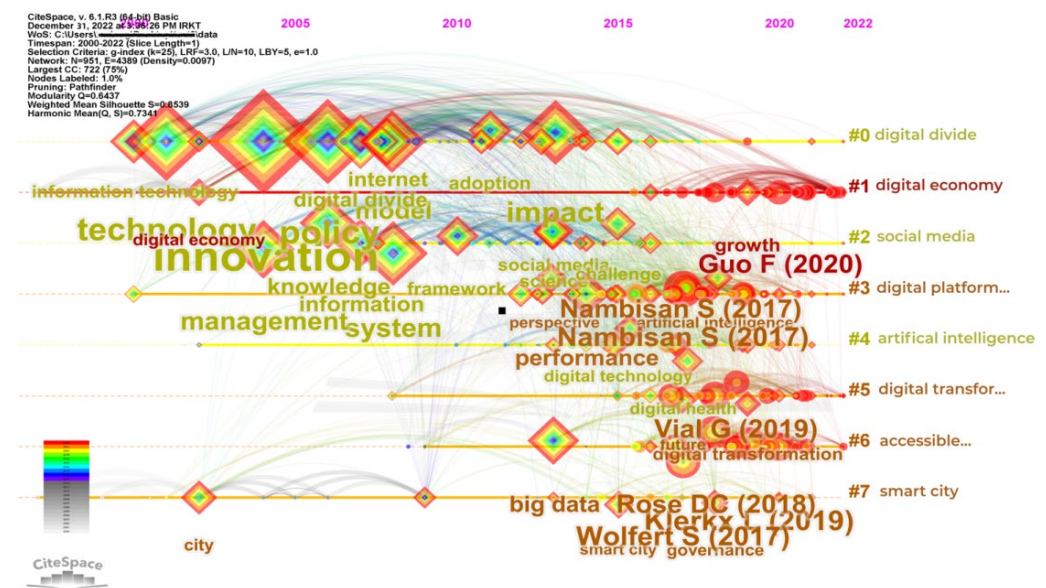


Figure 1. The map of digital innovation policy research based on the co-citation timeline. (Note: The keyword clustering label with...on the right side of Figure 1 means that the data of this cluster are relatively sparse).

In Figure 1, the node represents the citation potential, the greater the compactness of the branches, the higher the citation frequency of the document, the thicker the connection, the higher the number of citations between the documents, and the color and thickness of the node reflects the research age and the number of citations. The analysis of Figure 1 shows that there is a close relationship among the three research themes of digital transformation, R&D and innovation activities and policy issues. The color depth and thickness of most nodes have increased since 2013, indicating a gradual increase in the number of citations. That is to say, the research on digital transformation, R&D and innovation activities and policy issues is on the rise after 2013. In recent years, it has formed some important research fields, such as digital economy, digital platform, digital transformation, availability, smart city and so on.

2.2. Research Trends and Hotspots

On the basis of keyword clustering time graph analysis, the first ten main sudden keywords of digital innovation policy research based on citation intensity and duration shown in Figure 2 are obtained through burst keyword detection analysis.

The ten keywords in Figure 2 are sorted from high to low according to the citation intensity, and the keyword appears and lasts as shown by the red line segment on the right side of the figure. The more the red line segment appears to the right, and the longer the line segment is, it shows that this keyword is an important research trend in recent years. From the analysis of Figure 2, we can see that the digital divide is the earliest keyword that began to emerge in 2007. Information technology, diffusion effect, intellectual property rights and policy improvement are the continuous focus of digital innovation policy research from 2007 to 2017. Since 2018, scientific research, digital media, social participation, network, big data and so on have gradually become new research focuses. In this regard, a further analysis of Figures 1 and 2 shows that:

(1) The research of digital innovation policy has gradually changed from “binding policy to controlling negative influence” to “constructive policy to expand positive influence”. The research themes of the top eight key words clustering (serial number 0~7 on the right of

Figure 1) are “digital divide”, “digital economy”, “social media”, “digital platform”, “artificial intelligence”, “digital transformation”, “availability” and “smart city”. This shows that with the development of new-generation information technology, such as 5G, IOT, artificial intelligence, AR/VR, blockchain and so on, digital innovation not only drives the digital transformation of R&D process, but also becomes an important part of digital economy. The existing achievements have formed a basic policy framework to ensure the digital transformation of innovation activities from the aspects of digital innovation opportunities, organizational models, interactive communication, ecological construction and so on. The current policy framework is further improving the relevant policy dimensions around the driving basis, system application and social impact of digital innovation.

(2) There are many research perspectives and research points of digital innovation policy, which shows that digital transformation has brought multi-dimensional and deep influence on the governance of innovation activities. “Digital divide” (including keywords such as digital inclusion, niche strategy, agency economy, intangible assets, technology unemployment, etc.), “digital economy” (including network infrastructure, digital finance, sharing economy, spatial spillover effects, environmental constraints, green technology innovation, industry innovation, etc.), “social media” (including digital methods, media impact, climate change, environmental impact, public health, dynamic capability, etc.), “digital platform” (including keywords such as digital capacity, niche market, technological innovation, sustainable business model innovation, adaptive policy, etc.), “artificial intelligence” (including system technology, information technology, lean algorithms, digital health, systems biology, systems medicine, etc.). These five clustering keywords have been the main research content since 2000, and they constitute an important basis for exploring the governance policy of innovation activities in the digital context. This shows that digitalization not only greatly improves the organizational efficiency of modern complex innovation activities with the support of digital platforms and tools in the process of design, analysis, simulation, test and verification, but also enhances the value of innovation activities in the existing economic system. It has changed the traditional relationship between production subjects, promoted the transformation of innovation activities from traditional department-level division of labor to network sharing and intelligent applications, and greatly enhanced the scene empowerment value of innovation activities. However, the existing progress pays less attention to the changes in the governance scope, demand and orientation of innovation activities in the process of digital transformation, and there is a lack of integrated research results on the relevant policy framework and change trend.

(3) In the past four years, the research focus of digital innovation policy has gradually evolved to three themes of “digital transformation”, “accessibility” and “smart city”. However, except for Guo et al. (2020) [10] (focusing on the innovation speed quality paradox of the operation performance of small and medium-sized enterprises in the high-tech industry), Nambisan et al. (2017 a, 2017 b) [1,11] (focusing on the basic structure and ecology of digital innovation, as well as the theoretical elements and analytical logic of digital innovation management such as digital technology, digital entrepreneurship and entrepreneurship), Vial (2019) [12] (focusing on the digital technology, organizational strategy, value creation path, etc. jointly form the dynamic capability transformation of digital innovation), Rose and Chilvers (2018) [13] (focus on the key content and sustainable framework of expanding responsible innovation in the era of intelligent agriculture), Klerkx et al. (2019) [14] (focus on digital agriculture, intelligent agriculture and agriculture 4.0 in different fields of social sciences have an important impact on social organization, economic development, institutional changes, etc.), Wolfert et al. (2017) [15] (focusing on the role of big data in the development of intelligent agriculture and its role in supply chains, regional governance, etc.), highly cited research results have not yet appeared. The burst word detection analysis in Figure 2 also shows that “scientific research”, “digital media”, “social participation”, “network” and “big data” are important keywords that have emerged in recent years. It shows that it is of great theoretical significance to explore the governance policy of digital innovation for digital innovation system construction, social

innovation environment construction and data-driven innovation capability construction. Therefore, follow-up research needs to further expand the policy research content of these themes: “digital transformation” (including key words such as absorptive capacity, digital capacity, innovation ecosystem, innovation sustainability, etc.), “availability” (including convenient access, affordability, public policy, collaborative mechanism, general design, etc.), “smart city” (including citizen participation, social innovation, citizen crowdfunding, social mission platform, new infrastructure, etc.).

Top 10 Keywords with the Strongest Citation Bursts

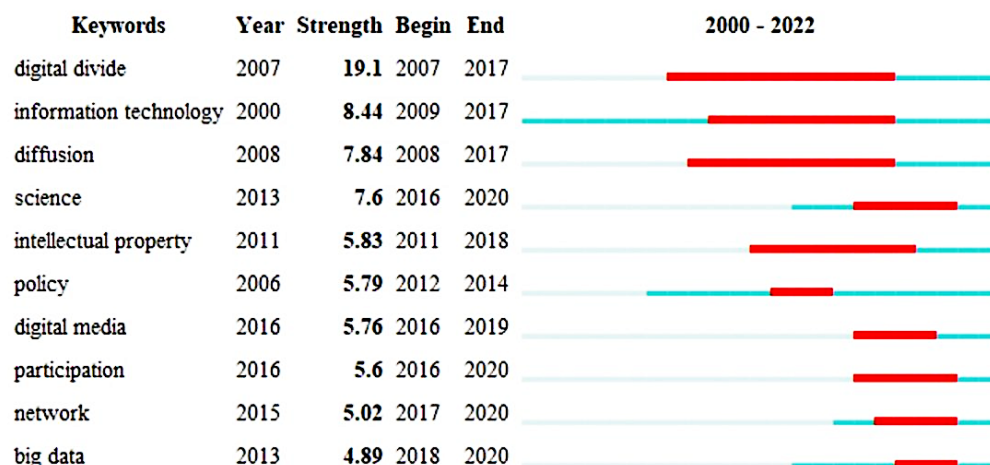


Figure 2. Detection of burst words in digital innovation policy research based on citation strength and duration.

2.3. Research Directions of Digital Innovation Policy

Through the citation analysis results of the relevant research progress, we can see that the construction of digital innovation policy system undertakes the key driving force and important engine in the digital transformation of global digital economy carrier construction, integration application and governance mode. In recent years, the basic paradigm of digital innovation has become increasingly clear, under the condition of the gradual improvement of the relevant hardware foundation, the policy system urgently needs to speed up the system construction. The research direction of digital innovation policy is shown in Figure 3.

(1) Bridging the digital divide and improving the affordability, commercial value and enthusiasm of social participation in innovative digital-related scientific and technological services. On the one hand, in view of the particularity of innovation activities in system construction, resource intensity and correlation impact, we should bridge the gap between human-centered and machine-centered activities (Dennehy et al., 2022) [16] and improve the intellectual property management system for digital innovation products and services, increase financial support for high-performance computers, skills and data access, reduce the cost and threshold of data use by the majority of participants and promote the prosperity and development of regional digital innovation activities. On the other hand, facing the new requirements of artificial intelligence, big data, blockchain and cloud computing for innovation activities and the transformation and development of traditional industries, we should control the social risks that may be caused by digital innovation, eliminate the potential space-time barrier of innovation decision-making and the limitation of democratic decision-making (Curran, 2018) [17], improve the inclusive value of limited R&D resources and support the efficient connection and agile operation of multi-level R&D core business. Based on this, further enhance the systematic support of innovation and digitization to enterprise operation, administration, social culture and other related work and provide diversified digital services for the government, enterprises and the public.

(2) Enhance the multiplier role of R&D data in STI (science, technology and innovation) digital scenarios. On the one hand, centering on the systematic process of data-driven innovation (DDI), from the aspects of product conceptualization, data collection, data extraction, data storage and retrieval, distribution, demonstration and market feedback, etc. (Sultana et al., 2021) [18], build a bridge between innovative data analysis and intuitive decision-making, especially for key core technologies such as the prevention and control of sudden infectious diseases and biosafety risks, drugs and medical devices, key components and basic materials and promote the development of a digital transformation system that is balanced and fully and disciplined governance. On the other hand, in combination with technological innovations such as key industrial transformation, improvement of living standards, eco-friendliness and modern governance capacity building needs, the innovation strategy for artificial intelligence-enabled predictive modeling tools is clarified. Accordingly, it is necessary to rely on policy support to form a high-throughput multi-dimensional innovation solution exploration capability (Konstantopoulos et al., 2022) [19], support unbiased, decentralized and data-driven innovation decision-making, digital innovation activity organizations such as government systems, universities, enterprises and industry associations enhance the efficiency and effectiveness of scientific research in the digital context by enhancing the multiplier role of R&D data and accelerate the transformation of research results for socio-economic benefits.

(3) Standardize the construction of open scientific paradigm of digital innovation. On the one hand, digital innovation entities such as government agencies at all levels, universities and science and technology management departments attach importance to the development and sharing of digital resources in digital innovation and accelerate the development of artificial intelligence applications for digital innovation in the general field by formulating R&D data sharing frameworks and plans and build R&D routes and tasks coordination mode for government, industry and diversified social partners. On this basis, accelerate the value reorganization in the open pattern of digital innovation (Henfridsson et al., 2018) [20], improve the innovation and digital crowdsourcing and open challenges and other scientific and technological unveiling methods, in order to form an innovative atmosphere of digital products, services and business models in which small and medium-sized enterprises widely participate. On the other hand, activities primarily related to digital innovation improve the level of incentives for open access to shared R&D data resources, promote international and domestic R&D network infrastructure access standardization construction cooperation and accelerate the formation of general public policies for R&D data sharing. In addition, by adding professional gatekeepers responsible for technology adoption decision-making (Karunakaran, 2022) [21], we can promote standardized trust in the inter-organizational relationship of platform-mediated digital innovation and improve the consistency and trust of R&D data policies among different organizations.

(4) Promote the coordinated development of digital innovation and digital economy. On the one hand, we should enhance the role of cities in promoting digital entrepreneurship and overcoming the resistance to institutional innovation, reduce the institutional instability that may be caused by digital innovation and entrepreneurship (Geissinger et al., 2019) [22] and increase the role of government systems, universities, enterprises, industry associations and other organizations in the collection of innovative big data, collation and analysis of infrastructure construction investment, provide a more diversified and intelligent way for international and domestic regional scientific research, scientific and technological cooperation and achievement sharing and transformation, promote enterprises, scientific research institutions and policies to participate in the construction of digital innovation carriers, and regulate from agenda-setting to a social R&D digital environment for experimentation, knowledge sharing and public engagement. On the other hand, government agencies, institutions for scientific research and businesses and enterprises focus on core functions such as pre-investment testing of one-stop innovation ecology, search for investment support, innovation ecosystem, network, skills and training, etc., to speed up the definition and

restoration of the value of R&D data elements in the digital economy, and build a digital innovation center value proposition of the network to support ecosystem sustainability (Sassanelli and Terzi, 2022) [23]. In this process, facing the massive and explosive R&D data growth generated by digital innovation, guide digital innovation centers, academic partners, R&D organizations, technology providers, users, etc. to participate collaborative innovation in digital innovation-related technology R&D, business models, industrial ecology and of R&D system.

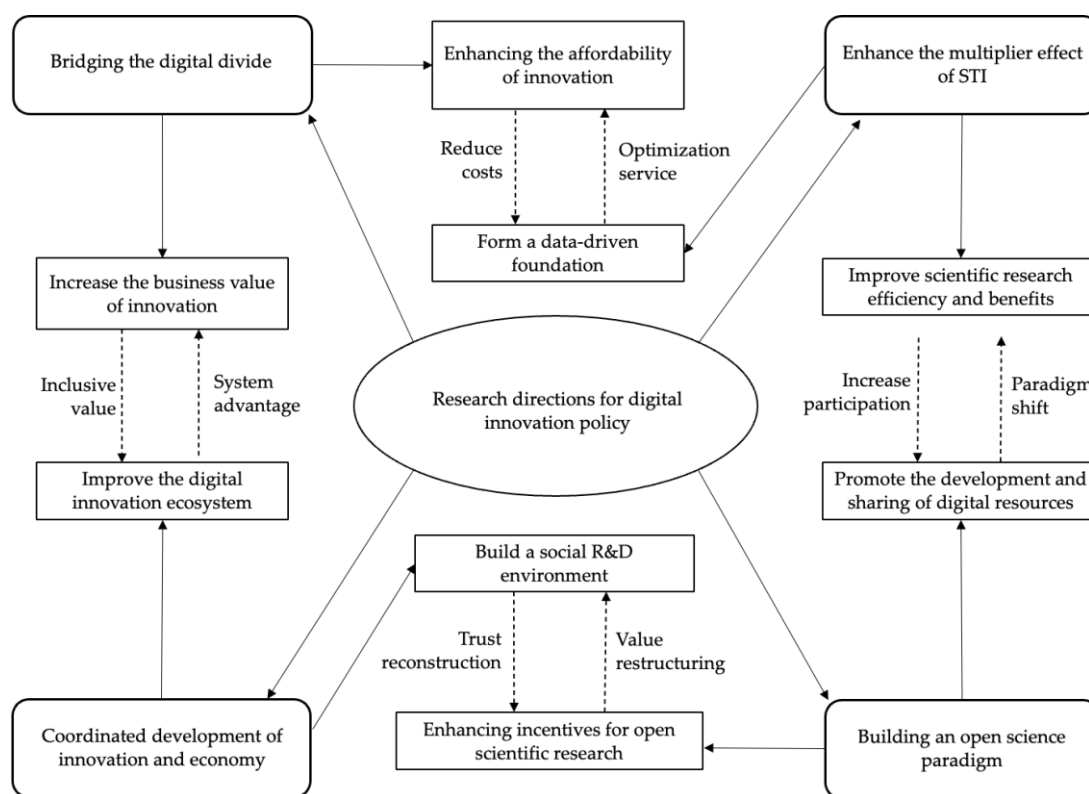


Figure 3. Research directions of digital innovation policy.

3. The Policy Demand of the Sustainable Transformation Process of Digital Innovation

In order to further clarify the sustainable transformation process and policy needs of digital innovation in the digital economy environment, we systematically summarize the research achievements of Bican and Brem (2020) [24] and other scholars from four aspects: digital innovation opportunity, digital innovation organization, digital innovation ecology and digital innovation governance. The main research progress and core viewpoints are shown in Table 1.

3.1. Create R&D Opportunities and Reduce R&D Costs

Digital technology can promote the mobility of R&D resources and improve R&D efficiency, but due to the lack of normative governance and incentive and restraint mechanisms at present, digitization may further strengthen the “Matthew effect” in the field of R&D. Considering these concepts of openness, sharing and value co-creation, which are contrary to the digital economy, it is necessary to accelerate the formation of policy guarantees for innovative digital transformation in terms of R&D digital resource sharing, digital innovation exchanges and cooperation and digital innovation opportunity acquisition.

Table 1. Main research progress and policy requirements of innovation digital transformation process.

Dimensions of Innovative Digital Transformation	Representative Literature	Core Point of View	Key Points of Policy Requirements
Digital Innovation Opportunities	[24–27]	The output of innovation data in different dimensions and processes has different mobility, the network foundation and soft environment for data-driven innovation have not yet been formed and the participation threshold for general entities is relatively high.	Promote the sharing of R&D digital resources, digital innovation exchanges and cooperation and the acquisition of digital innovation opportunities, and systematically reduce the R&D costs of multi-dimensional entities.
Digital Innovation Organization	[28–32]	The connectivity and embeddedness of digital innovation, as well as the understanding and utilitarian orientation of the innovative role among participants (including human and non-human), limit the realization of the integrity of digital innovation.	Implement digital innovation organizational management reforms for key areas and leading companies, promote the update of innovative digital organizational models at the enterprise level, and comprehensively improve the efficiency of digital innovation.
Digital Innovation Ecosystem	[33–36]	Common knowledge and tacit knowledge sharing are more important in the knowledge management of digital innovation and have a profound impact on shaping an intelligent, cross-cutting and open scientific paradigm.	Strengthen hidden R&D data management, support the implementation of data-based R&D decisions, and give full play to the ecological advantages of the digital innovation system.
Digital Innovation Governance	[1,3,4,37–39]	Oriented to the established stage, quality, value contribution, etc., digital innovation has changed the previous rules of innovation preparation, cooperation and value creation.	Build a digital evaluation foundation, promote scientific and technological cooperation based on innovative big data, monitor R&D risks and improve R&D governance.

First of all, strengthen the policy guarantee of R&D digital resource sharing. In view of the mobility differences in the output efficiency, quality and value of scientific research data, and facing the relationship between digital preparation, digital technology, digital business model and sustainable innovation (Bican and Brem, 2020) [24], digital innovation organization takes into account the differences in the basis, ability to be shared by scientific research groups in terms of human resources, achievements, data, instruments, etc. On the basis of the previous sharing mechanism of large-scale instruments and equipment, the network foundation of data-driven innovation is constructed by combining the four-stage digital innovation process of discovery, development, diffusion and diffusion (Hodapp and Hanelt, 2022) [25]. According to this, it can promote data collection in R&D planning, design, process, inspection and other links, and form an incentive and restraint mechanism for data sharing for key R&D tasks and specific R&D needs.

Secondly, promote the reorganization and innovation of digital assets involved in digital innovation. In the process of implementing digital innovation, strengthen national policies, regulations and international business environment defined by infrastructure and culture for digital innovation exchanges and cooperation and international business policy guarantees (Nambisan, 2022) [26]. Aiming at the basic characteristics of big data-supported R&D data such as enhanced mobility, increased versatility and enhanced reuse value, the information interoperability between multiple digital innovation systems is increased with the help of digital innovation hyperlink ecosystems. Accordingly, the role of R&D data in driving the flow of other scientific and technological resources will be enhanced, and important scientific research platforms and institutions will be guided to form R&D data

sharing, data quality control and multi-dimensional cooperation strategies. At the same time, it encourages scientific researchers to go out of their own laboratories and face a more efficient model and a broader stage to form cross-regional, cross-professional and cross-field cooperation in talent training, achievement transformation and collaborative research and development. On this basis, accelerate the collaborative R&D process through digital innovation cooperation, promote the reconstruction of the R&D business chain and value chain and realize the scientific and rational use of R&D resources.

Finally, strengthen the policy support for access to digital innovation opportunities. In view of the situation that general R&D institutions and small and medium-sized enterprises are unable to bear the cost of digital innovation system development and platform construction, digital innovation services for general R&D entities are encouraged to implement digital empowerment services. At the same time, considering the core role of key laboratories and leading enterprises in the construction of a digital innovation system, it is necessary to focus on key areas and typical models of innovative digital transformation to ensure that technological innovation initially supported by government funding is subsequently widely and rapidly adopted by market participants (Campagnolo et al., 2019) [27]. Accordingly, it is necessary to use technology to reshape the status of participants in the innovation space and coordinate the different timeliness and technical return rates of expected innovation tasks in the ecosystem. In addition, it is necessary to use SaaS and PaaS to provide low-cost, low-code digital innovation participation opportunities for small and medium-scale R&D participants, to stimulate their enthusiasm for participating in R&D crowdsourcing, technology unveiling and achievement transformation, so as to give full play to their basic role in the digital innovation system.

3.2. Optimize R&D Organization and Improve R&D Efficiency

The socialized technological work of digital innovation has a general impact on the traditional mode of operation and a wide range of social changes. It is necessary to develop an effective and evolutionable complex innovation organization system for digital innovation for multiple participants such as application experts, software engineers, data scientists, business managers, economists, venture capitalists, various user groups and entrepreneur leaders (Hevner and Gregor, 2020) [28]. In response, the statistical results of the 2018 OECD survey of international scientific authors show that the application of digital technology is changing all stages of scientific research, from agenda setting to scientific experiments to the exchange and evaluation of research results. The report “the Future of Scientific Research: drivers and scenarios for the next decade” released by Elsevier in 2019 also points out that the open sharing of scientific data will become the most prominent feature of scientific research activities in the next decade and is expected to lead to major changes in the mode of scientific research organization and scientific research innovation. Therefore, in order to promote the digital transformation of innovation, we need to focus on key areas, leading enterprises to implement the reform of digital innovation organization and management mode, as well as innovation digital organization model update at the enterprise level and speed up the improvement of relevant policies and measures.

On the one hand, promote the reform of digital innovation organization and management of key areas and leading enterprises. In order to ensure the advantages of digital innovation connectivity and embeddedness in bringing together innovation participants and form a digital innovation whole that transcends organizational and industry boundaries (Wang, 2021) [29], it is necessary to accelerate the formation of basic policies for the governance of the innovation digital macro system. In this regard, it is necessary to first avoid “market failure” problems such as unbalanced distribution of digital resources and lack of efficiency caused by the accumulation of scientific and technological resources to large scientific research institutions and leading companies in the process of digital transformation. From important aspects such as data ownership, privacy protection, content supervision and fair competition, the guiding policies for the construction of a digital innovation ecosystem are given. At the same time, it is also necessary to form a discussion

medium for understanding the connection and role of digital innovation between human and non-human participants (Kolloch and Dellermann, 2018) [30] and promote the coordinated implementation of digital innovation infrastructure, industrial digital empowerment and enterprise digital transformation. Accordingly, it is also necessary to support the optimization of industrial resource allocation for industrial technology flow, capital flow, talent flow and material flow through innovative digitalization.

On the other hand, promote the construction of an innovative digital organization model with enterprises as the main body. Taking innovative digitalization as the basis for driving the digital transformation of enterprises and supporting enterprises, the main body of digital innovation activities and relying on digital social innovation (DSI), solves the special social and technical common problems in the process of digital transformation of enterprises and supports enterprises to balance the special utility of DSI in the transformation process socialist (commercial) and collectivist (social) identity orientations [31]. Moreover, focusing on the unique needs of DSI in solving social and technological common problems, with the help of innovative digital transformation, it supports core enterprises to meet the core needs of the entire chain of business, product, R&D and operation. At the same time, it is also necessary to rely on digital, online and intelligent R&D management to improve the overall operating efficiency of the industry, reduce operating costs and give full play to the role of digital platforms in promoting digital innovation and sustainable development of small and medium-sized enterprises in a frugal environment (Yousaf et al., 2021) [32]. In addition, it is also necessary to promote the improvement of digital innovation service procurement policies by organizing digital innovation technological transformation and digital innovation project declarations and support enterprises to form cost-effective and frugal business models to cope with digital challenges and rapid technological transformation.

3.3. Build Ecological Advantages and Support R&D Decisions

Through the overall construction of the digital innovation system in various industries, fields and multi-level entities, a new R&D system centered on the creation, flow and value creation of innovative big data will be gradually established. At the same time, the flow of talent, knowledge and technology driven by data flow will jointly promote the formation of a digital innovation ecosystem. In this context, how to strengthen the management of hidden innovation data and support the development of data-based innovation activities is a difficult problem. Based on this, it is necessary to give full play to the ecological advantages of the digital innovation system and implement policy optimization.

On the one hand, strengthen the policy guarantee of R&D data management. Aiming at the process data accumulated through continuous trial and error, improvement and reorganization in innovation activities, promote the digital management of tacit knowledge related to misconfiguration, research and development errors and management experience. In this regard, it is necessary to introduce reciprocal policies for implicit data collection and sharing and support the development of multidisciplinary heterogeneous scientific data analysis tools based on text analysis (Rizk and Elragal, 2020) [33]. At the same time, it is also necessary to encourage relevant participants to extract common knowledge and transform them into knowledge for application in the process of R&D, design, production and organization, so as to reduce trial and error costs and improve the accuracy of R&D design. In addition, policies to guide the appropriate use of patent and copyright protection in digital products will need to be developed based on the nature of R&D data generation and key product values. This can provide a reference for digital products to adopt differentiated digital content elements and achieve differentiated design (Boudreau et al., 2022) [34], so as to promote the integration and innovation of digital technology, application scenarios and business models.

On the other hand, strengthen the policy guarantee of data-based innovation activities. Knowledge production activities present a trend of intelligence, crossover and openness. Based on previous experimental science, theoretical science and computational science, it supports the exploration and creation of a data-intensive scientific research paradigm

for human–computer collaboration. At the same time, in industry/government plans and large-scale infrastructure construction, it is also necessary to optimize the delivery mode of digital innovation projects around the elaboration of supply chain relationships, digital workflow analysis and formulation of integrated solutions (Whyte, 2019) [35]. On this basis, it is necessary to give full play to the novel role of digital innovation cross-domain collaboration and cross-border tools to promote work collaboration between experts rooted in different digital innovation fields and non-digital knowledge fields (Perschina et al., 2019) [36]. Accordingly, research design, experimental operation, data analysis and other scientific research links are integrated into cloud computing and artificial intelligence decision-making assistance, to collect large-scale data, solve complex computing problems, optimize experimental design and provide division of labor and big data processing support for researchers.

3.4. Promote Reform through Evaluation and Improve R&D Governance

Innovation activities generally have the basic characteristics of long cycle, high uncertainty and difficulty in effective evaluation. In the context of lack of innovative big data support, it is difficult to objectively evaluate the quality and improvement direction of innovation activities based on the established stage, quality and value contribution. In fact, most of the current evaluations for innovation activities are still in the stage of “post-evaluation” and “subjective evaluation”. They usually judge success or failure based on results, or use expert consultation to give qualitative evaluation and reference opinions for improvement. At present, digital transformation provides an objective basis for scientific evaluation to promote reform and scientific governance of innovation activities. It also puts forward urgent policy requirements for building a digital evaluation foundation, promoting scientific and technological cooperation and monitoring R&D risks in complex innovation activities.

First of all, strengthen the construction guidance of evaluation criteria for digital innovation. In view of the fact that digital innovation changes, threatens, replaces or supplements the existing rules of the game in the field, guide the implementation of three new institutional arrangements for digital organizational forms, digital institutional infrastructure and digital institutional building blocks (Hinings et al., 2018) [37]. On this basis, facing the evaluation needs of the R&D team’s task value, contribution and delivery capabilities, etc., form guidance on the construction of a dynamic evaluation database including R&D resource input-output data, R&D process management data and R&D quality evaluation methods (Nambisan et al., 2017) [1]. Accordingly, support R&D team managers, digital innovation platforms, key project organizers and other participants to achieve scientific evaluation of R&D teams and individual work with the help of more powerful analysis tools and more comprehensive, accurate and timely R&D information.

Secondly, strengthen the evaluation guidance of interdisciplinary projects and the process of scientific and technological cooperation. Facing the impact of digital innovation on the collaboration and competition of innovative organizations, policy research needs to pay attention to the openness of innovation data in the Digital Business Ecosystem (DBE) and the evaluation of the effects of scientific and technological cooperation and co-creation of value (Senyo et al., 2019) [38]. In this process, it is necessary to promote the digital science and technology cooperation values of collaborative innovation, equal cooperation and value co-creation based on the delivery of R&D tasks and scientific research data sharing, interoperability and information reuse. At the same time, with the help of digital tools and big data analysis advantages in DBE, the precise docking of scientific research equipment and data resources among different R&D subjects is promoted (Kohli and Melville, 2019) [3]. Accordingly, it is possible to discover the potential relationship between the choice of digital innovation behavior and the quality of work results, to select digital innovation cooperation strategies for different levels of R&D subjects, to improve R&D efficiency and to provide decision-making basis and policy-dimensional incentive and constraint guarantees.

Finally, give full play to the role of innovative big data in the macro-governance of digital innovation. Using artificial intelligence to create new opportunities to comply with the General Data Protection Regulation (GDPR) during digital innovation data collection and analysis can systematically improve the rationality of R&D decisions in key areas, avoid R&D risks and eliminate low-level duplication and vicious competition. At the same time, in order to reduce the bias of public R&D decision-making (Trocin et al., 2021) [39], it is also necessary to promote the construction of evaluation systems for digital innovation strategies and projects by major scientific research management institutions. Therefore, while regulating participants to prevent digital technology application risks, strengthening R&D process assessment and monitoring potential default risks, it is also necessary to deepen R&D strategic evaluation and R&D integrity big data system construction. Accordingly, an ontological decision-making and data-driven legalization mechanism for digital innovation will be formed (Nambisan et al., 2019) [4] and R&D resources will be guided to increase investment in original and leading innovation fields.

4. The Policy Orientation to Promote the Sustainable Transformation of Digital Innovation

On 11 February 2020, the Organization for Economic Cooperation and Development (OECD) issued “Digitalization of Science, Technology and Innovation: Key Development and Policies”. It puts forward the important contents of ensuring the efficiency of digital innovation and promoting the transformation of research achievements from the aspects of building an open scientific paradigm, supporting the innovation and development of digital economy and perfecting digital innovation policies. On this basis, by analyzing the policy background of digital innovation and the policy needs of the process of digital transformation of innovation, we can see that digital innovation not only involves the digital transformation of innovation itself, but also has a complex relationship with the reorganization of multi-dimensional production factors and new industries and new business type exploration in the innovation development economic system. As a result, R&D data, a crucial component of production, is crucial to the innovation economic system’s foundational functions, extensions, implementation processes and overarching management methods. Digital innovation organizations must ensure and strengthen the role of innovation-driven digital innovation. The study separates the policy direction of implementing creative digital transformation from the aspects of knowledge generation, empowering application, collaborative promotion and standardized management on the basis of referencing pertinent research findings. Figure 4 illustrates the four fundamental orientations’ key implications and relationships.

4.1. Knowledge Creation That Encourages Digital Innovation

Facing the open source development trend of the national innovation system in the digital economy environment, it is necessary to take the digital transformation of innovation as an important basis for promoting the upgrading of R&D capabilities and the integration of science and technology. Accordingly, it will continue to enrich and standardize the digital knowledge production and dissemination tools, approaches and modes of innovation activities and promote the knowledge production and diffusion of digital innovation.

On the one hand, ensure and promote the knowledge production of digital innovation. Through the development of digital innovation cooperation system construction and model guidance for important R&D platforms, scientific and technological cooperation projects and R&D service centers, it is possible to reduce the communication costs of experts in different research fields and build an open innovation knowledge production base that expands the frontier of science and technology in a digital innovation environment (Guo et al., 2020) [10]. In the face of different industries and product life cycles, it is also necessary to give full play to the role of data production factors in reducing information asymmetry between supply and demand in the open source technology system. Accordingly, it can

improve the effect of data-supported learning-by-doing and learning-by-memory and enhance the role of feedback learning in knowledge production in co-creation, co-production and open innovation (Vendrell-Herrero et al., 2022) [40].

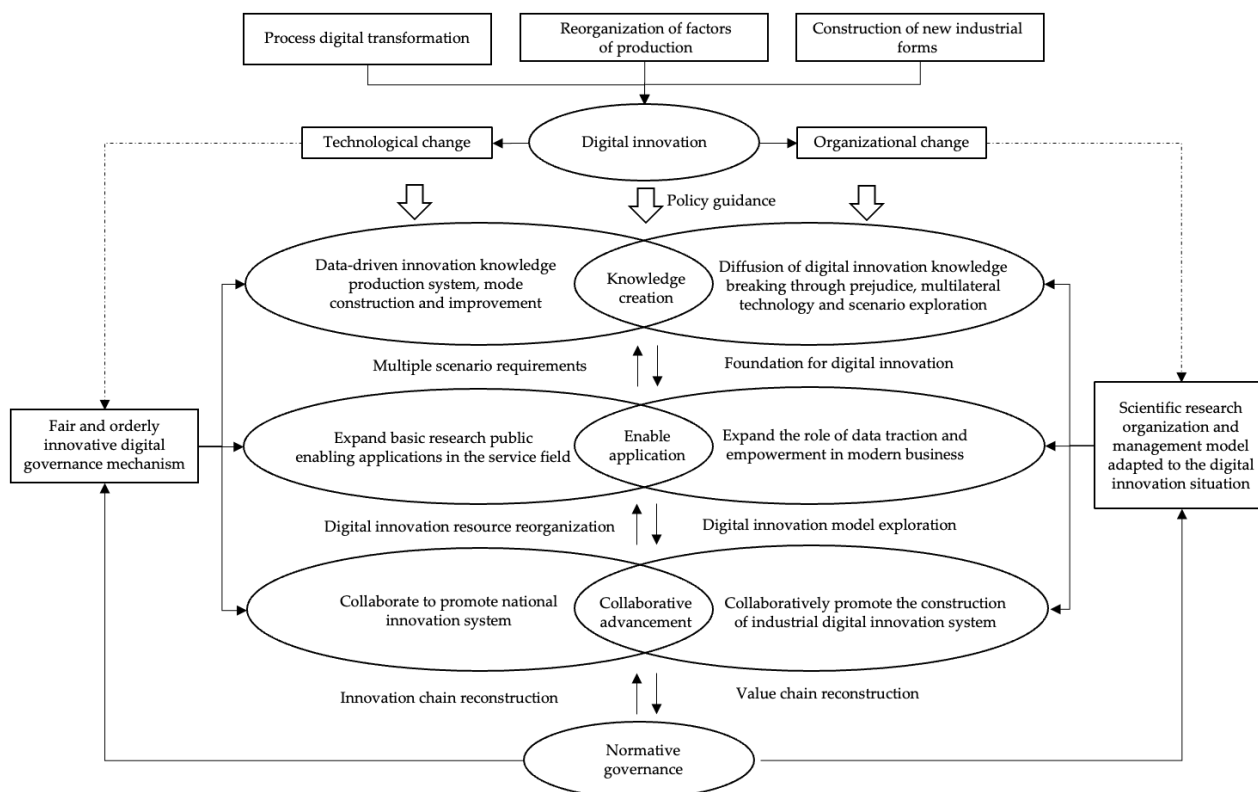


Figure 4. Policy orientation and interaction of innovative digital transformation.

On the other hand, promote the knowledge diffusion of digital innovation. With the help of digital media, digital publishing and other digital tools, media and model innovations, the limitations of time, space, language and mechanism of traditional innovation activities in knowledge dissemination can be eliminated. At the same time, by focusing on the impact of Employee's artificial intelligence awareness (EAIA) on not-invented-here syndrome (NIHS), it can help support them to reduce bias in digital technology adoption assessment (Arias-Pérez and Vélez-Jaramillo, 2022) [41]. All of these help to spread the R&D knowledge achieved through on-site cooperation, personnel flow and face-to-face communication and transform it into data-based, scenario-based and repeatable interactive sharing of digital innovation. At the same time, in order to break through the previous "one-way" communication path centered on R&D personnel, it is necessary to pay attention to the impact of ad valorem tax and unit tax on bilateral and multilateral digital platform intellectual property policies in the digital context (Sánchez-Cartas, 2021) [42]. On this basis, these policies can reshape the ecology of R&D knowledge dissemination for complex and large-group innovation activities, realize the diversification, refinement, platformization and interactive broadcast of R&D knowledge and further improve the efficiency and breadth of knowledge diffusion in innovation activities.

4.2. Expand the Enabling Application of Digital Innovation

Facing the wide penetration and compatibility of digital technology, it is necessary to take digital innovation as an important basis for tapping new momentum for the innovation and development of the digital economy. By giving full play to its special role in multi-subject co-construction, multi-technology integration and multi-scenario linkage, it can

improve the empowerment and application value of digital innovation in the field of basic research public services and modern business scenarios.

On the one hand, expand the enabling application of digital innovation in the field of basic research and public services. Facing complex, diverse and dynamic R&D needs in key R&D fields such as new materials, medical care, energy and transportation, it is necessary to promote the application of digital service models such as virtual reality/augmented reality, blockchain, digital twins, distributed systems and smart networks. At the same time, it is also necessary to improve the organizational driving role of digital complementary assets in IT innovation adoption and discontinuous digital innovation in related fields on the basis of existing equipment sharing (Steinhauser et al., 2020) [43]. Therefore, in order to form digital service advantages in detection, inspection, modeling, repeated experiments, etc., it is necessary to pay attention to product attributes such as product modularization and upgradeability, as well as the influence of support environment such as degree of uncertainty avoidance and technical proficiency (Alvarado-Vargas et al., 2020) [44]. Accordingly, it is possible to further expand the service scope of modern innovation activities, improve service availability, reduce service costs, form digital public service capabilities that meet diverse R&D scenarios and promote the equalization and inclusiveness of public services for digital innovation.

On the other hand, expand the data traction and enabling role of digital innovation in modern business scenarios. Accelerating the integration of digital innovation, Industry 4.0 empowerment, and smart enterprise construction will help support enterprises' efforts to transform their existing business models into ones with more "self-adjusting" advantages (Del Giudice et al., 2021) [45]. With the help of continuous mining, innovation drive and system application of R&D data, the advantages of massive data, vast market space and rich application scenarios can be fully released, and the value of data elements in digital innovation can be stimulated. At the same time, relying on the deep integration of digital innovation, product service innovation, application paradigm exploration and business model creation, it can also promote relevant enterprises to master the concepts and methods of operating and innovating based on external triggers on the basis of intelligent production processes (Van Veldhoven and Vanthienen, 2022) [6]. These are all helpful to realize the improvement of information perception and operation efficiency in the whole production process, accelerate the establishment of an intelligent foundation for industrial innovation and development and promote the agile, adaptable and dual development of enterprises.

4.3. Coordinate the Collaborative Promotion of Digital Innovation

Based on the actual needs of digital innovation system construction and industrial digital innovation capacity building, it is necessary to coordinate the promotion of the government, scientific research institutes, enterprises and relevant social entities to form a multi-dimensional participation, linkage and co-construction mechanism for innovative digital transformation. This will help give full play to the decisive role of the market in the allocation of innovation resources and further straighten out the system functions of different entities in the innovation and development of the new digital economy.

On the one hand, with the help of innovative digital transformation, the construction of the national innovation system should be promoted synergistically. In view of the unique high penetration and high integration attributes of digital and information technology, it is necessary to accelerate the construction of digital platforms, resource structures and ecosystems for technological innovation in the process of building new scientific research paradigms, exploring new technology fields and empowering new application scenarios. Accordingly, in view of the contradiction between distributed value creation of digital innovation and centralized value capture of organizations, a coordination mechanism to deal with this digital platform paradox should be gradually built. With the help of this mechanism, digital platform companies can limit the abuse of their ecosystem members' economic power, labor relations and privacy (Gawer, 2022) [46] and enhance the social responsibility of digital innovation platform companies. At the same time, by focusing on

the impact of technology preparation and digital technology development on technology entrepreneurship and technology market expansion (Jafari-Sadeghi et al., 2021) [47], it can promote the cross-integration development of new-generation information technology and science such as artificial intelligence and cloud computing with digital innovation systems. Under the combined effect of these, relying on scientific research big data analysis can promote auxiliary decision-making in R&D management activities, enhance the positive effect of digital transformation on the generation of innovation value and systematically improve the development efficiency of the national innovation system.

On the other hand, with the help of innovative digital transformation, collaboratively promote the construction of industrial digital innovation system. Engaged in digital innovation, including all levels of government, science and technology management divisions, businesses and industry associations focus on the digital transformation needs of industrial technology integration, productive service industry construction and business model innovation, digital innovation needs to be built as the technical foundation for the digital transformation of conventional businesses and the digital value of demand research, procurement, manufacturing, logistics, warehousing and other businesses needs to be enhanced. This can promote the establishment of a platform-based and ecological digital innovation service foundation at the industry level and form a technical framework and governance mechanism for managing independent and complementary participants for the digital innovation platform (Saadatmand et al., 2019) [48]. At the same time, facing new models and new formats such as shared manufacturing, service-oriented manufacturing and personalized customization, it is necessary to realize multi-subject, multi-dimensional R&D resource integration and “technology-business” integrated cooperation at the level of the industrial chain and value chain. Accordingly, with the help of industry-level R&D digital service capability improvement and inclusive equal service mechanism construction, enterprises can be supported to adjust the functions and forms of their digital cores (such as search engines, data mining technologies, platforms, or voice interfaces) through templates (Huang et al., 2022) [49]. These can further reduce the risk of digital expansion, improve the business environment of the industry and accelerate the bridging of the digital divide.

4.4. Strengthen the Normative Governance of Digital Innovation

A new round of technological revolution driven by digital technology is accelerating. Technological breakthroughs, diffusion and application speed are accelerating, bringing greater uncertainty to the construction of a digital innovation system. Therefore, in order to ensure the important role of innovative digital transformation in reshaping the national innovation system and assisting the construction of the industrial digital innovation system, the government needs to improve the technological innovation policy in the digital environment. By promoting the establishment of a fair and orderly innovative digital governance mechanism, a scientific research organization and management model that adapts to the digital innovation situation can be formed. Accordingly, standardized management of digital innovation can be implemented for departments, links and channels that may affect the efficiency and effectiveness of digital innovation.

On the one hand, actors in the digital innovation space establish a fair and orderly innovative digital governance mechanism. Building a digital innovation governance structure that is government-led, multi-participatory and guaranteed by the rule of law can form a cross-departmental and cross-regional collaborative supervision mechanism for digital innovation. In order to maintain the bottom line of safety and improve the relevant macro-control and policy and regulatory systems, it is also necessary to pay attention to digital innovation activities such as demand-driven digital disruption, rapid digital adaptation and continuous digital migration. The development of these regulations (Dong, 2019) [50] can guarantee the status of competitive policy foundation. At the same time, in order to promote both industrial development and regulatory norms, it is also necessary to coordinate the entire value chain of R&D, production, distribution, service and consumption driven by R&D data resources and enhance the top-level design and control orientation of

digital innovation information systems and the transformation of methods (Wiener et al., 2019) [51]. Accordingly, promoting the orderly development of the marketization of R&D data elements such as data rights confirmation, pricing and transactions can guide the construction of an income distribution mechanism that is compatible with the value and contribution of R&D data elements and stimulate the innovation vitality of multi-level R&D subjects.

On the other hand, promote the construction of a scientific research organization and management model that adapts to the digital innovation situation. Facing major scientific research strategies, key tasks and key research and development links, it is necessary to consider the duality of digital innovation governance in the main scientific research management departments. This helps balance the innovation-oriented inhibitory effect of efficiency creep and the unapproved innovation-enhancing effect of shadow innovation support (Magnusson et al., 2020) [52]. At the same time, with the help of digital innovation public service platform construction, distributed R&D model innovation and technology unveiling team training, a symbiotic and co-constructed R&D organizational model that helps release the value of digital innovation can be formed, and the stock value of the entire chain of technological innovation can be tapped. In the process of creating a data-intensive scientific research paradigm, it is also necessary to face the basic characteristics of increased innovation input correlation, innovation process compression, innovation output platformization, data collection strengthening, behavior analysis and asset demand matching feedback among innovation participants (Ayre et al., 2019) [53]. This will promote the optimization of the funding and management methods of science and technology plans and science funds and improve the quality and efficiency evaluation system and methods of science and technology projects based on digital innovation data. These measures will guide the transformation of R&D resources to high-efficiency and intelligent digital innovation and form a “bottom-up” market-oriented R&D policy coordination.

5. Policy Dimensions to Promote Sustainable Transformation of Digital Innovation

Facing the main policy orientation of implementing innovative digital transformation, in order to give full play to the characteristics of data elements such as continuous iteration, self-added value and sharing and co-construction, systematically build a policy system for innovative digital transformation. On the basis of referring to the research results of Tate [54], etc., this study summarizes and proposes to build a national digital innovation system as the guide, to accelerate digital construction as the basis, to improve innovative big data governance capabilities as a way and to enhance innovation digital security. Figure 5 shows the core content and interrelationships of each policy dimension. Among them, creating a prosperous and orderly industrial digital innovation environment provides an open and collaborative scenario for accelerating the digital innovation infrastructure, enhancing innovation big data governance capabilities with data drive, further improving the efficiency of innovation digital security and balancing the stakes on this premise to address the opportunities and challenges of complex innovation activities. At the same time, the improvement of innovative digital security provides a guarantee for the transformation of innovative big data into valuable information and knowledge, thereby promoting the change of digital innovation infrastructure paradigm. Enhancing the digital governance capabilities of scientific research management departments and creating a new pattern of multiple co-governance for digital innovation provides a basis for scientific decision-making and a benign competitive environment for improving innovative big data governance capabilities.

5.1. Guiding the Construction of a National Digital Innovation System

For the construction of digital technology innovation system, digital industry innovation system and digital society innovation system, it is necessary to guide the construction of a national digital innovation system and improve the overall efficiency of national R&D. These contents mainly involve enhancing the digital governance capabilities of scientific

research management departments, creating a new pattern of multiple co-governance for digital innovation, creating a prosperous and orderly industrial digital innovation environment and building an international scientific research cooperation network for digital innovation.

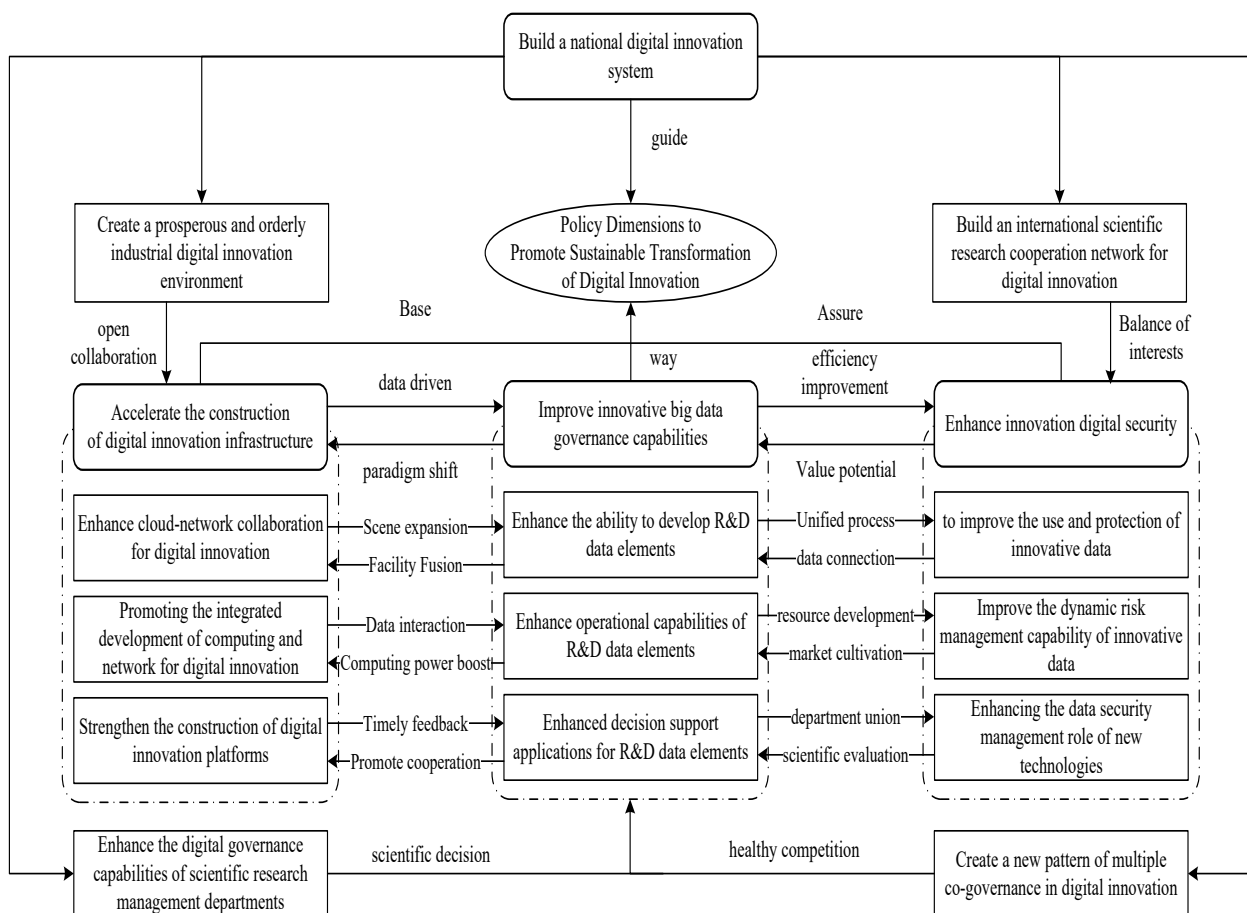


Figure 5. Policy dimensions and interrelationships to promote digital transformation of Innovation.

First, enhance the digital governance capabilities of scientific research management departments. Digital innovation policies are being implemented, and innovative subjects combine the basic needs of digital innovation's open project operation, R&D process and service capacity building, it is necessary to build a "fuzzy front end" (FFE) for R&D public sector open digital service innovation (Tate et al., 2018) [54]. Accordingly, on the basis of implementing cross-agency commitments on R&D funds and physical objects, the government needs to increase the overall planning of scientific research and government information construction and establish and improve a statistical monitoring and decision-making analysis system for digital innovation. This will help improve the accuracy of R&D strategy formulation and the coordination and effectiveness of implementation in the digital environment and improve the risk identification and prevention level of the R&D system.

Second, create a new pattern of pluralistic co-governance for digital innovation. In order to improve the effectiveness of digital innovation and the multi-subject participation scenario of R&D data element market construction, it is necessary to improve the digital innovation participation mechanism including the government, platforms, enterprises, industry organizations and the public. At the same time, it is also necessary to accelerate the formation of important institutional foundations for participation in digital innovation activities, such as qualification certification for participation in digital innovation activities, data security responsibilities, intellectual property protection and fair competition

review. These measures can provide guidance for enterprises to adapt to the legal conflict between business operation logic and digital innovation logic caused by digital openness (Thorén et al., 2018) [55] and form a digital innovation ecology with multiple governance, coordinated development and healthy competition.

Third, create a prosperous and orderly industrial digital innovation environment. Government agencies at all levels, industry associations and other departments support leading enterprises to implement digital innovation system construction at the industrial chain level for the reciprocity of R&D resources, capacity sharing and supply chain interoperability, which will help form a digital innovation service platform for parks, industries and regions as a whole. This will promote the generative emergence of digital innovation at the socio-technical system level, forming seven generative components: generative architecture, generative governance, generative community, generative fit, combinatorial innovation, generative results and generative feedback (Thomas and Tee, 2022) [56]. These measures are conducive to the construction of open source communities, developer platforms and distributed R&D cooperation networks for industrial digital innovation and the systematic convergence of R&D resources such as R&D conditions, standard formulation and revision, testing and evaluation, application training and business incubation. Ultimately, they can promote the construction of an industrial digital innovation service foundation for open collaboration between large, medium and small enterprises and social developers.

Fourth, build an international scientific research cooperation network for digital innovation. In view of the opportunities and challenges of international cooperation, talent exchange and mechanism innovation of complex innovation activities, it is necessary to enhance the role of digitalization in accelerating the demise of distance and reducing the inequality of innovation space. Focusing on the regional spillover effects of digital innovation, digital capabilities and entrepreneurial activities (Haefner and Sternberg, 2020) [57], it is necessary to break through the boundaries of scientific research organizations and rely on digital innovation platforms to explore new cooperation methods such as “public science”, virtual laboratories and technology unveiling teams. These measures help to absorb the innovative wisdom of scientists and engineers on a global scale based on local resources and knowledge advantages and further improve and enrich the international scientific research cooperation mechanism.

5.2. Speeding Up the Infrastructure of Digital Innovation

Facing the role of digitalization in promoting the optimization of the knowledge production process of innovation activities and multi-subject information collaboration, it is necessary to enhance the cloud-network collaboration of digital innovation, promote the integrated development of computing and network in digital innovation and strengthen the construction of digital innovation platforms. These policies will promote the transformation of scientific research paradigms such as traditional experimental science, theoretical deduction and computer simulation to data-driven scientific research paradigms and accelerate the construction of a collaborative, symbiotic, open and shared digital innovation ecosystem.

First, enhance cloud-network collaboration for digital innovation. For the data production and application requirements of the whole process of digital innovation and process management collaboration (Mendling et al., 2020) [58], it is necessary to improve digital infrastructure such as 5G, data centers, software platforms and industrial Internet platforms based on the basic principles of green, low-carbon, intensive and efficient. At the same time, to promote the intelligent integration of R&D-related facilities around networking, intelligence and collaboration, it is necessary to create a digitally innovative cloud-network collaborative infrastructure supply system to promote the application of machine vision, machine learning and other technologies. These infrastructure constructions can support the expansion of application scenarios such as data sharing, knowledge dissemination, achievement transformation, scientific and technological cooperation and popular science promotion of digital innovation and provide hardware support for the

digital transformation of important R&D entities. Accordingly, it is possible to improve the ubiquitous connection, flexible supply and efficient allocation of R&D data resources in the economic system and build digital innovation carriers and digital innovation public service capabilities.

Second, promote the integrated development of computing and networks for digital innovation. On the basis of the construction of computing power network hub nodes in important economic regions, it is necessary to promote the collaborative construction of research and development data center clusters of government, universities, enterprises and other institutions and improve the cross-network and cross-regional data interaction capabilities of data centers. By accelerating the establishment of a large national scientific and technological innovation database and strengthening edge computing capabilities in key R&D areas, an innovative big data support system that coordinates computing power, algorithms, data and application resources can be formed (Rizk and Elragal, 2020) [33] to meet the needs of digital innovation and computing network integration. At the same time, facing the basic orientation of creating a new type of intelligent infrastructure integrating intelligent computing power, general algorithms and development platforms, it is also necessary to build a regional, multi-level, multi-departmental, multi-dimensional technological innovation information platform and a diverse and open scientific and technological management innovation platform. Accordingly, exploring a new model of ternary interaction of big data, Internet of Things and cloud computing can support enterprises to adopt certain types of software tools such as innovation management software (IMS) or digital innovation management system and promote innovation plans, stakeholders and resource integration (Endres et al., 2022) [59].

Finally, strengthen the construction of digital innovation platforms. In order to support the use of big data, artificial intelligence and other digital technologies to promote the construction of virtual laboratories and academic interactive scenes, it is necessary to accelerate the experimental design and operation of scientific researchers, the construction of intelligent auxiliary systems for analysis and guide the creation of digital scientific research paradigms of intelligent cooperation and human–computer collaboration (Trocin et al., 2021) [39]. This will reduce the cost of scientific and technological exchanges and cooperation due to time, space, culture and background, reduce the low-value physical work of scientific researchers in the R&D process and promote timely feedback between the R&D knowledge production process and the product production process. At the same time, new types of participants in decentralized applications (dApps), such as transaction validators, bring a lot of generative and unpredictability (Leiponen et al., 2022) [60]. Accordingly, it is also necessary to enhance the blockchain governance capabilities of the digital innovation platform based on the basic operating characteristics of the decentralized blockchain platform. These policies help to improve the cooperation between different innovation elements and innovation subjects in the innovation system and thereby optimize the commercialization and value creation process of innovative technologies.

5.3. Improve the Governance Ability of Innovative Big Data

In the past, innovation activities were prone to problems such as resource dispersion, lack of competition and closed knowledge due to single-subject and centralized R&D. Facing the changing trend of data-driven scientific research paradigms and the high-quality management requirements of innovation activities, it is urgent to enhance the governance capabilities of innovative big data from the aspects of data element development, operation and decision support. With the help of networked and distributed research and development of digital innovation, complex scientific problems can be solved more efficiently and the allocation efficiency and market value of research and development resources can be improved.

First, enhance the ability to develop R&D data elements. While promoting the research and development of big data digital basic technology, the formulation of digital technology and digital economy standards, promote the unification of the process of research and

development of digital technology updates and the improvement of compatibility of communication protocols in various fields. In this process, it is necessary to break down the R&D process, technology and protocol barriers around the collection, storage, transmission and processing of data in the whole process of R&D and the requirements of standardized management (Steinhauser et al., 2020) [43]. At the same time, it is also necessary to promote the standard system of R&D data resources and the construction of a complete R&D data chain and guide the formulation of analysis units, digitalization degrees and social-technical attributes of digital platforms in different architectural levels and different industry environments (De Reuver et al., 2018) [61]. In the long run, data-oriented labeling, cleaning, desensitization, decryption, aggregation, analysis and other links will gradually realize the intercommunication and interoperability of R&D data. Accordingly, it is also necessary to explore the management system and business model of R&D data sharing, exchange, collaboration and openness for business applications, improve the quality of R&D data and cultivate and expand the R&D data service industry.

Second, enhance the operational capabilities of R&D data elements. In view of the increasingly prominent cross-industry and multi-party innovation collaboration characteristics in the process of digital innovation, it is necessary to pay attention to the non-competitive and non-scarce characteristics of data elements, as well as the attributes that the value of data elements is significantly positively correlated with the scale and richness of data. Accordingly, it is necessary to speed up the construction of asset evaluation, market transaction rules and transaction demand matching mechanisms for R&D data elements (Gawer, 2022) [46], promote the deep integration of data, technology and scenarios in the R&D value chain and improve the resource processing capabilities of R&D data. At the same time, it is necessary to reverse the inherent technological bias in the dominant view of innovation, starting from the market dimensions of demand, action and behavior used or replaced by market participants (Makkinen and Komulainen, 2018) [62] and mobilize industry associations, scientific research institutes, enterprises and other parties to participate in R&D data operations. In addition, it is also necessary to support other market entities to carry out the commercial value mining business of R&D data in accordance with laws and regulations through data openness, licensed development and authorized applications, so as to promote the productization and service of R&D data value. These policies will help reduce the information asymmetry between the supply and demand sides of elements, accelerate the cultivation of market players, improve the governance system, promote the growth of the R&D data element market and form a diversified R&D data asset operation mechanism that supports “open innovation”.

Third, enhance the decision support application of R&D data elements. Based on the relevant platforms and achievement documents and patent databases of digital technology services, it is necessary to accelerate the establishment of a Digital Science and Innovation Policy (DSIP) system. This will break down the data barriers between science and technology and industrial sectors and promote continuous competition in digital innovation in terms of digital integration capabilities, digital platform capabilities and digital innovation capabilities by integrating R&D plans and progress information of different industries, regions and departments (Annarelli et al., 2021) [63]. At the same time, the new relationships, skills, arrangements, technologies and equipment required to innovate the value of activities and to profit from digital tools and services all challenge previous players. Accordingly, it is necessary to speed up the digitization process of innovation policy formulation from the aspects of policy effect evaluation, innovation index definition, R&D funding gap evaluation, R&D application evaluation, social and economic impact analysis of achievements, forward-looking technology and representative scholars’ recommendation (Wiener et al., 2019) [51]. These policies can provide digital R&D consulting support for scientific and technological planning formulation, precise scientific research management and transformation of scientific and technological achievements and improve the decision-making efficiency of multi-dimensional scientific research management.

5.4. Enhance Security for Digital Innovation

At present, the innovation of digital and network technologies is accelerating, the competition in key research and development fields is intensifying, and the demand for innovative big data security continues to increase. In this context, it is necessary to further enhance the role of relevant bill construction, risk assessment and technological innovation in the construction of an innovative digital security system in combination with the system construction, multi-dimensional management and technological progress requirements of innovative digital transformation.

First, study and formulate relevant bills on the use and protection of innovative data. The platform model in the public domain has brought economies of scale, demand integration, data-attracting innovation and significant infrastructure benefits, all of which have brought challenges to effectively implement the requirements for simultaneous planning and simultaneous construction of network security technologies. Therefore, the platform's dominant policy support, promotion of open standards, long-term planning and focus on incentives will make privacy policy updates, governance and regulatory method differentiation more important (Thompson and Venters, 2021) [64]. Accordingly, according to the entire life cycle of R&D data collection, transmission, storage, processing, sharing and destruction, it is necessary to further clarify important content such as the boundaries of rights and responsibilities of different participants, usage specifications, information protection responsibilities and intellectual property management. Based on this, it is also necessary to accelerate the formulation of policy frameworks for multi-agency coordination and cooperation, resource sharing and public sector data sharing and reuse and improve the ethical norms for digital technology application in innovative activities. These policies help to update the settings of digital innovation platforms and projects' strategic and commercial goals, delivery models, risks, governance, roles, incentive structures, possible architectures, openness to cooperation, etc. (Mendling et al., 2020) [58]. The implementation of policies can enhance the trust of multi-dimensional R&D subjects, especially non-government personnel, in the digital empowerment of innovation activities, support the expansion of the scope and scale of data use for digital innovation and optimize the application environment for digital empowerment innovation and development.

Second, improve the dynamic risk management capabilities of innovative data. To secure public support for innovative data use (and re-use), a public engagement-promoting trust relationship-building approach to digital innovation public values and social license is needed (Aitken et al., 2020) [65]. Facing the practical needs of co-design, co-creation and co-governance of R&D digital ecology, it is necessary to build a unified innovation data open platform and development and utilization port and improve data sharing and interoperability in innovation management with the help of standardized construction of identity and behavior identification. At the same time, in order to deepen the security risk assessment, monitoring and early warning, emergency response and traceability of innovative data use, it is necessary to rely on the orderly sharing of research and development data across levels, regions and departments and systematically improve the level of openness and hierarchical and classified management capabilities of innovative data. Accordingly, by supplementing the innovation supervision basis of data-intensive industries, it can provide information for the formulation of relevant digital innovation ethical codes of conduct (Endres et al., 2022) [59] and promote cross-domain network security information sharing and work collaboration for complex scientific tasks.

Finally, enhance the data security management role of new technologies such as blockchain. Combining the application experience of blockchain technology in innovative digital processes in the fields of biomedicine, energy and smart cities, it is necessary to enhance the data protection and network security of blockchain at the level of industry technology integration and application (Amenta et al., 2021) [66]. Accordingly, in order to simultaneously update the existing data regulatory framework and important rules, it is necessary to encourage the exploration of diversified data security technologies and pilot commercial applications, promote the application of network security technologies

such as mimic defense and data encryption and strengthen system security assessment. These policies will improve the quality of digitally empowered products and services for innovative activities (Thompson and Venters, 2021) [64] and avoid data crises such as vicious competition, discriminatory access and “big data deception” caused by the unrestricted dissemination of R&D data.

6. Research Conclusions

Under the background of accelerated innovation of Internet, big data, cloud computing, artificial intelligence, blockchain and other technologies, digital innovation is becoming a key force in global restructuring of innovation resources, changing R&D organization and reshaping the competition pattern. Although the relevant digital technology and paradigm research has been paid more attention by many scholars, it is necessary to strengthen the policy system research of digital innovation to promote the digital transformation of industrial and social innovation. At present, the basic policy framework for the sustainable transformation of digital innovation has not been formed.

In order to systematically sort out and propose policy points for the digital transformation of innovation activities, this study analyzes and summarizes relevant research results on the antecedent variables, basic effects and potential mechanisms of digital innovation and mainly carries out research work in four aspects. First, combined with the citation analysis of relevant achievements, based on the Citespace method to analyze the citations of digital innovation topics, the overall research progress, research trends and research orientations of digital innovation policies are sorted out. The research shows that academic research on digital transformation, digital R&D, innovation activities and policy issues has gradually increased and research results have been widely used in important research fields such as digital economy, digital platform, digital transformation, accessibility and smart cities. Second, it summarizes the policy requirements for the innovation and digital transformation process from four aspects: creating R&D opportunities, optimizing R&D organizations, building ecological advantages and improving R&D governance. The policy requirements for the innovative digital transformation process proposed in this study include promoting the sharing of R&D digital resources, digital innovation exchanges and cooperation and opportunity acquisition, reducing the R&D costs of multi-dimensional subjects, improving the efficiency of digital innovation, strengthening hidden R&D data management and supporting the implementation of data-based R&D decisions, giving full play to the ecological advantages of the digital innovation system and building a digital evaluation foundation. Third, put forward the basic policy orientation for the implementation of innovative digital transformation from the four aspects of knowledge creation, empowerment application, collaborative promotion and standardized management and propose tools, approaches and models for digital knowledge production and dissemination to further enrich and standardize innovation activities; digital innovation is an important basis for tapping new momentum of innovation and development of the digital economy, collaboratively promoting digital innovation organizations to form a multi-dimensional participation, linkage and co-construction mechanism for innovative digital transformation, building a fair and orderly innovative digital governance mechanism and implementing digital innovation norms management orientation. Fourth, from the four aspects of national digital innovation system, digital innovation foundation, data governance capabilities and digital security assurance, key policy dimensions for promoting innovation and digital transformation are proposed and the relationship between the core contents of each policy dimension is explored. In the context of the accelerated construction of the global digital economy construction model, the research viewpoint can also provide certain theoretical reference and practical guidance for the systematic implementation of digital innovation system construction in various countries.

The world's major economies are changing from the stage of rapid economic growth to the stage of high-quality development and are in a critical period of changing the mode of development, optimizing the economic structure and changing the driving force of

growth. In this context, facing the general trend of accelerating the construction of regional digital innovation systems and infrastructure around the world, it is of great significance to carry out further research on the policy system around the policy requirements of reducing R&D costs, improving R&D efficiency, coordinating R&D decision-making and leaning R&D management. In the follow-up research, it is not only necessary to strengthen policy research on innovative big data governance and digital security, but also to give full play to the R&D value co-creation of multi-level participants such as the government, universities, research institutes and enterprises. These policies will help innovative entities with different foundations get rid of the constraints of historical factors such as path dependence and low-end lock-in, optimize the allocation of innovation resources as a whole and form a broad social foundation for digital innovation.

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References

1. Nambisan, S.; Lyytinen, K.; Majchrzak, A.; Song, M. Digital Innovation Management: Reinventing Innovation Management Research in a Digital World. *MIS Q.* **2017**, *41*, 223–238. [\[CrossRef\]](#)
2. Liu, Y.; Dong, J.; Ying, Y.; Jiao, H. Status and digital innovation: A middle-status conformity perspective. *Technol. Forecast. Soc. Chang.* **2021**, *168*, 120781. [\[CrossRef\]](#)
3. Kohli, R.; Melville, N.P. Digital innovation: A review and synthesis. *Inf. Syst. J.* **2019**, *29*, 200–223. [\[CrossRef\]](#)
4. Nambisan, S.; Wright, M.; Feldman, M. The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Res. Policy* **2019**, *48*, 103773. [\[CrossRef\]](#)
5. Gao, P.; Wu, W.; Yang, Y. Discovering Themes and Trends in Digital Transformation and Innovation Research. *J. Theor. Appl. Electron. Commer. Res.* **2022**, *17*, 1162–1184. [\[CrossRef\]](#)
6. Van Veldhoven, Z.; Vanthienen, J. Digital transformation as an interaction-driven perspective between business, society, and technology. *Electron. Mark.* **2022**, *32*, 629–644. [\[CrossRef\]](#)
7. Liu, Y.; Dong, J.; Mei, L.; Shen, R. Digital innovation and performance of manufacturing firms: An affordance perspective. *Technovation* **2023**, *119*, 102458. [\[CrossRef\]](#)
8. Sgroi, F.; Marino, G. Environmental and digital innovation in food: The role of digital food hubs in the creation of sustainable local agri-food systems. *Sci. Total Environ.* **2022**, *810*, 152257. [\[CrossRef\]](#)
9. Lyytinen, K. Innovation logics in the digital era: A systemic review of the emerging digital innovation regime. *Innovation* **2022**, *24*, 13–34. [\[CrossRef\]](#)
10. Guo, F.; Bo, Q.; Tong, X.; Zhang, X. A paradoxical view of speed and quality on operational outcome: An empirical investigation of innovation in high-tech small and medium-sized enterprises. *Int. J. Prod. Econ.* **2020**, *229*, 107780. [\[CrossRef\]](#)
11. Nambisan, S. Digital Entrepreneurship: Toward a Digital Technology Perspective of Entrepreneurship. *Entrep. Theory Pract.* **2017**, *41*, 1029–1055. [\[CrossRef\]](#)
12. Vial, G. Understanding digital transformation: A review and a research agenda. *J. Strateg. Inf. Syst.* **2019**, *28*, 118–144. [\[CrossRef\]](#)
13. Rose, D.C.; Chilvers, J. Agriculture 4.0: Broadening Responsible Innovation in an Era of Smart Farming. *Front. Sustain. Food Syst.* **2018**, *2*, 87. [\[CrossRef\]](#)
14. Klerkx, L.; Jakku, E.; Labarthe, P. A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS Wagening. J. Life Sci.* **2019**, *90*, 100315. [\[CrossRef\]](#)
15. Wolfert, S.; Ge, L.; Verdouw, C.; Bogaardt, M. Big data in smart farming—A review. *Agric. Syst.* **2017**, *153*, 69–80. [\[CrossRef\]](#)
16. Dennehy, D.; Schmarzo, B.; Sidaoui, M. Organising for AI-powered innovation through design: The case of Hitachi Vantara. *Int. J. Technol. Manag.* **2022**, *88*, 312–334. [\[CrossRef\]](#)
17. Curran, D. Risk, innovation, and democracy in the digital economy. *Eur. J. Soc. Theory* **2018**, *21*, 207–226. [\[CrossRef\]](#)

18. Sultana, S.; Akter, S.; Kyriazis, E.; Wamba, S.F. Architecting and Developing Big Data-Driven Innovation (DDI) in the Digital Economy. *J. Glob. Inf. Manag.* **2021**, *29*, 165–187. [\[CrossRef\]](#)
19. Konstantopoulos, G.; Koumoulos, E.P.; Charitidis, C.A. Digital Innovation Enabled Nanomaterial Manufacturing; Machine Learning Strategies and Green Perspectives. *Nanomaterials* **2022**, *12*, 2646. [\[CrossRef\]](#)
20. Henfridsson, O.; Nandhakumar, J.; Scarbrough, H.; Panourgias, N. Recombination in the open-ended value landscape of digital innovation. *Inf. Organ.* **2018**, *28*, 89–100. [\[CrossRef\]](#)
21. Karunakaran, A. In Cloud We Trust? Co-opting Occupational Gatekeepers to Produce Normalized Trust in Platform-Mediated Interorganizational Relationships. *Organ. Sci.* **2022**, *33*, 1188–1211. [\[CrossRef\]](#)
22. Geissinger, A.; Laurell, C.; Sandström, C.; Eriksson, K.; Nykvist, R. Digital entrepreneurship and field conditions for institutional change—Investigating the enabling role of cities. *Technol. Forecast. Soc.* **2019**, *146*, 877–886. [\[CrossRef\]](#)
23. Sassanelli, C.; Terzi, S. Building the Value Proposition of a Digital Innovation Hub Network to Support Ecosystem Sustainability. *Sustainability* **2022**, *14*, 11159. [\[CrossRef\]](#)
24. Bican, P.M.; Brem, A. Digital business model, digital transformation, digital entrepreneurship: Is there a sustainable “digital”? *Sustainability* **2020**, *12*, 5239. [\[CrossRef\]](#)
25. Hodapp, D.; Hanelt, A. Interoperability in the era of digital innovation: An information systems research agenda. *J. Inf. Technol.* **2022**, *37*, 407–427. [\[CrossRef\]](#)
26. Nambisan, S. Digital innovation and international business. *Innovation* **2022**, *24*, 86–95. [\[CrossRef\]](#)
27. Campagnolo, G.M.; Nguyen, H.T.; Williams, R. The temporal dynamics of technology promises in government and industry partnerships for digital innovation: The case of the Copyright Hub. *Technol. Anal. Strat. Manag.* **2019**, *31*, 972–985. [\[CrossRef\]](#)
28. Hevner, A.; Gregor, S. Envisioning entrepreneurship and digital innovation through a design science research lens: A matrix approach. *Inf. Manag.* **2020**, *59*, 103350. [\[CrossRef\]](#)
29. Wang, P. Connecting the Parts with the Whole: Toward an Information Ecology Theory of Digital Innovation Ecosystems. *MIS Q.* **2021**, *45*, 397–422. [\[CrossRef\]](#)
30. Kolloch, M.; Dellermann, D. Digital innovation in the energy industry: The impact of controversies on the evolution of innovation ecosystems. *Technol. Forecast. Soc.* **2018**, *136*, 254–264. [\[CrossRef\]](#)
31. Bonina, C.; López-Berzosa, D.; Scarlata, M. Social, commercial, or both? An exploratory study of the identity orientation of digital social innovations. *Inf. Syst. J.* **2021**, *31*, 695–716. [\[CrossRef\]](#)
32. Yousaf, Z.; Radulescu, M.; Sinisi, C.I.; Serbanescu, L.; Păunescu, L.M. Towards Sustainable Digital Innovation of SMEs from the Developing Countries in the Context of the Digital Economy and Frugal Environment. *Sustainability* **2021**, *13*, 5715. [\[CrossRef\]](#)
33. Rizk, A.; Elragal, A. Data science: Developing theoretical contributions in information systems via text analytics. *J. Big Data* **2020**, *7*, 7. [\[CrossRef\]](#)
34. Boudreau, K.J.; Jeppesen, L.B.; Miric, M. Profiting from digital innovation: Patents, copyright and performance. *Res. Policy* **2022**, *51*, 104477. [\[CrossRef\]](#)
35. Whyte, J. How digital information transforms project delivery models. *Proj. Manag. J.* **2019**, *50*, 177–194. [\[CrossRef\]](#)
36. Pershina, R.; Soppe, B.; Thune, T.M. Bridging analog and digital expertise: Cross-domain collaboration and boundary-spanning tools in the creation of digital innovation. *Res. Policy* **2019**, *48*, 103819. [\[CrossRef\]](#)
37. Hinings, B.; Gegenhuber, T.; Greenwood, R. Digital innovation and transformation: An institutional perspective. *Inf. Organ.* **2018**, *28*, 52–61. [\[CrossRef\]](#)
38. Senyo, P.K.; Liu, K.; Effah, J. Digital business ecosystem: Literature review and a framework for future research. *Int. J. Inf. Manag.* **2019**, *47*, 52–64. [\[CrossRef\]](#)
39. Trocin, C.; Hovland, I.V.; Mikalef, P.; Dremel, P. How Artificial Intelligence affords digital innovation: A cross-case analysis of Scandinavian companies. *Technol. Forecast. Soc. Chang.* **2021**, *173*, 121081. [\[CrossRef\]](#)
40. Vendrell-Herrero, F.; Gomes, E.; Opazo-Basaez, M.; Bustinza, O.F. Knowledge acquisition throughout the lifecycle: Product and industry learning frameworks. *J. Knowl. Manag.* **2022**, *26*, 1633–1647. [\[CrossRef\]](#)
41. Arias-Pérez, J.; Vélez-Jaramillo, J. Ignoring the three-way interaction of digital orientation, Not-invented-here syndrome and employee’s artificial intelligence awareness in digital innovation performance: A recipe for failure. *Technol. Forecast. Soc.* **2022**, *174*, 121305. [\[CrossRef\]](#)
42. Sánchez-Cartas, J.M. Intellectual property and taxation of digital platforms. *J. Econ.* **2021**, *132*, 197–221. [\[CrossRef\]](#)
43. Steinhäuser, S.; Dobliger, C.; Hüsig, S. The Relative Role of Digital Complementary Assets and Regulation in Discontinuous Telemedicine Innovation in European Hospitals. *J. Manag. Inf. Syst.* **2020**, *37*, 1155–1183. [\[CrossRef\]](#)
44. Alvarado-Vargas, M.J.; Inamanamelluri, T.; Zou, Q. Product attributes and digital innovation performance: The importance of country and firm level supporting environment. *Int. J. Technol. Manag.* **2020**, *82*, 206–226. [\[CrossRef\]](#)
45. Del Giudice, M.; Scuotto, V.; Papa, A.; Tarba, S.Y.; Bresciani, S.; Warkentin, M. A self-tuning model for smart manufacturing SMEs: Effects on digital innovation. *J. Prod. Innovat. Manag.* **2021**, *38*, 68–89. [\[CrossRef\]](#)
46. Gawer, A. Digital platforms and ecosystems: Remarks on the dominant organizational forms of the digital age. *Innovation* **2022**, *24*, 110–124. [\[CrossRef\]](#)
47. Jafari-Sadeghi, V.; Garcia-Perez, A.; Candelo, E.; Couturier, J. Exploring the impact of digital transformation on technology entrepreneurship and technological market expansion: The role of technology readiness, exploration and exploitation. *J. Bus. Res.* **2021**, *124*, 100–111. [\[CrossRef\]](#)

48. Saadatmand, F.; Lindgren, R.; Schultze, U. Configurations of platform organizations: Implications for complementor engagement. *Res. Policy* **2019**, *48*, 103770. [\[CrossRef\]](#)
49. Huang, J.; Henfridsson, O.; Liu, M.J. Extending Digital Ventures through Templating. *Inf. Syst. Res.* **2022**, *33*, 285–310. [\[CrossRef\]](#)
50. Dong, J.Q. Moving a mountain with a teaspoon: Toward a theory of digital entrepreneurship in the regulatory environment. *Technol. Forecast. Soc.* **2019**, *146*, 923–930. [\[CrossRef\]](#)
51. Wiener, M.; Mähring, M.; Remus, U.; Saunders, C.; Cram, W.A. Moving IS Project Control Research into the Digital Era: The “Why” of Control and the Concept of Control Purpose. *Inf. Syst. Res.* **2019**, *30*, 1387–1401. [\[CrossRef\]](#)
52. Magnusson, J.; Koutsikouri, D.; Päiväranta, T. Efficiency creep and shadow innovation: Enacting ambidextrous IT Governance in the public sector. *Eur. J. Inf. Syst.* **2020**, *29*, 329–349. [\[CrossRef\]](#)
53. Ayre, M.; Mc Collum, V.; Waters, W.; Samson, P.; Curro, A.; Nettle, R.; Paschen, J.; King, B.; Reichelt, N. Supporting and practising digital innovation with advisers in smart farming. *NJAS-Wagen J. Life Sci.* **2019**, *90*, 100302. [\[CrossRef\]](#)
54. Tate, M.; Bongiovanni, I.; Kowalkiewicz, M.; Townson, P. Managing the “Fuzzy front end” of open digital service innovation in the public sector: A methodology. *Int. J. Inf. Manag.* **2018**, *39*, 186–198. [\[CrossRef\]](#)
55. Thorén, C.; Ågerfalk, P.J.; Rolandsson, B. Voicing the Puppet: Accommodating Unresolved Institutional Tensions in Digital Open Practices. *Organ. Stud.* **2018**, *39*, 923–945. [\[CrossRef\]](#)
56. Thomas, L.D.W.; Tee, R. Generativity: A systematic review and conceptual framework. *Int. J. Manag. Rev.* **2022**, *24*, 255–278. [\[CrossRef\]](#)
57. Haefner, L.; Sternberg, R. Spatial implications of digitization: State of the field and research agenda. *Geogr. Compass* **2020**, *14*, e12544. [\[CrossRef\]](#)
58. Mendling, J.; Pentland, B.T.; Recker, J. Building a complementary agenda for business process management and digital innovation. *Eur. J. Inf. Syst.* **2020**, *29*, 208–219. [\[CrossRef\]](#)
59. Endres, H.; Huesig, S.; Pesch, R. Digital innovation management for entrepreneurial ecosystems: Services and functionalities as drivers of innovation management software adoption. *Rev. Manag. Sci.* **2022**, *16*, 135–156. [\[CrossRef\]](#)
60. Leiponen, A.; Thomas, L.D.W.; Wang, Q. The dApp economy: A new platform for distributed innovation? *Innovation* **2022**, *24*, 125–143. [\[CrossRef\]](#)
61. De Reuver, M.; Sørensen, C.; Basole, R.C. The digital platform: A research agenda. *J. Inf. Technol.* **2018**, *33*, 124–135. [\[CrossRef\]](#)
62. Makkonen, H.; Komulainen, H. Explicating the market dimension in the study of digital innovation: A management framework for digital innovation. *Technol. Anal. Strat. Manag.* **2018**, *30*, 1015–1028. [\[CrossRef\]](#)
63. Annarelli, A.; Battistella, C.; Nonino, F.; Parida, V.; Pessot, E. Literature review on digitalization capabilities: Co-citation analysis of antecedents, conceptualization and consequences. *Technol. Forecast. Soc. Chang.* **2021**, *166*, 120635. [\[CrossRef\]](#)
64. Thompson, M.; Venters, W. Platform, or technology project? A spectrum of six strategic ‘plays’ from UK government IT initiatives and their implications for policy. *Gov. Inf. Q.* **2021**, *38*, 101628. [\[CrossRef\]](#)
65. Aitken, M.; Toreini, E.; Carmichael, P.; Coopamootoo, M.; Elliott, K.; Van Moorsel, A. Establishing a social licence for Financial Technology: Reflections on the role of the private sector in pursuing ethical data practices. *Big Data Soc.* **2020**, *7*, 2053951720908892. [\[CrossRef\]](#)
66. Amenta, C.; Sanseverino, E.R.; Stagnaro, C. Regulating blockchain for sustainability? The critical relationship between digital innovation, regulation, and electricity governance. *Energy Res. Soc. Sci.* **2021**, *76*, 102060. [\[CrossRef\]](#)

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