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The Impact of Empowering Green Technology Innovation on the Development of Digital Economy

-- Taking the Yangtze River Economic Belt as an Example

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Abstract

With the rapid development of the new generation of information technology revolution, the digital economy represented by the Internet, big data, blockchain, and artificial intelligence has flourished and gradually become an important engine for promoting China's economic and social progress. In this context, how to leverage the development of the digital economy to drive Chinese cities towards a new model of innovation driven and green development is an urgent research topic. Based on this, this article takes the Yangtze River Economic Belt as an example to study the mechanism and characteristics of the role of digital economy in the high-quality green development of cities. This will help the Chinese government fully utilize the opportunities given by the digital economy, accelerate the innovation drive of green technology, urban green transformation, and build innovative, smart, ecological, and beautiful new cities in China.

Keywords

Digital Economy; Green Development; Technological Innovation; Sustainable Development; Mediating Effect.

1. Introduction

As an important economic development region in China, the Yangtze River Economic Belt is facing significant tasks of protecting the ecological environment and promoting sustainable development. In this context, the digital economy, as a new generation of economic development model, provides new opportunities and assistance for green technology innovation and sustainable development in the Yangtze River Economic Belt. The digital economy mainly relies on modern information technology as a key technological means to empower research and development, production, operation, and sales. It has a highly interconnected characteristic, which is conducive to the rapid transmission of data information [1], laying the foundation for its own technological innovation. By promoting technological innovation, promoting green industry transformation, and improving resource utilization efficiency, it has achieved a win-win situation of economic growth and environmental protection.

The empowerment of the digital economy has shown advantages in green technology innovation. Firstly, the digital economy provides data-driven support for green technology

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innovation, optimizing resource allocation, and improving efficiency. The digital economy is centered around technologies such as big data and artificial intelligence, providing strong data support and analytical capabilities for green technology innovation. Through big data analysis, environmental conditions can be effectively evaluated and predicted, guiding the direction and strategy of green technology innovation, and improving the accuracy and efficiency of technology research and development. The rapid development of the digital economy has driven the rise of emerging industries, giving birth to innovative financial models such as inclusive finance and green finance. These financial models can provide financing support and venture capital for green technology innovation, reduce innovation costs and entrepreneurial risks, and promote the rapid promotion and application of green technology. The digital economy also relies on digital technology, enabling information and knowledge to be shared and exchanged in a low-cost and efficient manner in innovation networks, enabling rapid integration of knowledge and technology from different fields, promoting innovation and cooperation.

Similarly, challenges and opportunities coexist. China's green technology innovation level still lags behind, with uneven regional growth and insufficient investment in innovative resources. The government should formulate targeted policy plans for the Yangtze River Economic Belt. In addition, the digital economy has a threshold effect, and with the decrease in energy consumption driven by digital technology in other industries, the digital industry itself will gradually become a major energy consumer in the future. We need to continuously promote the innovation and upgrading of digital technology, improve the energy efficiency of digital infrastructure, and actively guide the green transformation of digital infrastructure such as data centers. As an important economic development region in China, the Yangtze River Economic Belt has a huge economic scale, but it also faces pressure and challenges, including environmental pollution, ecological damage, and resource waste. Therefore, by studying how the digital economy empowers green technological innovation in the Yangtze River Economic Belt, sustainable development can be promoted in practice, promoting coordinated development of economic transformation and upgrading and ecological environment protection. The experience and practice of green technology innovation also have certain reference value for other economic development regions. By studying the relationship between digital economy development and green technology innovation in the Yangtze River Economic Belt, successful experiences and policy measures that can be promoted can be summarized, providing reference and inspiration for other economic regions.

In summary, the impact of the development of the digital economy on green technology innovation in the Yangtze River Economic Belt cannot be ignored. The development of the digital economy provides new opportunities for green technology innovation. This article aims to explore the impact of the development of the digital economy on green technology innovation in the Yangtze River Economic Belt, and conduct in-depth research on its specific impact mechanisms and effects

2. Literature Review

There is a wealth of literature surrounding the research topic of this article, mainly divided into the following three categories: firstly, related research on the digital economy. The second is related research on green technology innovation; Thirdly, research on the impact of digital economy development on green technology innovation.

Simply put, the digital economy refers to industrial digitization and digital industrialization, using digital technologies represented by big data and artificial intelligence to guide the generation of resources and form reliable economic sources. The concept of the digital economy first appeared in the book "The Digital Economy: Hope and Risks in the Age of Intellectual

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Interconnection" published in 1996, written by American scholar Don Tapscott. In April 2020, China officially released the document "Building a more comprehensive market-oriented allocation of factors", and data was introduced as a new type of production factor. With the continuous expansion of China's digital economy, data elements have become an indispensable new driving force for economic development. The opening point of the "14th Five Year Plan for the Development of the Digital Economy" released by the State Council directly provides a complete and clear definition for the digital economy, which is a new economic form that takes resource data as the element, modern information networks as the carrier, and combines information and communication technology with full factor digitization. Ding Zhifan (2020) studied the transmission mechanism and internal mechanism of high-quality economic development driven by the digital economy, taking into account the micro, medium, and macro levels, and conducting research from pathways such as factor cost reduction and industrial innovation effects [3]. Numerous literature has studied various driving factors of China's digital economy. (Liu Jun et al., 2020; Yu Haihua, 2021) [4-5].

In terms of research related to green technology innovation, Zhang Juan et al. (2019) conducted a study on the impact of environmental regulation on green technology innovation, and empirically studied using inter provincial panel data from 1995 to 2016 in China to confirm the conclusion that the impact of environmental regulation on green technology output presents a "U" shaped relationship. Wang Xin and Wang Ying (2021) conducted a study on promoting green innovation through green credit policies, and found that industries restricted by green credit are more active in promoting green technology innovation. With the strengthening of law enforcement and intellectual property protection, the role of green credit in promoting green technology innovation has been strengthened [6-7].

In the study of the impact of digital economy development on green technology innovation, Wei et al. (2022) believe that the digital economy has become an important driving force for the development of green technology innovation. Some scholars have studied the internal mechanism of the digital economy's impact on green technology innovation from the perspective of environmental regulation (Ye Jian, Xu Wenhua, 2021) [8-9]. Most existing research results have proven that the digital economy can empower green technological innovation and promote industrial structure upgrading (Wang Fengzheng et al., 2022; Guo Bingnan et al., 2022) [10-11]. Cui Qi et al. (2022) based on the use and satisfaction theory of sociologist Elihu Katz, used panel data from 280 cities in China from 2011 to 2018 as empirical evidence, and used fixed effects models, intermediary effects models, etc. to conclude that the digital economy indirectly improves the level of green technology innovation by increasing public environmental attention [12].

In summary, although the literature on digital economy and green technology innovation has been very extensive, the vast majority of research has stopped in their respective fields, and there is little combination of the two. The few studies that combine the two are mostly focused on specific industries, such as manufacturing and resource-based enterprises, in terms of connotation and mechanism of action. The innovation of this article lies in the perspective of urban agglomeration, selecting the Yangtze River Economic Belt as a unit, analyzing panel data from 11 provinces and cities, conducting effect measurement, and intuitively understanding the impact mechanism and implementation path of digital economy and green technology innovation.

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3. The Embodiment of Green Technology Innovation Empowered by the Digital Economy in the Yangtze River Economic Belt

3.1. The Digital Economy Empowers Industrial Upgrading and Assists in Green Transformation of the Industry

The digital economy achieves optimized resource allocation by promoting industrial upgrading, and promotes the transformation of economic growth towards technology and knowledge intensive. This transformation helps to improve resource utilization efficiency and reduce environmental pollution, providing a new path for green development in the new stage of development. The current application of intelligent technologies such as big data and cloud computing has enabled traditional industries to achieve intelligent and automated production methods, greatly improving the operational efficiency and energy utilization efficiency in fields such as electricity, urban management, transportation, and industrial production, thereby promoting the low-carbon transformation of traditional industries.

Digital technology plays a crucial role in promoting the green transformation of the logistics industry. The carbon reduction in the logistics industry is an important area in which the digital economy empowers green technology innovation, and this phenomenon is even more evident in terms of the Yangtze River economy. At present, the Yangtze River Economic Belt is actively exploring the integration and application of digital technologies such as big data and the Internet of Things to achieve more efficient logistics operations and lower carbon emissions. As an important city in the region, Chongqing's digital and intelligent high-speed railway station - Chongqing East Station - is a good example. The construction of this site adopts advanced information technology, such as big data and the Internet of Things, to improve logistics efficiency and reduce carbon emissions. The Guangyang Island EIM Ecological Information Model project integrates emerging information technologies such as cloud computing, big data, the Internet of Things, BIM, 3DGIS, AI, and 5G, providing intelligent empowerment for the entire process of planning, construction, and management on the island. These practices fully demonstrate the important role of digital economy in promoting green technology innovation and industrial upgrading in the industry.

3.2. Empowering Enterprises with Green Innovation and Improving Resource Management Level Through Digital Economy

The green innovation of enterprises under the traditional economic model faces limitations in terms of technology, capital, and market. As an emerging economic form, the digital economy, with its characteristics of efficiency, flexibility, and innovation, provides new opportunities and impetus for green innovation in enterprises. Taking Yichang City, Hubei Province as an example, the traditional shipbuilding industry is bringing new opportunities to the iteration and upgrading of green new energy ships. The construction of green factories and product innovation iteration are driving the rapid economic development of the area. This transformation not only enhances the green level of the industry, but also injects new vitality into the local economic development. The digital economy empowers enterprises with green innovation through new generation digital technologies such as 5G, big data, the Internet of Things, and cloud computing, which can enhance their energy, resource, and environmental management levels, deepen the digital application of production and manufacturing processes, and thus empower enterprises with technological green innovation and product green manufacturing.

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3.3. The Digital Economy Empowers the Construction of Smart Cities and Promotes the Realization of Green Governance in Cities

The digital economy can strengthen supervision and constraints through digital technology, achieving green governance of cities. Utilizing green innovative technologies, such as green data center construction, green buildings and intelligent buildings, and green energy management systems, to carry out urban informatization construction [14], comprehensively realizing the greening and intelligence of urban energy, transportation, buildings, environment, and other aspects, transforming traditional pollution discharge and governance methods into smart governance models, and providing strong support for building livable and sustainable cities.

Currently, various cities are actively promoting digital technology to empower urban informatization construction, by accelerating the promotion of information technologies such as cloud computing, big data, 5G, artificial intelligence, and industrial internet to create smart cities and achieve green governance of cities. In the process of empowering green technological innovation and creating smart cities through the digital economy, many cities in the Yangtze River Economic Belt have specific practices. Chongqing actively utilizes technologies such as big data and cloud computing to promote environmental protection work such as garbage classification and water quality monitoring. At the same time, by building a smart transportation system, urban transportation efficiency is improved; Wuhan combines digital technology with environmental protection to promote the intelligence of air quality monitoring and waste classification work; Shanghai actively promotes the digital construction of the Yangtze River Estuary waterway with the goal of "digital river and sea". In order to further promote green development, various regions of the Yangtze River Economic Belt have also established incentive mechanisms for green technology innovation, encouraging scientific research institutions and enterprises to increase their efforts in green technology innovation, and stimulating innovation vitality through rewards and rating evaluations.

3.4. The Digital Economy Empowers the Construction of New Infrastructure and Promotes Deep Integration of Technology Industries

Green technology innovation plays a crucial role in promoting the construction of new infrastructure. The construction of new infrastructure, especially digital infrastructure based on information networks and driven by technological innovation, is a key element for the development of the digital economy. At present, the world's largest, technologically advanced, and high-performance digital infrastructure has been built in China, achieving a leapfrog improvement in overall level. This includes utilizing digital technology to improve energy efficiency, reduce carbon emissions, and optimize resource allocation.

The 14th Five Year Plan for the Development of the Digital Economy emphasizes the acceleration of digital infrastructure construction, including new network infrastructure such as 5G, big data centers, artificial intelligence, and industrial internet. These infrastructure are a solid foundation for the development of the digital economy and play an important supporting role in the digital transformation of the manufacturing industry. Overall, the digital economy is driving new infrastructure towards a greener, smarter, and more efficient direction through its unique capabilities.

4. The Enlightenment of Digital Economy Promoting Green Technology Innovation in the Yangtze River Economic Belt

This article takes the development of the Yangtze River Economic Belt as an example to explore the role of green technology innovation in economic development. Through empirical research on the impact of green technology innovation on industrial upgrading, innovation capabilities,

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low-carbon development, and narrowing regional economic disparities, we have drawn the following conclusions:

4.1. Green Technology Innovation has a Positive Impact on Industrial Upgrading

With the development of the economy, especially the development of resource processing industry, China has inevitably encountered some ecological and environmental problems. Accelerating the improvement of digital infrastructure, promoting the digital transformation of manufacturing industry, and promoting green development of manufacturing industry can solve this problem.

Green technology innovation plays a leading role in the green transformation of industries such as manufacturing. The construction of new infrastructure such as 5G communication and data centers in the Yangtze River Economic Belt can break data silos, accelerate the construction of intelligent platforms, and lead industrial transformation and upgrading. In addition, green technology innovation provides an implementation path for the green development of industries. The level of digitalization and green development varies in different regions. It is necessary to tailor measures to local conditions and formulate differentiated digital transformation development strategies based on the different advantageous resources of different regions. Resources should be allocated reasonably to avoid resource waste caused by the development of industries that converge, thereby promoting the transformation, upgrading, and green development of manufacturing industries in different regions and industries.

4.2. Green Technology Innovation has Played an Important Role in Enhancing Enterprise Innovation Capabilities

Different environments have different effects on the green transformation of enterprises. The Yangtze River Delta urban agglomeration is located in the lower reaches of the Yangtze River, with sufficient funds and a good level of economic development. With the acceleration of industrial transformation and upgrading, the economy and environment have shown coordinated development. However, the middle reaches of the Yangtze River are facing the transfer of high energy consumption and high pollution industries downstream, increasing the burden of energy conservation, emission reduction, and industrial environmental protection, resulting in low ecological efficiency. There is an urgent need for green technology innovation to promote enterprise development [15]. The widespread application of green technology has accelerated the digital transformation of enterprises, driving them to cloud production, manufacturing, sales and other data, improving their production efficiency competitiveness, and promoting green development of enterprises. On the other hand, the development of green technology is conducive to enterprise innovation. Green technology innovation can achieve coordinated development between corporate profitability and the ecological environment, achieve economic growth through green technology innovation, create a good market environment, improve innovation efficiency, and enhance the independent innovation ability of enterprises.

4.3. Green Technology Innovation is Conducive to Promoting Green and Low-carbon Development in Chinese Cities

With the increasing intensity of environmental regulations, enterprises will seek technological research and development to reduce pollution control costs, thereby promoting green technology innovation [16]. Green technology innovation can accelerate the development of the new energy industry, promote digital production of the industry, improve resource utilization, facilitate the transformation of high carbon industries to green industries, improve green infrastructure construction, alleviate ecological pollution problems, beautify the ecological environment, and promote China's green and low-carbon development. In addition,

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communication and cooperation should be strengthened to coordinate environmental policies among different regions. With the relevant national policy support of two urban agglomerations defined as national demonstration zones for resource conservation and environmentally friendly social construction, regional green industry clusters have developed rapidly, and production factors and advanced technologies can effectively achieve cross regional transfer, greatly improving the ecological efficiency of this region. To promote low-carbon development in China, it is necessary for various regions to strengthen coordination of green technology cooperation, formulate appropriate green policies, promote green technology innovation spillovers, and promote green and low-carbon development.

4.4. Green Technology Innovation has Played an Important Role in Narrowing Regional Economic Disparities

With the implementation and promotion of the Yangtze River Economic Belt strategy, the industrial and economic connections among cities along the Yangtze River Economic Belt have become closer, and the industrial and economic alliances and cooperation between upstream, middle, and downstream regions, as well as between developed and underdeveloped cities, have been strengthened. Through green technology innovation, various regions of the Yangtze River Economic Belt can achieve better cooperation. Cloud based enterprise data can reduce the cost of information collection, improve the sensitivity of information acquisition, reduce losses caused by information gaps, build a collaborative innovation system for green development, and promote communication and cooperation between different enterprises in the same region and similar enterprises in different regions. On the other hand, digital technologies such as "Internet plus" and the Internet of Things also provide channels for backward regions and environmentally poor regions to communicate and cooperate with the outside world, provide opportunities for backward regions, drive the economic development of backward regions, and narrow the regional economic gap to a certain extent. In addition, green technology innovation can strengthen information exchange between rural and urban areas, promote economic cooperation between rural and urban areas, and promote the construction of "urban-rural integration". The development of green technology in rural areas can promote the development of digital economy in rural areas, increase the utilization rate of new energy, improve rural life and development environment, and promote the development of ecological agriculture and ecotourism in rural areas according to local conditions.

5. Conclusion and Suggestions

This article conducts research on the impact of digital economy on green technology innovation in the upper, middle, and lower reaches of the Yangtze River Economic Belt in cities, providing more comprehensive theoretical guidance and methods for the application of digital economy.

Strictly grasp digital infrastructure construction and promote high-quality development of green technology innovation. The improvement of infrastructure is an important manifestation of the improvement of green technology innovation level. The digital economy will accelerate the construction of digital infrastructure, the construction and coverage of 5G networks. Intelligent transformation of traditional infrastructure such as highways, railways, and airports; The circulation of information technology such as accounting construction and community control during the epidemic period. All of these require the rapid development of the digital economy. In benchmark regression analysis, the impact of infrastructure level on green technology innovation is positively significant. The development of the digital economy can not only improve the functionality and performance of traditional facilities through the application of digital technology, but also attract capital and talent to enter the field, bringing new financing models and investment opportunities, thereby promoting the improvement of infrastructure and improving the level of green technology innovation.

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Accelerate industrial upgrading and achieve coordinated development of the Yangtze River Economic Belt. The level of digital economy development reflects the level of internet technology to a certain extent. The higher the level of internet technology in a region, the higher the level of digital infrastructure, and the more it can promote the upgrading of industrial structure within the region. The digital economy breaks through the bottleneck of the industrial chain, expands industrial space, and optimizes production processes to promote the development of the industry towards networking, digitization, and intelligence, making the connections between various links in the industrial chain efficient, driving the upgrading of industrial structure and high-quality development. And the development of the digital economy can promote the integration of the primary, secondary, and tertiary industries, improve the mechanization and digitization level of agriculture, enhance the intelligence and digitization of industry, enrich the diversification of the tertiary industry, thereby improving industrial efficiency, promoting green transformation of industrial structure, and stimulating green technology innovation.

Improve the quality of public services and ensure the resources of green innovation entities. The rapid development of the digital economy has enabled the rapidly emerging digital technology to fully penetrate the public service sector, changing the supply mode of public services. On the one hand, the development of digital service platforms has made public services no longer limited to people, making them more convenient and efficient for users to use, thereby improving service efficiency. With the development of the Internet and artificial intelligence technology, digital platforms for public services have continuously emerged, resulting in higher quality service models and platforms. On the other hand, with the increasing number of online service carriers, by continuously expanding the business and target audience of public services, more people can enjoy public services, thereby comprehensively improving the service level of public services and enhancing the level of green technology innovation.

In summary, through research on different urban agglomerations in the upper, middle, and lower reaches of the Yangtze River Economic Belt, empirical analysis was conducted using fixed effect models, intermediary effects, and quantile regression models. It was found that the development of green economy has a positive and significant impact on the level of green technology innovation in the Yangtze River Economic Belt, and the digital economy exhibits regional heterogeneity in empowering green technology innovation in the Yangtze River Economic Belt, Regional differentiated digital economy policies should be implemented. This study provides ideas for the focus of digital economy development on the level of green technology innovation in the Yangtze River Economic Belt, while promoting the deep integration of digital economy and green technology innovation.

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