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Research on the Path and Regional Heterogeneity of Digital Economy Enabling New Quality Productivity Based on Provincial Panel Data

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Abstract: The digital economy, as an emerging economic form, is a key force in promoting high-quality economic development, solving the current traditional mode of production that relies on a large number of resource inputs and highly consumes resource and energy development methods, and improving new-quality productivity. This paper analyzes the impact of digital economy from the comprehensive perspective of new quality productivity by using China's provincial panel data from 2010 to 2022, and panel fixed effect model and mediation effect model. The study shows that the development of digital economy has a positive impact on the improvement of new quality productivity. Industrial structure upgrading, factor optimization and improvement of innovation level are important mechanisms by which digital economy affects new quality productivity, while there is obvious regional heterogeneity. Our findings provide some insights into the mechanisms by which the digital economy affects new quality productivity.

Keywords: Digital economy, New qualitative productivity, Panel fixed effect model, Path mechanism.

1. Introduction

Since the reform and opening up, China's economy has made great achievements. However, under the current wave of scientific and technological revolution and digitalization, in the process of China's economy turning to high-quality development, more attention should be paid to the productivity changes brought about by digital technology [1]. In response, Xi Jinping first proposed the development of new quality productivity during his inspection in Heilongjiang in September 2023, and systematically expounded the concept of new quality productivity in March 2024. In terms of academic research, in just a few months, many scholars have had a systematic concept of new qualitative productivity [2], the implementation path [3], indicator construction [4] Today's world is facing unprecedented changes. The multipolarization of the world, the deepening of social informatization and the rise of digital economy have undoubtedly accelerated the process of reform of workers, labor factors and labor tools. It has also become a consensus that the digital economy is in line with the pattern of economic growth changing from factor-driven to innovation-driven and from scale and speed to quality and efficiency. The digital economy conforms to the current trend of high-quality development in China, especially the concrete manifestation of the current advanced productive forces [2].

Therefore, in this regard, what is the logical connection between the digital economy and the new qualitative productivity? If the digital economy can drive the improvement of new quality productivity, what is the path mechanism? In addition, is there regional heterogeneity in the impact of digital economy on the development of new qualitative productivity? In order to answer these important questions, in-depth exploration can provide a new perspective for the further development of digital economy, speeding up the digital development of China and promoting the implementation of new quality productive forces.

The main innovations of this research can be summarized as follows. First of all, the concept of new quality productivity has been put forward recently, and there are few articles about empirical research on digital economy on new quality productivity, which are basically theoretical framework, index system construction and path research. This project aims to provide new empirical thinking. Secondly, we think that the new quality productivity is a complex that covers various development situations. It is incomplete to measure the development of the new quality productivity only from the change of economic industry. This project constitutes a new quality productivity evaluation index system from multiple dimensions. In addition, this paper discusses the profound relationship between regions from various angles, and analyses the heterogeneity from the regional position. Fourthly, from both theoretical and empirical perspectives, the research finds that digital economy can improve the quality of new quality productivity development through upgrading industrial structure, optimizing factors and improving innovation level.

1.1. Literature Review

The digital economy has become an important engine of global economic change and a driving force for China's high-quality economic development. The digital economy takes data as the core factor of production, permeates every production link and gradually changes the types and proportions of factor inputs in the production process, breaking the shackles of the traditional factor market, and

further reducing resource mismatch and market distortion by intensifying market competition and optimizing industrial division of labor [5].

Many scholars' discussion on digital economy can be divided into two aspects: the measurement of digital economy and the influence mechanism of digital economy on certain factors. From the measurement perspective of digital economy, Liu Jun et al., Wang Jun et al. (2017) constructed an index system from multiple dimensions to examine the development path of digital economy. From the perspective of the impact mechanism of certain specific elements of the digital economy, some scholars carry out research from the perspectives of total factor productivity, innovation ability, industrial structure upgrading, high-quality economic development and coordinated development. Regarding total factor productivity, many scholars believe that the digital economy can promote total factor productivity (Zhao Chen Yu et al., Luo Jia et al., 2021), and further explore how the digital economic mechanism affects total factor productivity (Qiu Zixun et al., 2021). In addition, the digital economy has a spatial effect on total factor productivity (Yang Huimei et al., 2021). In terms of innovation capability, (Wang Hongming et al., 2022) digitalization can significantly reduce the mismatch level of innovation elements and promote the improvement of innovation capability. Regarding the upgrading of industrial structure, the digital economy can promote the upgrading of industrial structure (Zhang Xinyan et al., 2024), while Wu and Yang (2022) explored this effect from the perspective of segmentation (employment structure). With regard to high-quality economic development, this paper theoretically and empirically analyzes the impact of digital economy on economic quality development (Jing Wenjun et al., 2019; Xiao Yuanfei, Zhou Pingping, 2021). From the perspective of coordinated development, Kokina et al. (2019) take the digital economy as an example, believing that the digital economy is a model for the industrial internet to enable the traditional factors of production, reduce energy consumption, improve the efficiency of all sectors of the industry, realize energy efficiency and promote green development.

Innovation is the main driving force of new quality productivity, and the introduction of "knowledge", "data" and "technology" as factors of production also makes the marketization of data an important way to achieve the national strategic objectives and promote the development of new quality productivity [6]. The current articles focus on system concept (Zhou Wen et al., 2023), realization path (Shi Jianxun et al., 2024) (Zhai Xuquan et al., 2014), influencing factors (Lu Minfeng et al., 2014) and theoretical stage of index construction. The influencing factors mainly include certain specific factors such as education (Jiang Zhaohui et al., 2024), digitalization (science and technology, information, etc.), finance (Ren Yuxin et al., 2024), etc. Workers, working materials and working objects are the basic factors of productivity. Digital technology reshapes the existing productivity system from these three aspects. At present, there are relatively few academic researches on digital economy and new quality productivity, most of which focus on theoretical aspects. From a macro point of view, Yao Shujie and others believe that scientific and technological innovation, system optimization and factor coordination are important ways to promote the development of new quality productive forces with the help of digital economy. Microscopically, the digital economy enhances the quality and efficiency of the national innovation system by enhancing the innovation capability of enterprises, enhancing the integration of the industrial chain and innovation chain (Zhai Xuquan, 2024). From the micro, meso and macro levels, digital economy provides an inexhaustible motive force for accelerating the formation of new quality productive forces. Digital economy is the path and result of realizing new quality productive forces.

In summary, the literature on the impact of the digital economy is relatively rich. These research results also provide valuable reference for us to explore the logical connection between digital economy and new qualitative productivity. However, the mechanism of the impact of digital economy on the development of new qualitative productivity is not unified, and empirical research is also less. Therefore, this paper hopes to build a relatively complete framework, taking the provincial panel data as the research object to determine how the digital economy drives the development of new quality productivity.

2. Research and Design

2.1. Research Assumptions

New quality productivity represents the continuous transition of human social productivity. Advanced productivity continues to replace backward productivity. Productivity has achieved breakthrough and breakthrough in both quantity and quality. New quality productivity is the development of traditional productivity, among which advanced technology plays a leading role. The digital economy led by the application of digital technology has formed a scientific and technological revolution sweeping all countries in the world. The scientific and technological revolution, with digital technology innovation as its core, has profoundly affected social production and way of life and promoted a great leap in productivity.

Based on the above analysis, it is assumed that H1.

H1: the development of digital economy has a positive impact on the improvement of new quality productivity.

The emergence of digital economy has brought new factors of production, both digital technology and digital factors. Based on the digital technology-economy paradigm, the data factor breaks the inherent geographical distance constraint with its low circulation cost and high efficiency, and promotes the spatial flow of social resources and production factors, which means that the digital economy shows strong regional differences in the role of new qualitative productivity. According to the characteristics of China's vast territory, the geographical environment, resource endowments, capital stock and economic policies of different regions are quite different. Therefore, many scholars have analyzed the heterogeneity of digital economy on the development of productivity from different perspectives such as time, space and city scale [5]. This paper will analyze the regional heterogeneity from three major regions, namely, the eastern region, the central region and the western region.

Based on the above analysis, it is assumed that H2.

H2: the impact of digital economy on new quality productivity has regional heterogeneity.

The impetus of digital economy to new quality productivity is based on different dimensions:

The digital economy improves the level of new quality productivity through upgrading the industrial structure. On the one hand, the digital economy enables traditional

industries and provides digital and intelligent optimization strategies. On the other hand, it also breeds and accelerates the formation and growth of emerging industries. At the same time, digital technology breaks the boundaries of traditional industries, accelerates industrial integration, and promotes digital transformation and upgrading, such as smart medical care, online education, digital entertainment, etc. [7].

Based on the above analysis, it is assumed that H3A.

H3A: the digital economy will improve the level of new quality productivity through the upgrading of industrial structure.

Based on the above analysis, it is assumed that H3B.

H3B: the digital economy will improve the level of new quality productivity through factor optimization.

Based on the above analysis, it is assumed that H3C.

H3C: Digital Economy will improve the level of new quality productivity through technological innovation.

2.2. Description of Data and Variables

Considering the availability and comparability of variable index data, our research sample includes panel data of 30 provinces (autonomous regions and municipalities) in China from 2010 to 2022, excluding Hong Kong, Macao, Taiwan and Tibet. The data are from the National Bureau of Statistics Statistical Yearbook of China, Environmental Statistics Yearbook of China and EPS database, and some missing data are supplemented by linear interpolation. In addition, considering the need of empirical analysis, to prevent the estimation deviation caused by the heteroscedasticity problem, the natural logarithm value is adopted for all. The dependent variable is new qualitative productivity and the core independent variable is digital economy. Among the remaining control variables, there is a positive correlation between the development level of technology market, financial support, transportation infrastructure, openness, labor level and new quality productivity. The definition and description of the variables are shown in Table 1.

Table 1. Description of Variable Definition

Variable name	variable name	Variable symbol	variable declaration
dependent variable	new—quality productive forces	NPF	Constructed by entropy method
Core argument	digital economy	Digital	Constructed by entropy method
independent variable	upgrading of an industrial structure	Ind	Ratio of tertiary industry to secondary industry
	Optimization of production factors	MIS	Resource mismatch
	Innovation level	inn	Number of invention patents
Control variable	Development level of technology market	Technical	Technology market turnover/GDP
	Financial support	Gov	General Budget Expenditure/GDP
	Transportation infrastructure level	transport	The number of road miles is logarithmic and the total freight volume is logarithmic.
	Degree of openness	OPEN	(Total imports and exports of goods *US$ to RMB exchange rate)/GDP
	Labour force level	labor	Natural logarithm for employed persons

2.2.1. Dependent Variable: New Quality Productivity

As for the measurement of new quality productivity, considering that the volatility and unidimension of the measurement obviously cannot meet the research demand, it is necessary to conduct comprehensive measurement through a multi-dimensional index system. Starting from the connotation of new quality production, and based on the principle of accessibility and the scientificity of indicators, this paper uses Lu Jiang and others for reference to construct from three aspects of scientific and technological productivity, green productivity and innovative productivity. Based on the improved entropy weight method, a new qualitative productivity evaluation index system is constructed. The dimension of science and technology productivity is based on innovation and technology productivity. Green productivity is considered from the aspects of resource-saving and environment-friendly productivity; Digital productivity is considered from two aspects: digital industry productivity and industrial digital productivity. The advantage of this method is that the entropy value is used to determine the index weight, which is helpful to overcome the randomness of subjective assignment and solve the problem of information overlapping among multiple index variables.

2.2.2. Core Independent Variable: Digital Economy

In the aspect of measuring the level of digital economy, this paper draws lessons from Wang Jun, etc. [10]. Based on the research, the digital economy is divided into four dimensions: digital infrastructure, digital industrialization, industry digitalization and digital innovation capability. For the digital infrastructure part and the industry digitalization part, learn from Liu Jun [11] Such as the practice of using the Internet penetration, mobile phone penetration and information transmission breadth evaluation of the former, using the enterprise digital development degree and digital inclusive finance to measure the latter. Among them, digital inclusive finance borrowed from Guo Feng, etc. [12]. The digital financial inclusion index. The digital industrialization draws lessons from Yang Huimei etc. Zhao Tao, etc. [13], through the software and information technology service industry, electronic information manufacturing industry development level and the level of development of the post and telecommunications industry; Digital innovation ability is evaluated by research and experiment development level and technological innovation ability. Through the method of principal component analysis, the data of the above four indicators are standardized and processed for dimension reduction, and finally the comprehensive development index

of digital economy is obtained.

Table 2. Index System of Digital Economic Evaluation

Level 1 indicators	Secondary indicators	Indicator description
Digital infrastructure	Internet penetration	Number of internet broadband access ports
		Number of Internet Broadband Access Users
		Number of internet domain names
	The popularity of mobile phones	Mobile phone base station density
		Mobile phone penetration rate
	Information transmission breadth	Long-distance optical cable length per unit area
Digital industrialization	Software and information technology services	Software revenue as a percentage of GDP
		Number of employees in information transmission, software and information technology services
	Development level of electronic information manufacturing industry	Information technology services revenue as a proportion of GDP
		Share of total telecom business in GDP
		Total telecom business per capita
	The development level of the post and telecommunications industry	Total postal services per capita
		Express delivery volume
		Business e-commerce transactions
Industry digitalization	The development degree of enterprise digitalization	Proportion of enterprises engaged in e-commerce transactions
		The number of computers used per 100 people in an enterprise
		Number of websites owned per 100 enterprises
	digital financial inclusion	Digital inclusive finance Index
Digital innovation capability	Research and experimental development level	R&D personnel equivalent to FTE in industrial enterprises above designated size
		R&D expenditure of industrial enterprises above designated size
		Number of R&D projects (projects) of industrial enterprises above designated size
	Technological innovation capability	Total technical contract transactions
		Number of patents granted

2.2.3. Other Independent Variables

Upgrade of industrial structure: expressed by the ratio of tertiary industry to secondary industry. The development experience of advanced industrialized countries shows that the transformation and upgrading of industrial structure is crucial to ensure that the economy continues to move to a higher level [14][15]. Factor optimization: with the acceleration of digitalization transformation of production activities, digitalization has penetration effect, substitution effect and synergy effect on the allocation efficiency of factors. Learn from Wang Hongming [16], others' approach is measured by constructing a research and development capital mismatch index and a research and development personnel mismatch index. Technological innovation: measured by the number of invention patents. The level of innovation often uses patent-related data to measure technological innovation. Patents include invention patents, utility model patents and design patents, among which invention patents are more likely to highlight the novelty of technological innovation [17].

2.2.4. Control Variables

The control variables in this paper include the level of technological market development, financial support, transportation infrastructure, openness and labor force. The Technical level of development in the technology market is expressed as the ratio of turnover in the technology market to GDP. With the continuous improvement and maturity of the technology market, scientific and technological achievements can be more efficiently converted into real productivity, which provides a powerful support for the formation and development of new quality productivity. Financial support intensity (Gov) is expressed as the ratio of general budget expenditure to GDP. Financial support will be provided to adjust policies and optimize the environment for scientific and technological innovation. Enterprises will be encouraged to increase their investment in research and development and improve their ability of independent innovation, thus promoting the formation and development of new quality productive forces. Openness is expressed as the ratio of total import and export to local GDP. The level of transport infrastructure is expressed as the logarithm of road mileage and the logarithm of total freight volume. The improvement of transportation infrastructure is helpful to optimize the industrial layout and resource allocation and promote the coordinated development of regional economy. The labor level is expressed as the natural logarithm of the number of people employed.

2.3. Model Setup

First of all, we constructed the following regression model to analyze the impact of digital economy on the development of new quality productivity and to test the research assumptions. The form of the model is as follows:

$$NPF_{nt} = \beta_0 + \beta_1 Digital_{nt} + \beta_2 X_{nt} + C_n + \alpha_t + \varepsilon_{nt} \quad (1)$$

Where, $NPF_{nt}$is the level of new quality productivity in

province n in year t, $Digital_{nt}$ is the level of the digital economy in province n in year t. The regression coefficient $\beta_1$reflects the effect of the digital economy on new quality productivity, X_{nt} denotes a series of control variables, C_n is an individual fixed effect, α_t is a time fixed effect, and ε_{nt} represents a random error term.

As mentioned above, the upgrading of industrial structure, optimization of factors and improvement of innovation level all play a role of mechanism transmission in the impact of digital economy on the development of new quality productivity. Considering that there is still a dispute in the academic circle as to whether the three-step test in the mechanism test is applicable to the field of economics, follow Jiang's suggestion [18], build a mechanism test model as follows:

$$NPF_{nt} = \alpha_0 + \alpha_1 M_{nt} + \alpha_2 X_{nt} + C_n + \alpha_t + \varepsilon_{nt} \quad (2)$$

$$M_{nt} = \delta_0 + \delta_1 Digital_{nt} + \delta_2 X_{nt} + C_n + \alpha_t + \varepsilon_{nt} \quad (3)$$

Where, M denotes the mediating variables, including industrial structure upgrading, factor optimization and innovation level improvement. It is used to verify that the effect of M on Y should be direct and obvious, mainly testing the causal relationship of $Digital$ on the mediating variables. When both α_1 and δ_1 are significantly positive, it indicates that the transmission mechanism exists.

3. Empirical Analysis

3.1. Descriptive Statistics

3.1.1. Descriptive Statistics of New Quality Productivity

According to the construction of the new quality productivity indicator system in the previous article, the new quality productivity data of 31 provinces in China from 2010 to 2022 have been compiled (omitted due to space constraints).Judging from the average value of the new quality productivity in each region, the development level generally presents a step-by-step increasing trend from the western region to the eastern region, indicating that the development level of the new quality productivity in the eastern region is relatively high and the growth potential in the western region is relatively large, with obvious regional focus. The eastern region, with its good geographical endowment, economic foundation and opening to the outside world, has a good impetus to speed up the new productive forces. The traditional industries in the central region are also undergoing continuous transformation and upgrading, and their innovation capabilities are constantly improving, laying a solid foundation for the development of new quality productive forces. There is still much room for development in the northeast and western regions. Judging from the growth rate, China's provincial-level new quality productivity is generally showing a trend of high-speed growth, which indicates that China's endogenous power to cultivate new quality productivity is continuously increasing.

From a regional perspective, the Yangtze River Delta (Shanghai, Jiangsu, Zhejiang and Anhui) region has a good foundation for new quality productivity and has the advantage of coastal provinces to absorb resources. The government has provided a lot of policy support for the formation of new quality productivity, which plays a role in promoting the cultivation of new quality productivity. In the Pearl River Delta region, the information technology service industry is also relatively developed, and then relying on its coastal advantages and opening-up policies, as well as its strong talent and foreign capital absorption capacity, it continuously improves the level of new quality productivity. In the Beijing-Tianjin area, the information technology service industry in Beijing is developed with high income from information technology services. It has accelerated the layout of the new quality productivity industry chain, strengthened original and disruptive scientific and technological innovation, and continuously improved the toughness and safety level of the industry chain supply chain. Its new quality productivity has developed rapidly. Although Ningxia, Qinghai and Tibet have some problems and challenges such as low development quality and efficiency, weak innovation capability, weak market players and high development cost, they now have advantages such as significantly enhanced industrial strength, continuous emergence of new quality industries, accelerated improvement of innovation capability, coordinated promotion of green development and continuous release of development vitality.

3.1.2. Descriptive Statistics of Other Variables

The statistical analysis of the explained variables, explanatory variables and control variables is shown in Table 3. It can be seen that the maximum value of Digital Economic Development Level is 0.6 and the minimum value is 0.01, indicating that the development level of digital economy in various regions of our country is not balanced. The maximum value of Innovation Level (inn) is 12.40, and the minimum value is 5.7. It can be seen that the innovation level of each province is also quite different. In resource allocation (MIS), the efficiency of resource allocation is not balanced.

Table 3. Descriptive Statistics of Variables

Variable	Average value	S.D.	Min	median	Maxi
NPF	0.2044	0.182	0.03	0.15	0.88
Digital	0.1202	0.104	0.01	0.09	0.60
Ind	1.3843	0.751	0.61	1.22	5.28
MIS	0.3851	0.239	0.03	0.36	1.46
inn	9.7405	1.358	5.70	9.88	12.40
Technical	0.0188	0.031	0.00	0.01	0.19
transport	11.7144	0.852	9.44	11.99	12.91
labor	7.6005	0.768	5.55	7.66	8.86
Gov	0.2538	0.105	0.11	0.23	0.76
OPEN	0.2430	0.271	0.00	0.13	1.44

3.2. Benchmark Regression

The regression results of each province's digital economy to the development level of new quality productivity are shown in Table 4. Column (1) is the regression result of the development level of new quality productivity when no control variable is added, the regression coefficient is 0.201, which is significant at the level of 1%. Column (2) is the regression result of adding control variables on the basis of column (1), the regression coefficient is 0.148, which is still 1% significant level, indicating that digital economy can directly promote the development of new quality productivity and is an effective way to enhance the development of regional new quality productivity. Assuming H1 holds.

Column (2) Among the control variables, the level of technological market development, transportation infrastructure, financial support and new quality productivity are significant at least at the level of 10%, indicating that the level of technological market development and transportation infrastructure play a role in promoting the development of regional new quality productivity. The possible reason for the negative strength coefficient of financial support is that the funds from financial support are not allocated effectively and reasonably, resulting in inefficient use of resources, which will have a negative impact on the development of new quality productivity, which requires efficient allocation and use of resources. The level of labor force and the level of opening to the outside world fail to pass the significance test under the level of 10%, indicating that the increase in the number of labor force and the level of opening to the outside world at the present stage has little impact on the new quality productivity, which emphasizes high-quality talents and independent innovation.

In order to ensure the robustness of the results, the annual interval regression method is used for testing. Columns (3) and (4) limit the time to 2012 to 2016. The results show that the influence of digital economy on the development level of new quality productivity is significant at 1% level respectively, and the coefficient is positive, assuming H1 is still valid.

Table 4. Benchmark Regression Results

Variable name	(1)	(2)	(3)	(4)
	NPF	NPF	NPF	NPF
Digital	0.201***	0.148**	0.422***	0.347***
	(0.070)	(0.071)	(0.102)	(0.099)
Technical		0.337*		0.428
		(0.192)		(0.482)
transport		0.085***		0.161***
		(0.028)		(0.052)
labor		0.047		-0.053
		(0.030)		(0.052)
Gov		-0.110*		-0.064
		(0.059)		(0.056)
OPEN		0.028		0.042*
		(0.020)		(0.024)
constant term	0.266***	-0.906***	0.069	-1.175*
	(0.070)	(0.334)	(0.103)	(0.606)
Fixed provinces	YES	YES	YES	YES
Fixed year	YES	YES	YES	YES
Sample size	330	330	150	150

3.3. Robustness Test

(1) Replace the interpreted variable. Drawing lessons from Ren Yuxin and others, it is constructed from three aspects: laborers, labor materials and labor objects.[4], based on the entropy method to build a new quality productivity evaluation index system. The individual dimension of workers is based on theory, skills and efficiency. The labor object is considered from the aspects of new quality industry and ecological environment; Labor data are considered from tangible and intangible means of production. The indicators of new quality productivity are re-synthesized, and the explained variables are replaced and then regressed. The results are shown in Table 5, Column (1), which indicates that the digital economy still significantly promotes the formation of new quality productivity; (2) Replace explanatory variables. The entropy method is adopted for the explanatory variable digital economy, which is regressed after replacement. The results are shown in column (2) of Table 5, indicating that the benchmark regression results are robust; (3) Delete the sample. After deleting the 2012 and 2022 samples for regression, the results are shown in Table 5, Column (3), indicating that the digital economy still significantly promotes the formation of new quality productivity; (4) due to the reverse causality and missing variables, there may be some endogenous problems. L. Digital, the lagging phase 1 term of digital economy, is used as the tool variable for regression. The weak correlation test is performed on the tool variables. After the test, the F value is 3000.05, which is greater than 10, indicating that L. Digital has passed the weak tool test. On this basis, a two-stage least squares regression is performed. The specific results are shown in columns (4) and (5) of Table 5. The results of the robustness test in Table 5 support the conclusion that the digital economy can promote the formation of new qualitative productivity, i.e. Hypothesis 1 holds.

Table 5. Results of Robustness Test

Variable name	(1)	(2)	(3)	(4)	(5)
	NPF2	NPF	NPF	firstDigital	second
				Digital	NPF
Digital	0.148**		0.447***		0.4122***
	(0.062)		(0.097)		(4.64)
Technical	0.267	-0.030	-0.140	0.3359***	-0.2042
	(0.199)	(0.249)	(0.340)	(3.62)	(-0.85)
transport	0.105***	0.149***	0.172***	-0.0173	0.1568***
	(0.029)	(0.037)	(0.043)	(-1.22)	(4.46)
labor	0.024	0.042	-0.003	0.0310**	0.0036
	(0.032)	(0.040)	(0.049)	(1.98)	(0.09)
Gov	-0.135**	0.097	0.090	0.0430	0.0449
	(0.059)	(0.075)	(0.090)	(1.44)	(0.61)
OPEN	0.060***	-0.012	-0.099**	-0.0092	-0.0264
	(0.023)	(0.031)	(0.041)	(-0.78)	(-0.90)
Digital2		0.480***			
		(0.090)			
L.Digital				0.9226***	
				(27.59)	
constant term	-0.851**	-1.565***	-1.322***	-0.0539	-1.2610***
	(0.331)	(0.421)	(0.494)	(-0.34)	(-3.21)
Fixed provinces	YES	YES	YES	YES	YES
Fixed year	YES	YES	YES	YES	YES
Sample size	330	330	270	300	300

4. Heterogeneity Analysis and Mechanism Research

4.1. Heterogeneity Analysis

Due to the uneven distribution of infrastructure, production efficiency, technology gap and other factors, there are differences in the formation of new quality productive forces in different regions of our country. There may be spatial heterogeneity in the formation of new quality productive forces promoted by digital economy. Areas with better development level of digital economy are more conducive to the formation of new quality productive forces. In order to study how regional differences affect the formation of new quality productivity, according to the National Bureau of Statistics, this paper divides the provinces (autonomous regions and municipalities) where the regions are located into three groups: the east, the middle and the west. The results are shown in Table 6.

The regression coefficients of the influence of digital economy on the development level of new quality productive forces are 0.414, 1.399 and 0.232 respectively. The digital economic coefficients are all positive, but there are obvious differences. Both the eastern region and the central region passed the significance test at the level of 1%, while the positive effect in the western region was not significant. It shows that the driving effect of digital economy on the development of new quality productivity is geographically different, assuming H2 holds water.

Compared with the central and western regions, the digital economy in the eastern region plays a more obvious role in promoting the development of new quality productive forces. Possible reasons are: the eastern region has a good economic foundation and resource endowments, abundant human resources, and more financial expenditures, which can provide a more perfect support for the development of digital economy, and thus has a significant positive effect on the formation of new quality productive forces. The digital economy in the western region does not play an obvious role in promoting the development of new quality productive forces. Possible reasons are: the western region has a large area, the development of digital economy is relatively late, the construction of digital infrastructure is not perfect, the level of digital industrialization, industry digitalization and digital governance is low, and the effect on the formation of new quality productive forces is not obvious. Therefore, the regression coefficient is not significant. This is also the same as the research results of some scholars [19]. The development of digital economy in the eastern and central regions has a significant positive effect on the formation of new quality productive forces, which can provide some reference for the western region. The western region should strengthen its efforts to develop digital economy, continuously improve economic quality and promote the formation of new quality productive forces.

Table 6. Regression Analysis of Regional Heterogeneity

Variable name	(1)	(2)	(3)
	eastern region	middle	the west
Digital	0.414***	1.399***	0.232
	(0.090)	(0.447)	(0.209)
constant term	-0.323	0.000	0.000
	(0.596)	(.)	(.)
Contorls	YES	YES	YES
Fixed provinces	YES	YES	YES
Fixed year	YES	YES	YES
Sample size	132	99	99

4.2. Mechanism Study

Taking the upgrading of industrial structure, optimization of factors and improvement of innovation level as explanatory variables, the regression is performed again, and the results are shown in Table 7. On the whole, the digital economy can promote the formation of new quality productivity through the upgrading of digital industry structure, optimization of factors and improvement of innovation level.

Specifically, in column (1) and column (2) of table 7, the

regression coefficient of industrial structure upgrading is significantly positive at the level of 5%, indicating that industrial structure upgrading has a direct and obvious relationship with the development of new quality productivity, which can be tested subsequently. As can be seen from column (2), the impact coefficient of digital economy on industrial structure upgrading is 0.938, which is significantly positive at 1%. Based on the above regression results, it can be concluded that the upgrading of industrial structure is an intermediate variable for the digital economy to promote the development of new quality productivity, assuming that H3A is verified. The digital technology enables the development of the industry, which can improve the total factor productivity in the upstream and downstream of the industrial chain, accelerate the transformation and upgrading of the industry digitalization, promote the transformation of the industrial structure, spawn new industries, new models and new formats, and lead to qualitative changes in the traditional productivity.

In column (3) and column (4) of table 7, the regression coefficient of element allocation is significantly positive at the level of 1%, which can be subsequently tested. As can be seen from column (4), the coefficient of influence of digital economy on factor allocation is 0.525, which is significantly positive at 1%. Based on the above regression results, it can be determined that the allocation of production factors is an intermediate variable for the digital economy to promote the development of new quality productivity, assuming that H3B is verified. The digital economy can attract data, capital and labor through the depression effect, realize reasonable distribution through the function of industrial competition mechanism and policy guidance mechanism, and promote the rational allocation of production factors. The rational allocation of factors of production can promote the transformation of traditional productive forces, drive the improvement of total factor productivity through the transformation of power, efficiency and quality, and further boost the emergence of new qualitative productive forces.

In column (5) and column (6), the regression coefficient of innovation level is significantly positive at the level of 5%, which can be subsequently tested. As can be seen from column (6), the impact coefficient of digital economy on innovation level is 2.394, which is significantly positive at 1%. That is, the improvement of innovation level is the intermediary variable of digital economy to promote the development of new quality productivity, assuming H3C is verified. With the continuous improvement of innovation level, significant breakthroughs have been made in core technologies in the field of digital economy, such as big data, cloud computing and artificial intelligence. These technological advances have not only improved the ability of data processing and analysis, but also provided strong technological support for various application scenarios of the digital economy, and promoted the development of the digital economy in the direction of higher-level and higher-quality new productivity.

Table 7. Research on the Mechanism of Digital Economy Promoting New Quality Productivity

	(1)	(2)	(3)	(4)	(5)	(6)
	NPF	Ind	NPF	MIS	NPF	inn
Ind	0.041**					
	(0.289)					
MIS			0.620***			
inn					0.013**	
					(0.006)	
Digital		0.938***		0.525***		2.394***
		(0.289)		(0.105)		(0.467)
constant term	1.389***	0.224	-1.257***	0.311	-1.257***	-10.606***
	(0.435)	(1.533)	(0.385)	(1.912)	(0.385)	(3.490)
Contorls	YES	YES	YES	YES	YES	YES
Fixed provinces	YES	YES	YES	YES	YES	YES
Fixed year	YES	YES	YES	YES	YES	YES
Sample size	330.000	330.000	330.000	330.000	330.000	330.000

5. Conclusions and Suggestions

5.1. Conclusions

Based on the panel data of 30 provinces (autonomous regions and municipalities) in China from 2010 to 2022, this paper constructs a comprehensive evaluation index system of new quality productivity from the three dimensions of "scientific and technological productivity, green is productivity and innovative productivity", and constructs a two-way fixed effect model to empirically test the interactive relationship between digital economy and the development level of new quality productivity. The results show that the digital economy has a positive impact on the development of new quality productivity, and the upgrading of industrial structure, optimization of factors and improvement of innovation level have some intermediary effects on the promotion of new quality productivity. The results of regional heterogeneity analysis show that the digital economy in the eastern and central regions plays a role in promoting the development of new quality productivity, but the promotion effect in the western region is not significant.

5.2. Suggestions

First of all, based on reality, the digital economy can promote the improvement of balanced and full development. The government can actively expand its investment in the information industry, speed up the construction of new digital infrastructure, such as 5G base stations, artificial intelligence and industrial Internet, promote the development of the digital industry, consolidate the integration of the digital economy in the industry, and enable the digital economy to further become an effective way to promote balanced and full development. Secondly, considering that the digital economy has a better effect in the western region, the government can implement dynamic and differentiated strategies to match its local resource advantages. It is appropriate to form a reasonable development system for the digital economy itself,

which can further ease the imbalance and inadequacy of regional development. Third, based on the fact that the digital economy has spatial spillover effect, the government can use digital technology to build a regional coordinated development network, promote digital industrialization and industrial digitalization, and realize cross-regional division of labor and cooperation, so as to improve the unbalanced and insufficient development within and between regions

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