

# Research on the Impact of the Digital Economy on Regional Innovation

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**Abstract:** As a new type of economy following the agricultural and industrial economies, the digital economy is reshaping the regional innovation landscape through the non-competitive nature of data elements, the strong penetration of digital technologies, and the network externalities of platform ecosystems. Based on data from 31 provinces in mainland China from 2011 to 2023, this paper constructs a two-way fixed effects model to analyze the impact and mechanisms of the digital economy on regional innovation capabilities. The study shows that: (1) the digital economy significantly promotes the enhancement of regional innovation capabilities; (2) the moderation effect analysis further indicates that government support plays a positive moderating role in the relationship between the digital economy and regional innovation capabilities; (3) the heterogeneity analysis reveals that the positive impact of the digital economy on regional innovation capabilities exhibits significant regional differences: its innovation-promoting effect is significantly positive in the eastern region, while the effect is relatively weaker in the central and western regions. This paper enriches research on how the digital economy empowers the enhancement of regional innovation capabilities and provides valuable insights and decision-making references for regional innovation breakthroughs.

**Keywords:** Digital Economy; Regional Innovation Capacity; Government Support

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## Introduction

As the core driving force of the new round of technological revolution and industrial transformation, the digital economy has become the key engine driving the leap in regional innovation capabilities. The Third Plenary Session of the 20th CPC Central Committee proposed accelerating the construction of systems and mechanisms that support comprehensive innovation. As regions are the core carriers of the national innovation system, their innovation systems are crucial for enhancing overall national strength and promoting high-quality economic development. Especially against the backdrop of increasingly fierce global technological competition, regional innovation capability has become an important indicator of a country's comprehensive strength and a key factor in promoting high-quality economic development and cultivating new quality productivity. With global technological competition intensifying, the digital economy, using data as a key element and modern information networks as the carrier, is reshaping the regional innovation ecosystem, providing new opportunities for technological research and development, industrial upgrading, and breaking the West's technological monopoly<sup>[1]</sup>. Therefore, in-depth research on the role of the digital economy in regional innovation is not only a theoretical requirement for building

a modern regional innovation system in the era of the digital economy but also a practical key to bridging the ‘last mile’ in implementing the national innovation-driven development strategy.

The rapid rise of the digital economy has not only profoundly transformed traditional production paradigms but also provided unprecedented strategic opportunities for the reconstruction and optimization of regional innovation ecosystems. Existing research has explored the mechanisms through which the digital economy affects regional innovation from multiple perspectives. On one hand, some studies focus on the digital element empowerment path, pointing out that enhancing the digital literacy of regional talent and promoting the expansion and efficiency of financial service markets are important transmission paths for the digital economy to enable high-quality regional development<sup>[2]</sup>; other studies suggest that leveraging the digital economy to drive urban innovation is a new approach to implementing an innovation-driven development strategy and achieving high-quality growth<sup>[3]</sup>. On the other hand, some scholars concentrate on the institutional environment optimization path. Research indicates that the digital economy can create favorable conditions for effectively stimulating regional innovation activities by fostering entrepreneurial spirit, reducing transaction costs, and improving the innovation environment; however, some scholars argue that the inherently highly concentrated market structure of digital economy development may hinder innovation<sup>[4-8]</sup>. The ‘winner-takes-all’ phenomenon in the platform economy can lead to over-concentration of innovation resources and reduce the innovative vitality of heterogeneous small and medium-sized enterprises. Moreover, the market demand-driven path has also attracted scholarly attention. Through bridging the information gap between regional market supply and demand, the digital economy effectively unleashes domestic demand potential and enhances the economies of scale and scope of collaborative innovation, thereby using strong market demand as a driving force to encourage diverse innovation actors within the region to deeply integrate into innovation networks.

Against the backdrop of an increasingly turbulent global landscape and intensifying technological competition, how regions can leverage the digital economy to achieve innovation-driven development has become an important issue that urgently needs to be addressed. Based on this, this paper takes 31 provinces in China as samples and constructs a theoretical framework analyzing the impact of the digital economy on regional innovation. It explores the direct effects of the digital economy on regional innovation capacity as well as the moderating effects of government support, and examines the boundary conditions of the external environment in this context. Grounded in the reality of regional development in China, this study deepens the understanding of how the digital economy enhances regional innovation capacity and provides a reference for governments to formulate differentiated digital development strategies. It holds significant theoretical value and practical guidance for accelerating digital economy development and boosting innovation capacity.

## **1.Theoretical Analysis and Research Hypotheses**

### **1.1 Analysis of the Direct Effects of the Digital Economy on Regional Innovation Capability**

The digital economy is becoming a powerful force reshaping resource allocation, changing economic structures, and influencing shifts in competitive landscapes. As an economic system that takes digital information as the core production factor, is supported by information and communication technologies and internet technologies<sup>[8]</sup>, and is carried by modern information networks, it fundamentally transforms the entire economic environment and economic behavior<sup>[9]</sup>. The digital economy features low cost, high efficiency, and all-time-space technological characteristics<sup>[10]</sup>, and it can foster new industries, new business formats<sup>[3]</sup>, and new models through deep integration of digital technology with traditional industries<sup>[11]</sup>, empowering the transformation and upgrading of traditional industries, thereby driving the transformation of China’s economic development path and achieving high-quality development<sup>[12]</sup>. In this process, the unique attributes and flow logic of data elements, the innovation-supporting role of digital technology, and the collaborative functions of digital platform ecosystems combine to jointly construct the theoretical framework for the digital economy empowering regional innovation.

First, as a fundamental core driver, data elements reshape the regional innovation factor supply system. Data elements are basic production factors in the digital economy era and differ from traditional production factors in that they are virtual resources existing in digital space<sup>[13]</sup>. They have unique characteristics such as unlimited reuse, fast dissemination, and high utilization efficiency. These traits fundamentally change the scarcity constraints of traditional production factors, providing

a completely new model of factor supply for regional innovation. Digital infrastructure, as the physical and technological foundation for the efficient, low-cost, and extensive dissemination of data elements, supports the free flow and reuse of data in virtual space. Moreover, the further dissemination of data elements exhibits a significant Metcalfe effect—the value of the network grows quadratically with the number of nodes<sup>[14]</sup>, continuously amplifying innovation efficiency through multiple mechanisms. From the perspective of the mechanism of action, the extremely low marginal cost of data elements allows regional enterprises, universities, research institutions, and other innovation entities to reuse the same dataset at almost zero cost, reducing basic innovation investment costs while supporting higher-level technology development and model innovation. More importantly, the accumulation and use of data elements have increasing marginal returns, with their value continuously increasing through ongoing application and iteration, breaking the traditional law of diminishing marginal returns on factors and forming a sustained driving force for innovation activities. Additionally, data elements promote innovation diffusion by accelerating knowledge spillovers, improve innovation precision through optimized resource allocation, expand innovation boundaries through cross-sector integration, and further incubate emerging business models to open new innovation pathways, comprehensively reshaping the structure and efficiency of factor supply for regional innovation. In this process, the development of the digital economy accelerates the maturity and widespread application of new technologies such as artificial intelligence, big data, and cloud computing<sup>[13]</sup>, further driving the regional economy toward information-intensive and knowledge-intensive directions, and forcing governments to deepen their understanding of the digital economy and proactively use digital technologies to enhance innovation guidance and service capabilities.

Secondly, digital technology, as an amplifier of innovation effectiveness, is restructuring the implementation path of regional innovation. Digital technology, which underpins the digital economy, is centered on information and communication technology, artificial intelligence, big data, and cloud computing. It serves as the core support for enhancing regional innovation efficiency. Its rapid iteration speed and strong penetration capability are profoundly changing the tools, processes, and models of regional innovation<sup>[15]</sup>, achieving a multiple-fold increase in innovation effectiveness. In the context of the digital economy, technology and knowledge have become the core endogenous factors in the endogenous economic growth model. A digital technology system that aligns with the development of the digital economy is a key vehicle for activating these endogenous factors. From a practical perspective, digital technology first enhances the precision and efficiency of innovation by upgrading the innovation toolchain. For instance, the use of artificial intelligence algorithms significantly shortens experimental trial-and-error cycles, cloud computing provides low-cost computing support for small and medium-sized enterprises, and technological breakthroughs effectively reduce the knowledge transfer costs among regional innovation actors, breaking the constraints imposed by traditional equipment and technology barriers on regional innovation. Secondly, digital technology drives regional innovation to transform from a ‘linear model’ to a ‘collaborative model.’ By digitally encoding the stages of research and development, design, testing and verification, and market feedback, innovation activities can be integrated into digital space, enabling cross-time-and-space collaboration<sup>[16]</sup>. The restructuring of processes significantly improves the coordination efficiency of different nodes in the innovation chain, accelerating the transformation of outcomes from the laboratory to the market. Meanwhile, the permeable and boundaryless nature of digital technology breaks the temporal and spatial limitations of innovation activities, making technological exchanges and collaboration between different regions and actors more convenient. This further enhances the spillover effects of innovation activities, making imitative innovation the primary choice for ‘latecomers’ while compelling ‘leaders’ to continuously strengthen their innovation capabilities to maintain competitive advantage.

Finally, as a collaborative carrier, the digital platform ecosystem optimizes the operational efficiency of regional innovation systems. The digital platform ecosystem constructed by the digital economy is based on a multilateral market, integrating innovative entities such as enterprises, universities, and research institutions, service entities such as financial institutions and intermediary organizations, as well as diverse participants including users. It serves as a key carrier for promoting the efficient collaboration of regional innovation elements, with its core function being the cross-temporal and spatial optimization and integration of regional innovation resources through organizational innovation. In the digitalized regional innovation ecosystem, digital platforms have become the central hub of innovation activities, supporting value co-creation and co-

evolution among multiple stakeholders. The optimization effect of the digital platform ecosystem on regional innovation is mainly reflected in two aspects: on the one hand, it improves resource allocation accuracy by lowering the matching costs of innovation elements<sup>[17]</sup>. Digital platforms leverage three technical elements—generalized modules, standardized interfaces, and scalable architecture—to build efficient mechanisms for connecting resources, enabling technology demanders, suppliers, and financiers within the region to match quickly. This effectively reduces resource mismatches caused by information asymmetry in traditional innovation<sup>[18]</sup>, allowing regional innovation resources to be more precisely invested in high-value innovative activities. On the other hand, it releases the vitality of actors by constructing an open and shared innovation collaboration network. The platform ecosystem breaks the constraints of traditional vertically managed organizational structures, promotes the transformation of enterprise functions from management to empowerment, and incorporates users deeply into the innovation process, creating a co-prosperity and symbiotic innovation environment. This network effect allows innovation to no longer be confined within a single entity, but to form a collective innovation force within the ecosystem. Based on this, this paper proposes the following hypothesis:

H1: The digital economy has a positive effect on enhancing regional innovation capabilities.

## 1.2 The moderating effect of government support

Government support, as a core component of the institutional environment, plays a positive regulatory role in enhancing regional innovation capabilities driven by the digital economy through three main channels: policy guidance, resource provision, and risk-sharing. It effectively addresses the high investment and high-risk challenges of digital technology innovation and amplifies the allocation efficiency of innovation resources by the digital economy.

On one hand, the government supports the optimization of the compatibility of digital economy and innovation elements through policy guidance and resource allocation. By formulating special policies, the government clarifies the direction of digital technology research and development and the distribution of innovation resources, guiding resources to concentrate in key areas such as artificial intelligence and blockchain<sup>[19]</sup>. At the same time, use financial subsidies and tax incentives to reduce the cost of digital transformation for enterprises and alleviate the financial constraints of small and medium-sized enterprises<sup>[20]</sup>. And by promoting cross-regional interconnection of digital infrastructure, building unified data platforms and computing centers, breaking down barriers to data flow, and improving the efficiency of integrating innovative elements<sup>[21]</sup>.

On the other hand, the government supports the enhancement of innovation entities' willingness to apply technology through risk-sharing and results transformation guarantees. The government has established tools such as innovation risk compensation funds and technology insurance to share the losses from corporate R&D failures and reduce perceived risks. At the same time, it strengthens intellectual property protection, improves digital technology patent examination and infringement protection mechanisms, and safeguards the rights of innovation entities. In addition, it builds platforms for industry-university-research collaboration to promote the transfer and commercialization of digital technology achievements from universities and research institutions to enterprises, thereby improving the efficiency of innovation commercialization. Based on this, this paper proposes Hypothesis 2:

H2: Government support plays a positive moderating role between the digital economy and regional innovation capability.

## 2. Research Design

### 2.1 Analysis of the Direct Effects of the Digital Economy on Regional Innovation Capability

This study ultimately selected panel data from 31 provinces in mainland China (excluding Hong Kong, Macau, and Taiwan) from 2011 to 2023 as the research sample. The data mainly come from the National Bureau of Statistics, the "China Regional Innovation Capability Evaluation Report," the "China Statistical Yearbook," the urban statistical yearbooks of various provinces, the EPS database, and the CNRDS database. Missing data for certain years in some regions were supplemented using linear interpolation.

### 2.2 Model Settings

To advance the empirical study, the following empirical model is constructed:

$$INNO_{i,t} = \beta_0 + \beta_1 DIG_{i,t} + \sum \beta_2 Controls_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t} \quad (1)$$

In the above model,  $INNO_{i,t}$  represents the regional innovation capability of province  $i$  in period  $t$ ,  $DIG_{i,t}$  represents the level of the digital economy in province  $i$  in period  $t$ , and  $Controls_{i,t}$  are a series of control variables.

### 2.3 Variable Description

The core explanatory variable of this article is the digital economy (DIG). Referring to the existing research of scholars such as Zhao Tao and Wang Jun<sup>[22,23]</sup>, this study selects digital infrastructure, digital industrialization, and industrial digitization as primary indicators, and further selects 16 secondary indicators to construct a comprehensive digital economy index evaluation system. The entropy weighting method is used to measure the comprehensive digital economy index and the digital economy level of each province in different years.

This paper refers to the approach of Xie Huiqiang et al.<sup>[24]</sup> and uses the regional composite index disclosed in the “China Regional Innovation Capability Evaluation Report,” compiled by the China Science and Technology Development Strategy Group in collaboration with the University of Chinese Academy of Sciences and the China Innovation and Entrepreneurship Management Research Center, to measure a region’s innovation capability.

This paper introduces the following control variables into the model : First is the level of economic development (GDP), measured by per capita GDP; second is the industrial structure (IND), measured by the proportion of the value added of the secondary industry to GDP; third is the level of financial development (FIN), measured by the proportion of loans from financial institutions to GDP; fourth is the degree of openness to the outside world (OPEN), measured by the proportion of total imports and exports to GDP; fifth is foreign direct investment (FDI), measured by the proportion of foreign direct investment to GDP; sixth is the level of urbanization (URBAN), measured by the ratio of the urban resident population to the total resident population.

## 3. Empirical Analysis

### 3.1 Digital Economy and Regional Innovation Capacity

This paper employs a double fixed-effects model for testing and empirically examines the impact of the digital economy on regional innovation capability. The regression results are shown in Table 1. Columns (1) and (2) present the regression results without control variables, controlling successively for city and year fixed effects. The estimated coefficients of digital economy development level (Dig) are 0.701 and 0.175, both significant at the 1% level. Columns (3) and (4) show the regression results after adding control variables on the basis of Columns (1) and (2), with the estimated coefficients of digital economy development level (Dig) being 0.467 and 0.114, both significant at the 1% level. This indicates that the digital economy, as a new economic model, has a stable promoting effect on the enhancement of regional innovation capability. Hypothesis H1 is thus verified.

Table 1 Benchmark regression results

	(1)	(2)	(3)	(4)
	INNO	INNO	INNO	INNO
DIG	0.701*** (19.701)	0.175*** (5.192)	0.467*** (13.558)	0.114*** (3.107)
GDP			-0.001 (-0.017)	0.221** (2.172)
IND			0.111*** (4.308)	-0.002 (-0.053)
FIN			-0.165*** (-6.171)	-0.009 (-0.331)
OPEN			0.611*** (19.391)	-0.030 (-0.630)
FDI			0.097*** (3.851)	0.121*** (7.844)
URBAN			-0.027	0.091***

	(1)	(2)	(3)	(4)
	INNO	INNO	INNO	INNO
Constant	-0.000 (-0.000)	-0.000 (-0.000)	-0.000 (-0.000)	-0.000 (-0.000)
CONS	NO	NO	YES	YES
Provincial fixed effects	NO	YES	NO	YES
Year fixed effects	NO	YES	NO	YES
N	403	403	403	403
Adj.R <sup>2</sup>	0.491	0.958	0.826	0.968

### 3.2 Test of Moderating Effect

To examine the moderating effect of the thickness of the technology market and the intensity of government support on the relationship between the level of the digital economy and regional innovation capability, this paper introduces an interaction term between the digital economy and government support intensity based on model (1). The coefficient of the interaction term can reflect the moderating effect of government support intensity on the relationship between the level of the digital economy and regional innovation capability.

Government support can play an indispensable strategic guiding role in the cultivation and advancement of regional innovation capability by creating an innovation-oriented institutional environment, directing key resource investments, and reducing systemic risks. Therefore, to test the moderating role of government support intensity in the impact of the digital economy on regional innovation capability, this paper includes an interaction term between government support intensity and the digital economy in model (1). As shown in column (2) of Table 2, the coefficient of DIG\*GOV is significantly positive at the 1% level, indicating that government support can provide innovation resources and mitigate innovation risks, thereby positively moderating the promotion effect of the digital economy on regional innovation capability, and hypothesis H2 is verified.

Through targeted policies, fiscal and tax support, and cross-regional digital infrastructure construction, the government optimizes the adaptability of innovation elements and reduces coordination costs. At the same time, by relying on innovation risk compensation, strengthening intellectual property protection, and building industry-university-research collaboration platforms, the government mitigates innovation risks and ensures the transformation of outcomes. This addresses the high-investment, high-risk dilemma of digital technology innovation, enhances the willingness of innovation entities to participate, and improves the efficiency of factor allocation, significantly amplifying the enabling effect of the digital economy on regional innovation.

Table3 Moderating effect test results

	(1)	(3)
	INNO	GOV
<i>Dig</i>	0.114*** (3.107)	0.263*** (4.885)
<i>GOV</i>		0.127 (1.364)
<i>DIG*GOV</i>		0.133*** (3.770)
<i>GDP</i>	0.221** (2.172)	0.211** (2.043)
<i>IND</i>	-0.002 (-0.053)	-0.058 (-1.384)
<i>FIN</i>	-0.009	-0.066**

	(1)	(3)
	INNO	GOV
	(-0.331)	(-2.117)
<i>OPEN</i>	-0.030	0.016
	(-0.630)	(0.329)
<i>FDI</i>	0.121***	0.113***
	(7.844)	(7.340)
<i>URBAN</i>	0.091***	0.096***
	(3.700)	(3.950)
<i>Constant</i>	-0.000	0.044***
	(-0.000)	(3.011)
<i>N</i>	403	403
<i>Adj - R<sup>2</sup></i>	0.968	0.969

#### 4. Further research

To examine whether there are significant regional differences in the relationship between the digital economy and regional innovation, the sample is divided into the eastern (East), central (Middle), and western (West) regions, and Model (1) is used to study the impact of the digital economy on regional innovation. Columns (1)–(3) in Table 3 present the regression results of the impact of the digital economy on regional innovation in the eastern, central, and western regions, respectively. The results show that the regression coefficient of the digital economy in the eastern region is significantly positive. This may be because the eastern region has fully built pervasive digital infrastructure and has gathered a large number of high-end talents, venture capital, and technological resources, possessing a high level of endowments and leveraging the latecomer advantage of the digital economy. By contrast, the impact of the digital economy on regional innovation in the central and western regions is not significant, which may be due to inherent deficiencies and subsequent losses in key innovation elements such as talent, capital, and technology, making it difficult to enhance the level of innovation.

Table 3 Regional Heterogeneity

	(1)	(2)	(3)
	INNO-East	INNO-Middle	INNO-West
<i>DIG</i>	0.163**	0.149	0.127
	(2.470)	(1.069)	(0.865)
<i>GDP</i>	0.118	0.211	0.020
	(0.486)	(1.081)	(0.131)
<i>IND</i>	0.088	-0.101	0.131**
	(0.669)	(-1.144)	(2.450)
<i>FIN</i>	0.024	-0.063	-0.069**
	(0.329)	(-0.570)	(-2.568)
<i>OPEN</i>	-0.103	0.317	0.057
	(-1.330)	(1.374)	(0.561)
<i>FDI</i>	0.122***	0.101**	0.201***
	(5.179)	(2.084)	(3.850)
<i>URBAN</i>	0.108***	-0.009	0.821***
	(3.087)	(-0.173)	(4.034)
<i>Constant</i>	0.622***	-0.050	0.095
	(2.916)	(-0.310)	(0.772)
<i>N</i>	143	104	156
<i>Adj.R<sup>2</sup></i>	0.969	0.857	0.900

## 5. Main Conclusions and Policy Recommendations

### 5.1 Main Conclusions

This study uses data from 31 provinces in China from 2011 to 2023 and employs a two-way fixed effects model to empirically examine the impact of the digital economy on regional innovation capabilities. The research findings indicate that: (1) the digital economy significantly promotes the enhancement of regional innovation capabilities; (2) further analysis of the moderating effect shows that government support plays a positive moderating role in the relationship between the digital economy and regional innovation capabilities; (3) heterogeneity analysis reveals that the positive impact of the digital economy on regional innovation capabilities varies significantly across regions: its innovation-promoting effect is significantly positive in the eastern regions, while the effect in the central and western regions is relatively weaker.

### 5.2 Policy Recommendations

First, to fully unleash the inclusive empowering effect of the digital economy on regional innovation capabilities, it is necessary to strengthen the foundation of digital economic development from three aspects: infrastructure, industrial integration, and factor allocation, and promote the deep integration of digital technology across the entire innovation chain. The goal should be “coordinated development across the eastern, central, and western regions, with integrated urban-rural coverage,” increasing investment in new digital infrastructure such as 5G networks and industrial internet in central and western regions and rural counties, and lowering digital access barriers. Focus should be placed on strategic emerging industries and the upgrading needs of traditional industries, with the establishment of a “Digital Innovation Special Fund” to subsidize companies for digital R&D transformation, cultivate digital transformation service providers, and build an industrial ecosystem that integrates digital technology and innovation. At the same time, improve data property rights definition and trading circulation rules, construct cross-regional data trading platforms, promote the open sharing of research data, and activate the multiplier effect of data on regional innovation.

Second, to leverage the government’s supporting role in enabling regional innovation through the digital economy, it is necessary to optimize government support methods and improve the precision and efficiency of such support, breaking down barriers to the integration of digital and innovation through policy guidance. In terms of financial and tax support, favor the “digital innovation” sector, implement preferential tax policies for high-tech companies in the digital economy, and increase the additional deduction rate for digital innovation R&D expenses, while supporting universities to conduct basic research in the digital economy through government service purchases and post-subsidies. Build a “Digital Economy Innovation Service Complex,” establish government-enterprise matchmaking meetings and a digital innovation project database, promote precise three-way matching, and prioritize resources for high-quality projects. Furthermore, establish an assessment system centered on innovation performance, using the digital economy’s contribution to innovation as a basis for fund allocation, and strengthen full-process supervision of fiscal funds to ensure that resources flow toward key innovation areas.

Finally, in response to the heterogeneous impact of the digital economy on regional innovation, differentiated policies should be implemented based on development differences between the eastern, central, and western regions, and coordination mechanisms should be used to narrow regional digital innovation gaps and promote coordinated regional innovation development. Support eastern provinces in building “Digital Economy Innovation Pilot Demonstration Zones,” granting them pioneering trial rights and positioning national-level frontier innovation platforms to create digital innovation origins, while promoting the establishment of a “digital innovation pairing assistance” mechanism between the eastern, central, and western regions, radiating resources through technology transfer and talent training. Implement a “Digital Innovation Catch-up Plan” for the central and western regions, using central transfer payments to support the construction of regional digital innovation carriers, and guide the gradient transfer of digital enterprises from eastern to central and western regions. Additionally, build an eastern-central-western digital innovation collaborative alliance, construct cross-regional achievement-sharing platforms, implement flexible talent mobility plans, and explore tax revenue sharing and achievement-sharing mechanisms to promote the cross-regional flow of innovation resources.

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