

# The Influence of Digital Economy on The Vitality of Urban Double Innovation

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**Abstract:** Under the new development pattern, the rapid development of digital economy is becoming the core force to change the global economic and social structure. At the same time, China is speeding up the conversion of old and new kinetic energy, and how to activate China's dual-innovation vitality is the focus of attention from all walks of life. Based on this, this project, based on the panel data of 285 prefecture-level cities in China from 2011 to 2019, studies the influence of regional digital economic development index on urban innovation vitality through two-way fixed effect model and intermediary effect model. It is found that the digital economy can promote the promotion of urban innovation vitality, and this conclusion is still valid after replacing the robustness test of the explained variables. The further mechanism test shows that the upgrading of industrial structure is an important intermediary variable for the digital economy to enhance the dual-innovation vitality of cities, and the digital economy can promote the dual-innovation vitality of cities through the upgrading of industrial structure.

**Keywords:** Digital economy; Upgrading of industrial structure; Urban innovation vitality; Transmission mechanism.

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## 1. Introduction

Since the 18th National Congress of the Communist Party of China, China has thoroughly implemented the strategy of strengthening the country by network and the national big data strategy, and successively issued the digital economy development strategy and the "14th Five-Year Plan". Relevant departments have conscientiously implemented various arrangements, accelerated the digital industrialization and industrial digitalization, and promoted the vigorous development of the digital economy. With the great attention of the party and the country, China's digital economy has achieved international development achievements, and its overall scale has ranked second in the world for many years. According to the latest data of China ICT Institute, in 2022, the scale of China's digital economy reached 50.2 trillion yuan, up 10.3% year-on-year, and the proportion of digital economy in GDP reached 41.5%, which played an increasingly prominent role in guiding and supporting economic and social development. Under the background of the new round of scientific and technological revolution and industrial transformation, digital economy, as the main economic form after agricultural economy and industrial economy, is becoming a key force to shape the global competition pattern with its rapid development, wide radiation range and unprecedented influence. By constantly tapping the advantages of China's massive data and constantly exerting the application of digital economy to empower traditional industries, it will help to promote the emergence of new industries, new formats and new models, which will greatly facilitate residents' lives and enhance their happiness. The digital economy has become a new engine for high-quality economic development. With the rapid development of digital economy, the problems of insufficient, unbalanced and irregular development of digital economy in China are increasingly apparent. How to solve the problems of insufficient innovation and imperfect governance system in key areas of digital economy, how to give full play to the potential of digital economy, and how to bridge the digital gap in different industries and regions? The solution of these

problems also needs more theoretical support. In this context, in-depth discussion on the impact and role of digital economy development on urban double innovation is not only conducive to tapping the vitality and value of digital economy to empower high-quality economic development, but also of key significance to realize the national innovation-driven development strategy in the new stage of development.

Previous studies have confirmed the positive impact of digital economy on urban innovation and entrepreneurship (Wen Jun, 2019; Yang Weiming, 2020; Zhao Tao, 2020), scientific and technological innovation and deepening social division of labor are its important mechanisms, but most scholars use the ratio of the number of urban private and individual employees to the urban resident population to measure the innovation and entrepreneurial vitality of a region, and the index measurement still has certain limitations. In addition, although many scholars have concluded that the digital economy has become the source of power for the continuous upgrading of China's industrial structure (Jiao Shuaitao, 2021; Li Zhiguo, 2021; Liu Yang, 2021). However, few scholars study the influence of digital economy on urban innovation and entrepreneurship by taking industrial structure upgrading as an intermediary variable. Based on this, this paper constructs an objective, real-time and multi-dimensional China regional innovation and entrepreneurship index by using the full enterprise information in the national industrial and commercial enterprise registration database. Taking the upgrading of industrial structure as the internal mechanism, this paper studies the impact of the development of digital economy on the city's dual-innovation vitality, and provides empirical support for further strengthening the construction of digital China and taking the road of independent innovation with China characteristics. In addition, this paper will further analyze the heterogeneous influence of digital economy on the development of urban innovation vitality. By exploring the heterogeneity of digital economy on cities of different regions and sizes, it will help to solve the problem of unbalanced development of digital economy in China, thus indirectly promoting the coordinated development of regional economy in China

## 2. Literature Review

The research on the influence of digital economy on urban innovation and the influencing factors of urban entrepreneurial innovation ability has been the focus of academic circles in recent years.

In terms of the impact of digital economy on urban innovation, many scholars have come to the conclusion that the development of digital economy is helpful to enhance the vitality of urban innovation through empirical analysis. Zhao Tao et al. (2020) constructed a comprehensive evaluation index of high-quality economic development at the regional level for the first time, and concluded that the digital economy mainly releases the dividend of high-quality development by stimulating the entrepreneurial activity of cities, and the spatial spillover effect generated by digital technology will also bring certain benefits to the high-quality development of neighboring cities. Jin Huan (2021) empirically analyzed the impact of digital economy development on urban innovation and innovation gap in 283 regions of China from 2015 to 2018 with the help of the "internet plus Digital Economy" index constructed by micro big data, and concluded that the development of digital economy can significantly promote the improvement of urban innovation level. Wu Ye (2023) studied the benchmark model and vector autoregressive model, and found that digital finance, green innovation and their synergy have a significant positive impact on urban economic resilience, and passed the robustness test. Wen Jun et al. (2019) found that the digital economy has improved the city's innovation ability by using the cross-sectional data of prefecture-level cities.

The research on the influencing factors of urban entrepreneurial innovation ability finds that FDI, new generation information infrastructure, and China-Europe trains are all helpful to enhance the vitality of urban dual innovation. Zheng Wanteng (2023) used the double difference model and the intermediary effect model to study the impact of the opening of the China-Europe train on the dual-innovation vitality of cities along the route. The opening of the China-Europe train can indirectly promote the promotion of the dual-innovation vitality of cities along the route through four paths: trade-driven, investment-driven, employment-driven and government support. Wang Jia (2021) found that with the increase of FDI scale, FDI has a positive impact on innovative entrepreneurship, and after exceeding a certain threshold, this impact turns negative. In addition, the inverted "U" relationship between them is more obvious in developing countries. Jason and Fu Kui (2021) took the pilot project of "Broadband China" as an exogenous policy impact, and studied the impact of the new generation of information infrastructure on urban innovation. It is concluded that the pilot policy of "Broadband China" strategy has significantly promoted the level of urban innovation, which is still valid after a series of robustness tests such as instrumental variables and propensity score matching.

In recent years, with the vigorous development of digital economy and its important role in economic development, many scholars have begun to study the digital economy, including its concept, characteristics and measurement. The related research of digital economy has laid a good foundation for this paper. Although previous studies have considered the effect of digital economy on urban innovation from many angles, no scholars have linked it with the research on the influencing factors of urban innovation vitality. Therefore,

this paper studies the influence of the development of digital economy on the dual-innovation vitality of cities, and provides empirical support for further strengthening the construction of digital China and taking the road of independent innovation with China characteristics.

## 3. Theoretical Analysis and Research Hypothesis

First of all, with the all-round integration of the digital economy into all fields of social and economic development, the digital economy has accelerated the widespread dissemination of knowledge and information, making the learning exchange between innovation subjects more convenient and efficient. Zhou Guangsu and Fan Gang (2016) believe that the digital economy greatly broadens the channels of information acquisition by providing a convenient information exchange platform, provides information for entrepreneurs' entrepreneurial decision-making, provides accurate market dynamics for entrepreneurial process, and provides information support for entrepreneurial activities. Song(2019) believes that the digital economy has built a convenient learning platform through digital technology, and searched the entrepreneurial learning and training content needed by entrepreneurs through online platforms, which has improved the professionalism of entrepreneurs and greatly reduced the time cost and material cost of entrepreneurship. In addition, the digital economy can not only alleviate the mismatch of resources in this region, but also promote technological progress and indirectly promote the promotion of regional innovation vitality. Guo Jiatang and Luo Pinliang (2016) found that the Internet has significantly promoted the technological progress of China, and the Internet with computers as the main terminal has significantly promoted the improvement of total factor productivity in China. Han Changgen and Zhang Li (2019) believe that the Internet can indirectly affect the allocation of resources and improve the mismatch of resources by improving the degree of marketization, promoting the development of financial markets and improving the level of opening up. Digital economy can improve the activity of local innovation and entrepreneurship by improving capital mismatch and labor mismatch and promoting regional total factor productivity.

At the same time, the development of digital economy also contributes to the industrial transformation and upgrading of China. Jiao Shuaitao and Sun Qiubi (2020) found that vigorously developing the digital economy can not only promote innovation, but also promote the upgrading of industrial structure, which will not only help solve people's livelihood problems, but also solve economic problems. The research of Liu Yang and Chen Xiaodong (2021) shows that the digital economy can not only directly promote the upgrading of industrial structure, but also indirectly have a significant positive impact on the upgrading and rationalization of industrial structure by accelerating the accumulation of human capital and improving the level of scientific and technological innovation. In addition, the Tenth Five-Year Plan points out that the integration of digital economy and real economy will help to upgrade the industrial structure, and then promote the emergence of new industries, new formats and new models.

Based on the current research, this paper puts forward the following research hypotheses by learning relevant theories:

Hypothesis 1: The development of digital economy can

enhance the vitality of urban innovation.

Hypothesis 2: The development of digital economy promotes the dual-innovation vitality of cities by promoting the upgrading of industrial structure.

## 4. Research Design

### 4.1. Model building

In order to explore the influence of digital economy development on urban innovation ability, the following basic model is constructed:

$$PI_{i,t} = c + a_1 \times DIG_{i,t} + a_2 \times \sum X_{i,t} + \lambda_t + \delta_i + \varepsilon_{i,t}$$

Among them,  $PI$  indicates the city's double innovation vitality,  $DIG$  indicates the development degree of digital economy, and  $\sum X$  indicates a series of control variables.  $\lambda$  and  $\delta$  are event-fixed effects and individual-fixed effects respectively, and  $\varepsilon$  is a random error term.

### 4.2. Selection of variables

(1) Explained variable: urban innovation vitality (PI)

In this study, Peking University Enterprise Big Data Research Center and Longxin Data Research Institute are used to measure the dual-innovation vitality of the city. This index uses the total enterprise information in the national industrial and commercial enterprise registration database from 1990 to 2019, and constructs an objective, real-time and multidimensional China regional innovation and entrepreneurship index from five dimensions: the number of new enterprises, attracting foreign investment, attracting venture capital, the number of patent authorizations and the number of trademark registrations, so as to reflect the innovation and entrepreneurship vitality and performance of various regions in China.

(2) The core explanatory variable: the development level of digital economy (DGI)

Based on the research of Huang Qunhui et al. (2019), this paper comprehensively measures the digital economy index at the city level from two aspects: the development of Internet and the development of digital inclusive finance. In terms of Internet development, four indicators are selected, namely, the total amount of telecom services per capita, the number of mobile phone users per 100 people, the number of Internet broadband users per 100 people, and the proportion of employees in the information software industry in the total employment. In the aspect of digital inclusive finance, the digital inclusive finance index jointly compiled by Digital Finance Research Center of Peking University and Ant Financial Group is selected. At the same time, the selected five indicators are standardized, and the final digital economic development index is obtained by entropy method.

(3) Control variables

In order to alleviate the influence of other variables on the estimation results, referring to the existing research, this study controls the following variables: (1) economic development (PG), expressed by per capita GDP; (2) Financial development (FI) is expressed by the ratio of deposit and loan balance of financial institutions to GDP; (3) Urbanization (UR), expressed by the proportion of urban construction land area; (4) Social consumption (SC), expressed by the proportion of total retail sales of social consumer goods to GDP; (6) R&D intensity (RD), expressed by the ratio of urban R&D expenditure to GDP; (7) Technological manpower (TE),

expressed by the number of employees in urban scientific and technological activities.

(4) Data sources

The data used in this paper is the balanced panel data of 285 prefecture-level cities from 2011 to 2019. Among them, the interpreted variable data comes from Peking University Enterprise Big Data Research Center "Langrun Longxin China Regional Innovation and Entrepreneurship Index 2019", the explanatory variable data comes from Peking University Digital Finance Research Center, Peking University Enterprise Big Data Research Center, CNRDS database, EPS database, China City Statistical Yearbook and statistical bulletins of national economic and social development of cities, and the control variable data comes from EPS database, China City Statistical Yearbook and China City Construction Statistical Yearbook. In addition, in order to eliminate the influence of heteroscedasticity, the data are logarithmized in this study.

**Table 1.** Descriptive statistics

Variable	N	Mean	Min	Max
PI	2566	50.79	1.370	99.31
DGI	2566	0.169	0.0370	0.462
UR	2551	8.297	0.140	45.06
SC	2559	38.39	13.43	69.51
FI	2559	239.7	98.68	676.0
IU	2559	228.9	196.7	263.1
POPU	2483	428.2	45	1180
GOV	2483	27.48	13.38	69.55
RD1	2512	16069	28.23	135137
RD2	2107	0.0150	0	0.144
PA	2483	13.73	0.0990	406.4
PL	2483	10.43	0.0650	306.6

## 5. Empirical Analysis

### 5.1. Benchmark estimation analysis

**Table 2.** Benchmark Regression Results

VARIABLES	(1)	(2)
	PI	PI
DGI	0.117** (2.03)	0.120** (2.07)
PG		0.270*** (4.40)
UR		-0.028 (-1.46)
SC		-0.105* (-1.72)
FI		0.043 (0.67)
RE		0.056*** (3.13)
Constant		1.119 (1.23)
Observations	2566	2,551
R-squared	0.892	0.892
cityname FE	YES	YES
year FE	YES	YES

Table 2 reports the linear estimation results of the impact of digital economy on urban innovation vitality. In model (1) and model (2), the estimation coefficient of the core

explanatory variable digital economy development level (DGI) is significantly positive, indicating that the development of digital economy can enhance the vitality of urban innovation, and the hypothesis is verified. In addition, in model (2) with control variables, there is a significant positive correlation between regional economic development level (PG) and urban innovation vitality, indicating that urban innovation vitality has been effectively improved with economic development; There is also a significant positive correlation between investment in science and technology (RE) and urban double innovation vitality, which shows that the expansion of investment in science and technology can promote the promotion of urban double innovation vitality; The coefficient value of social consumption (SC) is negative and significant, which means that social consumption will inhibit the promotion of urban innovation vitality in this region; Both financial development (FI) and urbanization (UR) failed to pass the significance test of 10% level. For financial development level (FI), there is a positive correlation with urban dual-innovation vitality, which shows the importance of building a high-level capital market to enhance urban dual-innovation vitality. At the same time, the negative of the latter means that the expansion of urban scale is not conducive to the promotion of the dual-innovation vitality of cities in this region.

## 5.2. Robustness test

In order to verify the reliability of the causal relationship between digital economy and urban double innovation vitality, this paper uses the methods of replacing explained variables and instrumental variables to test the robustness.

1. Replace the explained variables: Considering the number of patent applications and invention patents, it can also measure the city's innovation ability to some extent. Therefore, the per capita patent application amount (PA) and the per capita invention patent authorization amount (PL) are used as the substitution variables of the explained variables.

The regression results after replacing variables are shown in Table 3:

**Table 3. Regression Results after Replacing Variables**

VARIABLES	Test model	Test model	Original
	PA	PL	basic model PI
DGI	0.169*** (2.92)	0.232*** (3.92)	0.120** (2.07)
PG	0.520*** (8.64)	0.525*** (8.55)	0.270*** (4.40)
UR	0.005 (0.30)	0.009 (0.50)	-0.028 (-1.46)
SC	-0.229*** (-3.96)	-0.206*** (-3.50)	-0.105* (-1.72)
FI	0.372*** (6.11)	0.325*** (5.24)	0.043 (0.67)
RE	0.162*** (9.67)	0.106*** (6.20)	0.056*** (3.13)
Constant	-5.517*** (-6.03)	-5.481*** (-5.87)	1.119 (1.23)
Observations	2,483	2,483	2,551
R-squared	0.958	0.956	0.892
newcityname FE	YES	YES	YES
year FE	YES	YES	YES

According to the model regression results after replacing variables, the directionality of core explanatory variables and significant counties have not changed significantly, which shows that the regression of the original basic model is robust.

## 5.3. Heterogeneity test

Considering that the city size may have an impact on the digital economy's dual-innovation vitality, this project divides the total sample into big cities (more than 1 million) and small and medium-sized cities (less than 1 million) to investigate whether the impact of digital economy development on urban dual-innovation vitality exists the heterogeneity of city size. According to the results, it is found that the digital economy has a significant positive effect on the urban innovation vitality of big cities, while the impact on small and medium-sized cities is not significant and negative. It means that the development of digital economy is conducive to the promotion of innovation and entrepreneurship in big cities, but will inhibit the development of innovation and entrepreneurship in small and medium-sized cities.

**Table 4. Regression Results of Heterogeneity Analysis**

VARIABLES	big city	small-medium cities
	PI	PI
DGI	0.119** (2.00)	-0.022 (-0.11)
PG	0.286*** (4.44)	0.236 (1.19)
UR	-0.028 (-1.45)	-0.018 (-0.34)
SC	-0.152** (-2.39)	0.562*** (3.37)
FI	0.042 (0.63)	0.050 (0.30)
RE	0.056*** (2.96)	-0.014 (-0.30)
Constant	1.736* (1.79)	-1.544 (-0.55)
Observations	2,443	108
R-squared	0.892	0.891
newcityname FE	YES	YES
year FE	YES	YES

## 5.4. Analysis of intermediary effect

From the perspective of industrial upgrading, this paper theoretically analyzes the transmission mechanism of digital economy to urban double innovation vitality. In order to verify the hypothesis of this mechanism, this paper chooses the intermediary effect model for empirical test, and the regression is shown in table. On the basis of model (1) confirming that digital economy has a positive impact on the innovation vitality of high cities, model (2) puts the intermediate variable of industrial structure upgrading back into the regression equation of the influence of cross-digital economy on high-quality development, and judges by observing the coefficient values and significant changes of the core explanatory variables: the influence coefficient of digital economy in model (2) is lower than that in model (1), and it is significant at the level of 1%, indicating the industrial structure.

**Table 5.** Analysis of Intermediate Variable Results

VARIABLES	(1)	(2)
	IU	PI
DGI	0.021*** (7.27)	0.112* (1.93)
IU		0.726 (1.54)
Observations	2,447	(1.54)
Control	YES	YES
newcityname FE	YES	YES
year FE	YES	YES
R-squared	0.953	0.892

## 6. Conclusion and Enlightenment

Based on the balanced panel data of 285 prefecture-level cities from 2011 to 2019, this paper investigates the impact of digital economy on urban innovation vitality and its internal mechanism. The research conclusions are as follows: First, the digital economy has significantly promoted the promotion of urban innovation vitality, which is still valid after replacing the explained variables and using historical data as tool variables. Second, the mechanism test found that industrial upgrading is an important channel for the digital economy to promote the vitality of urban innovation. Thirdly, the heterogeneity analysis shows that the digital economy has a more obvious promoting effect on big cities. Based on the above conclusions, this paper puts forward the following policy suggestions:

First, speed up the construction of digital economy. To this end, China's government and enterprises need multi-layer efforts. For the government, it is necessary to pay equal attention to management, promote the unity of development and standardized management, build a digital rule system, and create an open, healthy and safe digital ecology. For enterprises, give full play to the advantages of massive data and rich application scenarios, promote the deep integration of digital technology and real economy, empower the transformation and upgrading of traditional industries, give birth to new industries, new formats and new models, and expand the new engine of innovation and entrepreneurship.

Second, continue to stimulate social innovation potential and entrepreneurial vitality. Digital economy can promote export growth by upgrading industrial structure, which shows that "digital industrialization" and other "industrial digitalization" policies and measures can effectively cultivate and promote new kinetic energy of urban innovation and entrepreneurship. Therefore, relevant government departments should continue to carry out and increase their support for digital transformation policies, support all kinds of market players to develop the potential of data elements, and constantly stimulate the potential of social innovation and entrepreneurial vitality. Specifically, encourage enterprises to open up data such as search, e-commerce, and social networking, and develop third-party big data service industries; Promote the inclusive application of digital services and build a digital life enjoyed by the whole people; Cultivate and expand emerging digital industries such as artificial intelligence, big data, blockchain, cloud computing and network security. Finally, the role of digital economy in promoting innovation and entrepreneurship in big cities is more obvious. Based on this, we should establish the demonstration role of big cities, strengthen the support of big cities on digital economy, promote the upgrading of industrial structure in big cities, and then accelerate the emergence of

new industries, new formats and new models in big cities, and apply innovative achievements to small and medium-sized cities, so as to promote the coordinated development of cities across the country.

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