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Research on the coupling and coordination relationship between digital economy and economic growth efficiency and regional differences

Xiao Sun *, Sini Hu, Qiuya Liu

Anhui University of Finance and Economics, Bengbu, Anhui 10378, China

*Corresponding Author

Abstract

At present, China's economy is in the stage of shifting from high-speed growth to high-quality development, and the development of the digital economy is a lasting driving force for improving the efficiency of economic growth. This project conducts the coupling and coordination relationship between the digital economy and economic growth efficiency and the correlation between regional difference research, measures the panel data of 30 provinces and cities in China from 2011 to 2019, and analyzes the measurement results from the perspectives of time series and regional differences. This paper studies the coupling and coordination effects of digital economy and economic growth efficiency. Based on this, this project puts forward policy recommendations to accelerate the coordinated development of digital economy and economic growth efficiency in various provinces and cities in China, reduce coordination differences, and promote the development of scientific and technological innovation, so as to achieve rapid social transformation and structural upgrading.

Keywords

Digital economy , coupling degree, economic growth efficiency.

1. Introduction

Currently, the Chinese economy is transitioning from high-speed growth to high-quality development, and the development of the digital economy is a lasting driving force for improving economic growth efficiency. This project measures the panel data of 30 provinces and cities in China from 2011 to 2019 and analyzes the results from the perspectives of time series and regional differences. Through the construction of a comprehensive index for analyzing the digital economy, the efficiency of economic growth, and the degree of coordination between the two, this project evaluates the regional differences in the coordination of the digital economy and economic growth efficiency, and studies the impact of the coordination between the digital economy and economic growth efficiency. Based on this, feasible and innovative suggestions are proposed for promoting the development of the digital economy, improving economic growth efficiency, and achieving coordinated development between the two.

Since the 18th National Congress of the Communist Party of China, China has attached great importance to the development of the digital economy and has gradually elevated it to a national strategy to expand the new space for economic development. In the report of the 19th National Congress of the Communist Party of China, it was proposed to promote the deep integration of the Internet, big data, artificial intelligence, and the real economy, and build a digital China and a smart society. The weight of the digital economy in China's national economy has gradually increased and has become a core component of the economic system. How does the development of the digital economy affect the efficiency of economic growth? Will this

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impact vary in different regions? Domestic and foreign scholars have proposed that the rapid development of the digital economy can further improve economic growth efficiency (Jing Wenjun, Sun Baowen, 2019; Li Xiaohua, 2019). Honohan pointed out that the digital economy promotes national economic growth, and Basu and Fernald pointed out that the digital economy can improve the efficiency of economic market operation. The digital economy can become a new driving force to promote high-quality economic development in China (Zhang Teng, Jiang Fu, 2021).

In terms of regional economic growth, domestic and foreign scholars have conducted extensive research and discussions on economic growth and regional disparities (Romer P, Lucas R E). Li Le and Zhou Lin Yi (2018) studied the significant role of the development of the digital economy in promoting regional economic growth and improving production efficiency. Yu Zhiqian and Zhu Ning (2021) pointed out that overall efficiency, the improvement of economic growth efficiency in underdeveloped areas is more prominent. In terms of enterprise productivity growth, Du Chuanzhong, Zhang Yuan (2021) analyzed that the digital economy can indirectly promote enterprise productivity growth. The above conclusions provide theoretical support for the digital economy to improve economic growth efficiency and also have certain enlightening significance for how to develop the digital economy to achieve high-quality economic development. Regarding the efficiency of economic growth as one of the main reasons for regional economic differences (Song Changqing, Li Zilun, 2013), this project selected the examples of the Yangtze River Delta region (Wang Yong, Du Pengfei, 2020) and Sichuan Province (Zhang Weidong, Ding Junchao, 2014) to examine whether the improvement of economic growth efficiency will narrow regional disparities and promote the development of the digital economy. Overall, the improvement of economic growth efficiency is achieved through the integration of regional elements, structural upgrades, and strengthened regional cooperation (Li Xuesong, Zhang Yudi, et al., 2017). In terms of regional research, the SBM-Undesirable model (Yuan Qingmin, Qiu Jing, 2015), DEA-BCC model (Zhang Weidong, Zhao Shihong, 2015), logarithmic Cobb-Douglas production frontier model (Li Yuxin, Zheng Liang, 2019), and others are used to select different panel data to study the promotion of the digital economy by improving economic growth efficiency. Most scholars' research focuses on the measurement of China's digital economy index system, the quality of digital economy development, and its influencing factors, etc., neglecting the research on the coupling and coordination relationship between the digital economy and economic growth, as well as the regional differences. Duan Xiufang, Xu Chuanang (2021) analyzed the overall and provincial levels of the coordination and coordination level between the above-mentioned digital economy development and economic growth efficiency in China; Li Xiaolong, Ran Guanghe (2021) used a two-way fixed model and a mediating effect model to empirically test the influence between the two systems; Wei Zhenxiang, Shi Xiangguo (2021) combined the degree of coordination and the PVAR model to analyze the coupling and interaction development between the two systems; Bai Xuejie, Song Pei, et al. (2021) used panel data from Chinese provinces to explain the specific impact of digital economic growth from the perspective of efficiency-type technological progress; Qin Kefeng, et al. (2021) explored the impact mechanism of the digital economy on economic growth from the perspective of regional innovation. These studies have certain practical significance for promoting the coordinated development of the digital economy and economic growth and narrowing regional disparities. However, there are still some shortcomings, such as the lack of comprehensive evaluation of the coordination level between the two systems and the regional differences, and the lack of targeted suggestions for promoting the coordinated development of the digital economy and economic growth in specific regions.

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2. The theoretical analysis and framework construction of the coupling and coordination relationship between the two are discussed in the overall system

The theoretical analysis and framework construction of the coupling and coordination relationship between the two are comprehensively discussed. By reviewing the relevant literature by domestic and foreign scholars on the digital economy and economic growth efficiency, it can be found that the existing literature has conducted extensive research on the digital economy's promotion of economic growth and realization of high-quality economic development. However, there is a relative lack of research on the coupling and coordination development between the digital economy and economic growth efficiency. As a major factor in improving economic growth efficiency, the digital economy inevitably has a mutually reinforcing and coordinating relationship with economic growth. On the one hand, the rapid development of the digital economy can further improve economic growth efficiency. On the other hand, the improvement of economic growth efficiency can reduce regional economic disparities, thereby promoting the development of the digital economy (Zhang Weidong, Ding Junchao, 2014). In response to the problem that traditional coupling coordination models are not standardized enough, Wang Shujia, Kong Wei, et al. (2021) have further proposed a modified model for coupling degree. This project analyzes the coupling and coordination relationship between the digital economy and economic growth efficiency, and analyzes the regional differences and spatiotemporal correlation evolution of the coupling and coordination between the two. It constructs the framework for this project and lays the theoretical foundation for subsequent construction and measurement of the indicator system.

Indicator System:The indicator system of this project mainly includes the comprehensive index of the digital economy, the comprehensive index of economic growth efficiency, the coupling and coordination index between the digital economy and economic growth efficiency, and the regional disparity index. By constructing these indicators, it is possible to comprehensively evaluate the level of development of the digital economy, economic growth efficiency, and the coordination relationship between the two, as well as their regional differences, and provide detailed data support for research.

Constructing a scientific and feasible indicator system is an important part of studying the coupling and coordination development relationship between the digital economy and economic growth efficiency. Based on a comprehensive analysis of the digital economy and economic growth efficiency, this paper adheres to principles of scientific and objectivity and constructs an indicator system from all aspects.

The digital economy indicator system: With the rapid development of the digital economy, domestic and foreign scholars have measured it from multiple dimensions. Observing the development process of the digital economy, infrastructure provides the basic conditions for development, industrial development is the objective carrier of the digital economy, the innovation environment is a key factor in the upgrading and development of the digital economy, and digital inclusive finance can be seen as a modern innovation of inclusive finance and is a social application of the digital economy. In addition to referring to existing research on digital economy evaluation indicators, this paper selects digital infrastructure, digital industrial development, digital innovation environment, and digital inclusive finance as the four primary indicators for studying the development of the digital economy, as well as 16 corresponding secondary indicators.

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耦合子系统	一级指标	二级指标	单位	指标属性
数字经济	数字基础设施	移动电话普及率	每百人部数	正向
		每平方千米长途光缆线路长度	公里	正向
		每万人互联网宽带接口数	个	正向
		每万人拥有互联网域名数	个	正向
	数字产业发展	软件业务收入	亿元	正向
		电信业务总量	亿元	正向
		信息服务业产值	亿元	正向
		信息传输、计算机服务和软件业从业人员数	万人	正向
	数字创新环境	地方财政科技支出	亿元	正向
		规模以上工业企业 R&D 人员	万人	正向
		规模以上工业企业 R&D 经费支出	亿元	正向
		专利申请数	个	正向
		专利申请授权数	个	正向
	数字普惠金融	数字普惠金融覆盖广度	指数	正向
		数字普惠金融使用深度	指数	正向
		数字普惠金融数字化程度	指数	正向

3. Results Analysis

3.1. Analysis of Coupling Coordination Degree between Digital Economy and Economic Growth Efficiency

The data value of coupling coordination degree ranges from 0 to 1, with a higher value indicating a greater overall interdependence and mutual restraint between the digital economy and economic growth. Based on the above, this project uses the coupling coordination degree model to calculate the coupling coordination degree between the digital economy and economic growth efficiency of various provinces from 2011 to 2019. It is divided into four intervals: low coordination (0-0.3), moderate coordination (0.3-0.5), high coordination (0.5-0.8), and extreme coordination (0.8-1). Regional analysis is conducted for the eastern region, central region, and western region of China.

Table 1 Coupling Coordination Degree between Digital Economy and Economic Growth Rate of Provinces from 2011 to 2019

地区		2011	2012	2013	2014	2015	2016	2017	2018	2019	年均增长率
东部地区	北京	0.5256	0.5777	0.5623	0.5555	0.6018	0.6764	0.7412	0.7805	0.7689	4.87%
	天津	0.3821	0.4278	0.4277	0.4228	0.4274	0.4826	0.5219	0.5466	0.5623	4.95%
	河北	0.3455	0.3744	0.3903	0.3407	0.3982	0.4193	0.4849	0.5107	0.5215	5.28%
	辽宁	0.4257	0.4371	0.4519	0.4330	0.4508	0.4919	0.5203	0.5525	0.5714	3.75%
	上海	0.5536	0.6004	0.6487	0.6332	0.6774	0.7259	0.7733	0.8081	0.8307	5.20%
	江苏	0.5632	0.6087	0.6124	0.6299	0.6492	0.6927	0.7571	0.8034	0.8035	4.54%
	浙江	0.4866	0.5678	0.5571	0.5239	0.5707	0.6270	0.7075	0.7368	0.7610	5.75%
	福建	0.4398	0.4770	0.4946	0.4886	0.5130	0.5696	0.6418	0.6777	0.6694	5.39%
	山东	0.4650	0.4765	0.4924	0.4958	0.5069	0.5597	0.6106	0.6364	0.6357	3.99%

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	广东	0.5776	0.6096	0.6067	0.6183	0.6372	0.7061	0.7474	0.8223	0.8356	4.72%
	海南	0.2883	0.3343	0.3464	0.3559	0.3810	0.3891	0.4466	0.4696	0.5045	7.25%
	均值	0.4593	0.4992	0.5082	0.4998	0.5285	0.5764	0.6321	0.6677	0.6786	5.00%
中部地区	山西	0.2863	0.3099	0.3170	0.3147	0.3272	0.3554	0.4129	0.4604	0.4415	5.56%
	吉林	0.2968	0.3220	0.3340	0.3077	0.3353	0.3783	0.4106	0.4447	0.4332	4.84%
	黑龙江	0.3245	0.3694	0.3783	0.3777	0.3859	0.4144	0.4583	0.4871	0.4954	5.43%
	安徽	0.3651	0.4069	0.4185	0.4156	0.4272	0.4770	0.5118	0.5578	0.5506	5.27%
	江西	0.2936	0.3511	0.3718	0.3647	0.4006	0.4283	0.4927	0.5149	0.5403	7.92%
	河南	0.3556	0.3859	0.3885	0.3730	0.3973	0.4497	0.5000	0.5227	0.5436	5.45%
	湖北	0.3857	0.4321	0.4557	0.4485	0.4732	0.5010	0.5574	0.5838	0.5975	5.62%
	湖南	0.3557	0.4010	0.4179	0.4041	0.4361	0.4618	0.5200	0.5389	0.5550	5.72%
	均值	0.3329	0.3723	0.3852	0.3758	0.3978	0.4332	0.4830	0.5138	0.5197	5.72%
西部地区	内蒙古	0.2717	0.3124	0.3407	0.3270	0.3328	0.3753	0.4420	0.4713	0.4765	7.27%
	广西	0.2580	0.3061	0.3141	0.3107	0.3212	0.3563	0.4299	0.4430	0.4666	7.69%
	重庆	0.3512	0.3877	0.4028	0.4195	0.4383	0.4788	0.5246	0.5431	0.5648	6.12%
	四川	0.3867	0.4289	0.4456	0.4335	0.4792	0.5027	0.5612	0.5987	0.6062	5.78%
	贵州	0.2530	0.3044	0.3152	0.3178	0.3264	0.3786	0.4278	0.4296	0.4631	7.85%
	云南	0.2783	0.3144	0.3447	0.3271	0.3292	0.3818	0.4260	0.4399	0.4353	5.75%
	陕西	0.3366	0.3651	0.3724	0.3606	0.4025	0.4179	0.4926	0.5177	0.5290	5.81%
	甘肃	0.2206	0.2903	0.3156	0.3138	0.3108	0.3517	0.3984	0.4426	0.4547	9.46%
	青海	0.1974	0.2572	0.2659	0.2598	0.2644	0.3366	0.3711	0.4023	0.3761	8.39%
	宁夏	0.2258	0.2825	0.2665	0.2804	0.2508	0.3146	0.3798	0.4084	0.4030	7.51%
	新疆	0.2724	0.3230	0.3417	0.3303	0.3510	0.3864	0.4143	0.4494	0.4471	6.39%
	均值	0.2774	0.3247	0.3387	0.3346	0.3461	0.3892	0.4425	0.4678	0.4748	6.95%
全国	均值	0.3589	0.4014	0.4133	0.4061	0.4268	0.4696	0.5228	0.5534	0.5615	5.75%

The eastern region includes 11 provinces such as Beijing and Tianjin. By analyzing the data in Table 1 over the years, it can be observed that the data is increasing year by year. Provinces with coupling coordination degrees fluctuating around 0.5 in 2011 have increased to fluctuate around 0.7 in 2019. Even provinces with initially small coupling coordination degrees (such as Fujian and Hainan) have increased by more than 0.5. In terms of average annual growth rates, the lowest is Liaoning Province at 3.75%, and the highest is Hainan Province at 7.25%. The rapid development of Hainan Province's tourism industry and other factors contributed to its rapid development of the digital economy and improved economic growth efficiency, leading to a faster growth in their coupling coordination degree. On the other hand, Liaoning Province, as one of the old industrial bases in Northeast China, relied too much on heavy industries in its early development, resulting in a lack of further foundation for the development of the digital economy and slow growth in economic growth efficiency, leading to a slow growth in their coupling coordination degree. From a longitudinal perspective, although the data sizes of provinces in the same year are different, their annual means are increasing, growing from an initial value of 0.4593 to 0.6786, with an average growth rate of 5.00%.

The central region includes eight provinces such as Shanxi and Jilin. The coupling coordination degree of each province in the central region steadily increases each year, with an average

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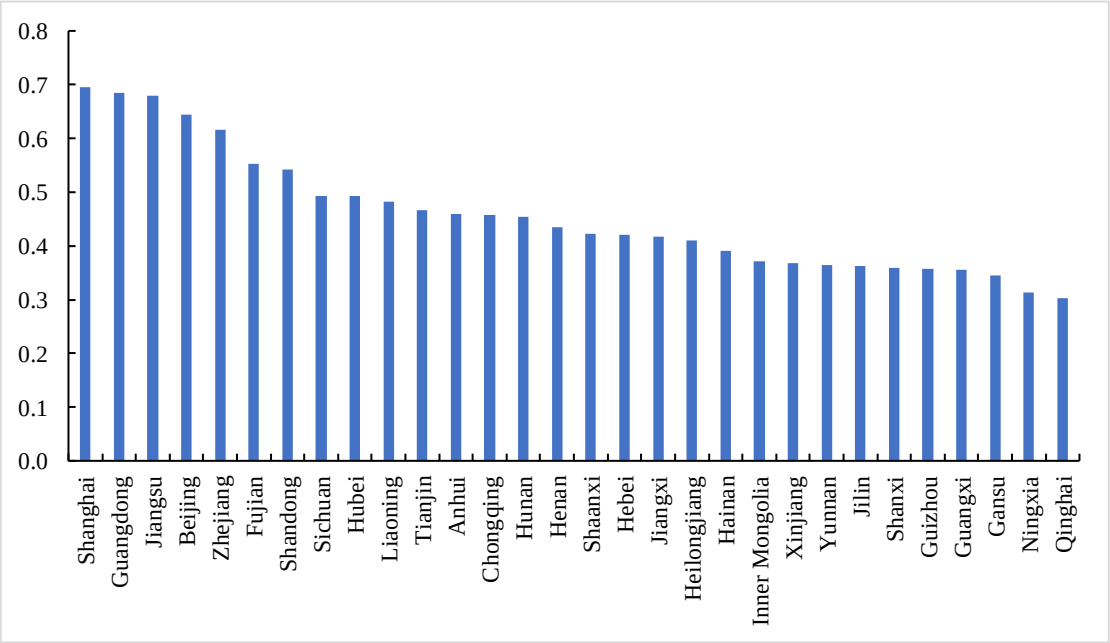
annual growth rate of 5.72%. Although the average annual growth rate in the central region is higher than that in the eastern region, the coupling coordination degree is relatively small. The data for each province fluctuated around 0.3 in 2011 and increased to fluctuate around 0.5 in 2019, which is equivalent to the coupling coordination degree of the eastern region in 2011. The western region includes 11 provinces such as Inner Mongolia and Guangxi. It has the highest average annual growth rate among the three regions, reaching 6.95%, but the coupling coordination degree is the smallest. The mean coupling coordination degree of each province in 2011 is 0.2774, and it increased to a mean value of 0.4748 in 2019, showing a stable growth trend. From the perspective of the growth rate of coupling coordination degree, the central and western regions have surpassed the eastern region. This is related to the limited space for growth in the eastern region in recent years and the strong support from the Chinese government for the development of the digital economy in the central and western regions.

The total national average annual value of all provinces grows at a rate of 5.75%, increasing from 0.3589 to 0.5615. The coupling coordination degree of each province increases year by year, indicating that the development of the digital economy is becoming more widespread and has gradually become an important pillar of economic growth, further promoting the improvement of economic growth efficiency. In some economically developed provinces and cities (such as Shanghai and Guangdong), the coupling coordination degree between the digital economy and economic growth efficiency is above 0.8, reaching the extreme coordination stage. This reflects the mutual promotion of the two at a high level, where the development of the digital economy promotes economic growth, and economic growth drives the development of the digital economy. Nationwide, the digital economy is gradually sweeping across various industries, ushering in new economic forms.



Graph 1 Ranking of the Mean Coupling Coordination Degree between Digital Economy and Economic Growth Efficiency of Provinces from 2011 to 2019

Using the coupling degree model, the average coupling coordination degree between the digital economy and economic growth efficiency of 30 provinces from 2011 to 2019 is calculated, and they are ranked in descending order (as shown in Graph 1). From the ranking of the mean values, Shanghai has the highest coupling coordination degree, followed by Guangdong, Jiangsu, Beijing, and Zhejiang. Provinces with lower rankings include Gansu, Ningxia, and Qinghai. This reflects the significant difference in the coupling coordination degree between the digital economy and economic growth efficiency between the eastern region and the central and

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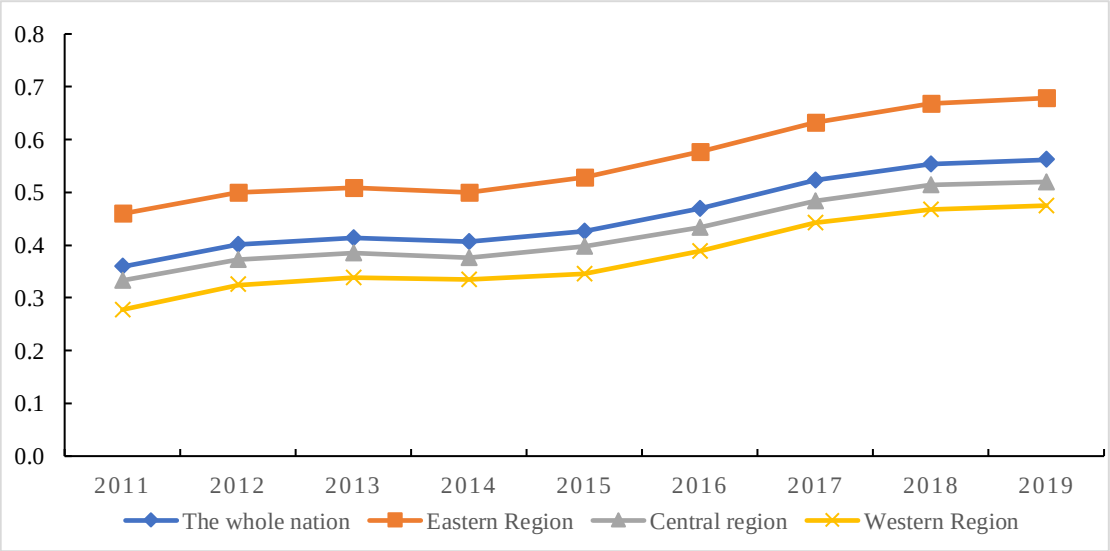
western regions of China. Provinces with higher mean rankings are mainly located in the eastern region, while provinces with lower rankings are concentrated in the western region.



Graph 2 Temporal Variation of Coupling Coordination Degree between Digital Economy and Economic Growth Efficiency in China and Various Regions from 2011 to 2019

3.1.1. The coupling coordination degree in China shows a gradual growth trend.

As shown in Graph 2, from 2011 to 2019, the coupling coordination degree between the digital economy and economic growth efficiency in China shows a gradual growth trend. From 2011 to 2012, there is a slight increase, indicating a slight increase in the level of coordinated development between the digital economy and economic growth efficiency during this period. From 2012 to 2014, it remains almost unchanged, without any significant turning points, indicating that the level of coordinated development between the digital economy and economic growth efficiency in China remains almost unchanged. From 2014 to 2019, there is a growth trend, indicating a further increase in the level of coordinated development between the digital economy and economic growth efficiency in China. Overall, the coupling coordination degree between the digital economy and economic growth efficiency in China is relatively low, ranging from 0.3 to 0.7, and the type of coupling coordination degree has transitioned from low coordination to moderate coordination. This indicates that with the transformation of economic and social development, the overall interdependence and mutual restraint between the digital economy and economic growth efficiency in China have become stronger, but there is still room for improvement.

3.1.2. Similar and comparable changes in coupling coordination degree between the digital economy and economic growth efficiency in the three major regions

Considering the changing characteristics of the coupling coordination degree, the development of coupling coordination between the digital economy and economic growth efficiency in China can be divided into three regions: the eastern region, the central region, and the western region. From a regional perspective, the changing trend of the coupling coordination degree between the digital economy and economic growth efficiency in the three major regions is generally consistent with the overall trend in China. Among the three regions, the coupling coordination degree between the digital economy and economic growth efficiency in the eastern region has transitioned from moderate coordination to high coordination, while the central region and the western region have similar but lower levels of coupling coordination degree compared to the eastern region, and their coupling coordination degree has transitioned from low coordination to moderate coordination. This indicates that the overall interdependence and mutual restraint

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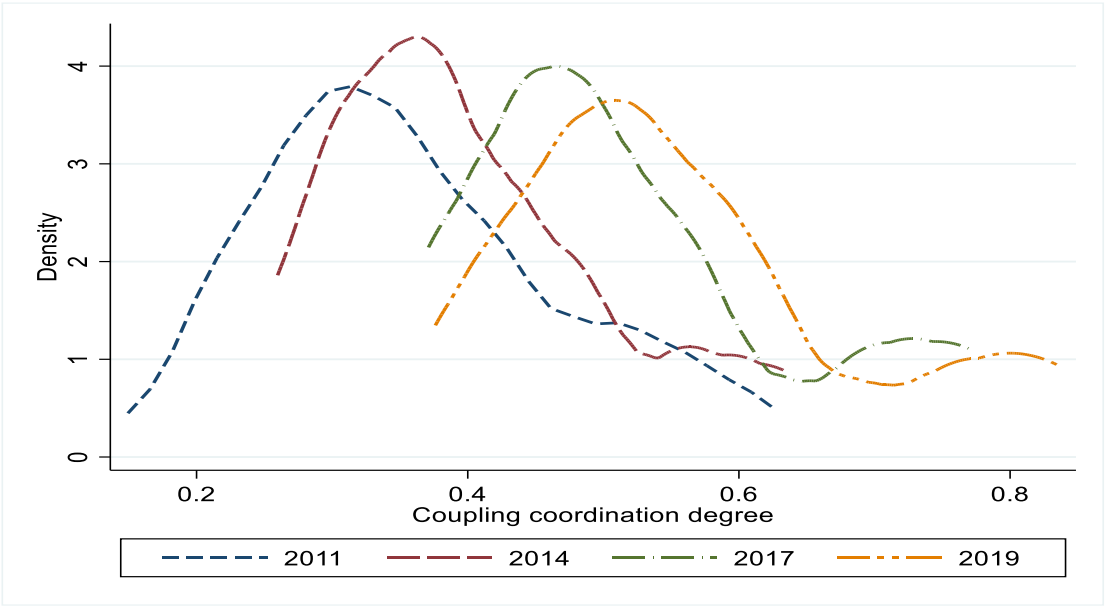
between the digital economy and economic growth efficiency in the eastern region are higher, while the level is lower in the central and western regions.

Based on the above analysis, it can be concluded that the higher coupling coordination degree in the eastern region is due to the fact that most provinces in this region have reached a higher level of development in the digital economy, and the overall level of economic growth efficiency is higher. The interdependence and mutual restraint between the two are higher, and they have achieved a stage of moderate coordination or above. The central region has a higher coupling coordination degree compared to the western region, which may be due to the radiation-driven effect of the eastern region on the central region, leading to higher levels of digital economy development and economic growth efficiency. The western region has always been in a stage of low coordination, which may be due to its weak economic foundation, poor location conditions, lower levels of digital economy development and economic growth efficiency, leading to a lower coupling coordination degree.



Graph 3 Kernel density estimation of coupling coordination degree between digital economy and economic growth efficiency

To further analyze the overall characteristics of the coupling coordination degree between the digital economy and economic growth efficiency in 30 provinces in China from 2011 to 2019, this project uses kernel density estimation to depict the overall form of the coupling coordination degree in 2011, 2014, 2017, and 2019 (Graph 3).

As the years go by, the peak of the kernel density graph shifts to the right, indicating an improvement in the level of coordinated development between the digital economy and economic growth efficiency in the whole country and in the eastern, central, and western regions. Regardless of the year, the coupling coordination degree between the digital economy and economic growth efficiency presents a skewed distribution with a right tail, and the graph is basically unimodal, reflecting the differences in the coupling coordination degree between the digital economy and economic growth efficiency among cities.

Compared with 2011, the unimodal in 2014 and 2017 is higher and more skewed to the right, and the kurtosis of the unimodal is steeper, reflecting the overall improvement in the level of coordinated development between the two in 2017, and the more obvious changes in kurtosis indicate a widening gap in coordinated development. As the years go by, the area from the left to the middle of the graph decreases year by year, while the area from the right increases year by year, indicating a faster speed of coordinated development between the digital economy and economic growth efficiency. In addition to the unimodal around 0.45, the kernel density graph

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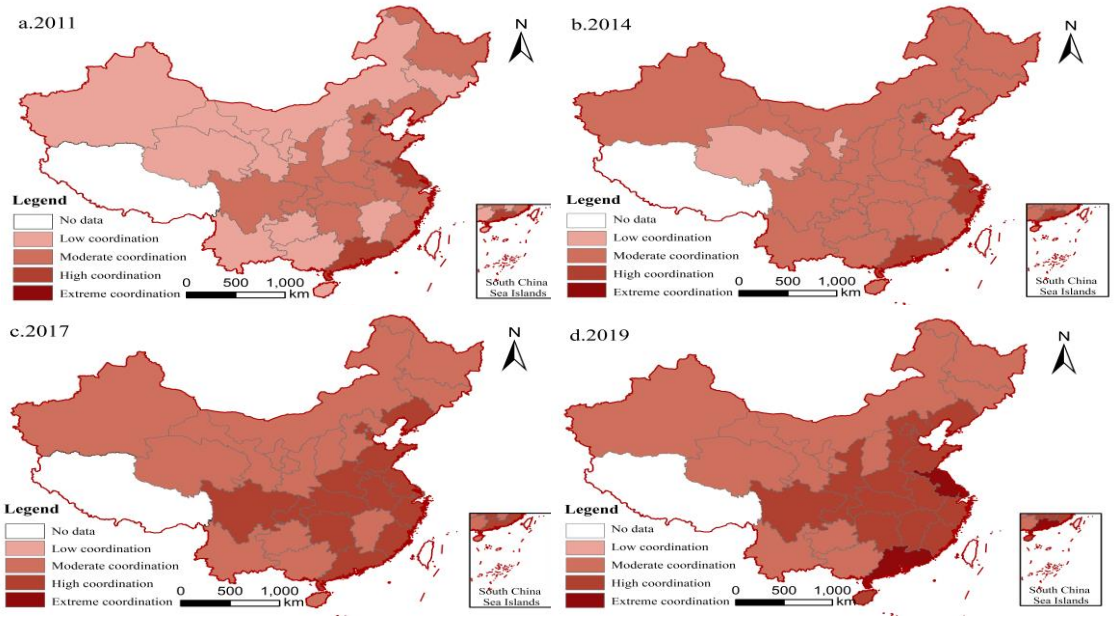
in 2017 and 2019 also shows a bimodal convexity between 0.6 and 0.8, indicating a trend of transformation from unimodal to bimodal, representing that some provinces have reached a high level of concentration in the coupling coordination degree between the digital economy and economic growth efficiency, and the level of coordinated development between the two has improved. The transformation from bimodal to bimodal indicates that the coupling coordination degree between the two is shifting from convergence to divergence, and the development among different provinces shows greater differences.

3.2. Analysis of the spatial-temporal evolution of the coupling coordination degree between the digital economy and economic growth efficiency



Graph 4 The spatial distribution map of the coupling coordination degree between the digital economy and economic growth efficiency.

By using the coupling degree model, the coupling coordination degree between the digital economy and economic growth efficiency in 30 provinces in China from 2011 to 2019 (excluding Tibet, Taiwan, Hong Kong, and Macao due to missing data) was calculated. Based on the changes in coupling coordination degree types (i.e., low coordination, moderate coordination, high coordination, and extreme coordination) and their evolutionary characteristics, representative years in the research period, namely 2011, 2014, 2017, and 2019, were selected to draw the spatial evolution map of the coupling coordination in the 30 provinces and cities in China. From the perspective of spatial structure, the high coordination areas show a progressive distribution trend from coastal to inland regions, mainly concentrated in the eastern region, while the coordination degree is weaker in the central and western regions, indicating that the development of the coupling coordination between the digital economy and economic growth efficiency in China exhibits a radiation distribution effect from coastal to inland regions. From the perspective of temporal structure, in 2011, 12 provinces and cities were classified as having low coordination, 14 provinces and cities as having moderate coordination, and 4 provinces and cities as having high coordination. With the continuous development of the economy, by 2014, the coupling coordination degree between the digital economy and economic growth efficiency had improved, with 2 provinces and cities having low coordination, 24 provinces and cities having moderate coordination, and 4 provinces and cities having high coordination. By 2017, further improvement was achieved,

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with 14 provinces and cities having moderate coordination, 15 provinces and cities having high coordination, and 1 province and city having extreme coordination. By 2019, the coupling coordination degree between the digital economy and economic growth efficiency in China had improved, with 11 provinces and cities having moderate coordination, 16 provinces and cities having high coordination, and 3 provinces and cities having extreme coordination.

3.2.1. The spatial pattern of the improved coupling coordination degree between the digital economy and economic growth efficiency in the Yangtze River Delta and Pearl River Delta regions shows a significant regional driving effect.

As observed from Graph a to d, as a whole, the high-growth areas of coupling coordination between the digital economy and economic growth efficiency from 2011 to 2019 are distributed in the Beijing-Tianjin-Hebei region, the Yangtze River Delta region, and the Pearl River Delta region. The moderate-growth areas are distributed in the economic belts near the Yangtze River Delta and the Pearl River Delta, and the moderate-high-growth areas are distributed in the eastern region. The low-growth areas are distributed in the central and western regions. In terms of regional distribution, the coupling coordination growth in the Beijing-Tianjin-Hebei region is not as good as that in the Yangtze River Delta and Pearl River Delta regions. The coupling coordination growth in the Yangtze River Delta and Pearl River Delta regions shows a structure that gradually increases from Jiangsu Province and Guangdong Province to the surrounding provinces and cities.

3.2.2. The coupling coordination degree shows a spatial pattern of "decreasing from coastal to inland."

As observed from Graph a to d, the highly coordinated areas of the digital economy and economic growth efficiency are concentrated in the southeast coastal areas, which share the common characteristics of having a developed economic foundation, providing strong support for the development of the digital economy. The moderately and low coordinated areas are widely distributed in central provinces. Due to the radiation effect of digital economic growth from highly coordinated areas, these provinces have the potential to achieve leapfrog development, such as Anhui, Shandong, and Fujian. As the implementation of various economic policies in China follows a gradual progression from coastal to inland regions, the eastern coastal regions represented by the Yangtze River Delta and the Pearl River Delta usually implement economic policies first, giving rise to significantly higher economic growth efficiency. Especially in Jiangsu, Zhejiang, and Guangdong, the speed and quality of digital economic development are much higher than in other coastal regions, providing favorable conditions for further improvement in economic growth efficiency.

3.3. Spatial correlation analysis of the coupling coordination degree between the digital economy and economic growth efficiency

Global spatial autocorrelation analysis

Table 2 The global Moran's I index for the coupling coordination degree between the digital economy and economic growth efficiency from 2011 to 2019

years	*Moran's I*	*Z values*	*P values*
2011	0.309	3.062	0.001
2012	0.337	3.322	0.000
2013	0.333	3.290	0.001
2014	0.321	3.192	0.001
2015	0.330	3.267	0.001

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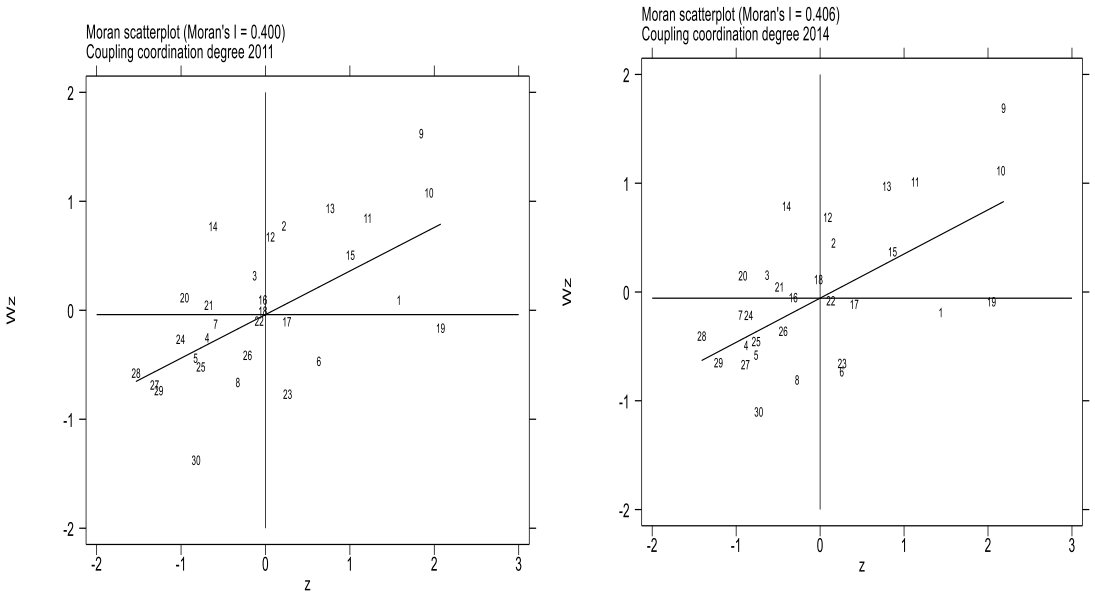
2016	0.336	3.321	0.000
2017	0.349	3.428	0.000
2018	0.323	3.203	0.001
2019	0.332	3.283	0.001

According to the global Moran's I index results of the coupling coordination degree between the digital economy and economic growth efficiency (Table 3), the Moran's I index for each year is positive and has passed the Z-test at the 1% significance level. This indicates a significant positive spatial correlation between the digital economy and economic growth efficiency. In terms of dynamic trends, the Moran's I index values show an "M"-shaped evolution, indicating a fluctuating dynamic process in the coupling coordination degree between the digital economy and economic growth efficiency. This suggests that the phenomenon of spatial agglomeration and distribution of the digital economy and economic growth efficiency becomes more pronounced over time. However, the global Moran's I index can only reflect the overall spatial correlation between the digital economy and economic growth efficiency among the 30 provinces in China, and cannot specifically describe its local spatial autocorrelation. The coupling and coordination development between the digital economy and economic growth efficiency not only has spatial agglomeration but also has a radiation effect among geographically adjacent provinces



Graph 5 Moran scatter plot of the coupling coordination degree between digital economy and economic growth efficiency

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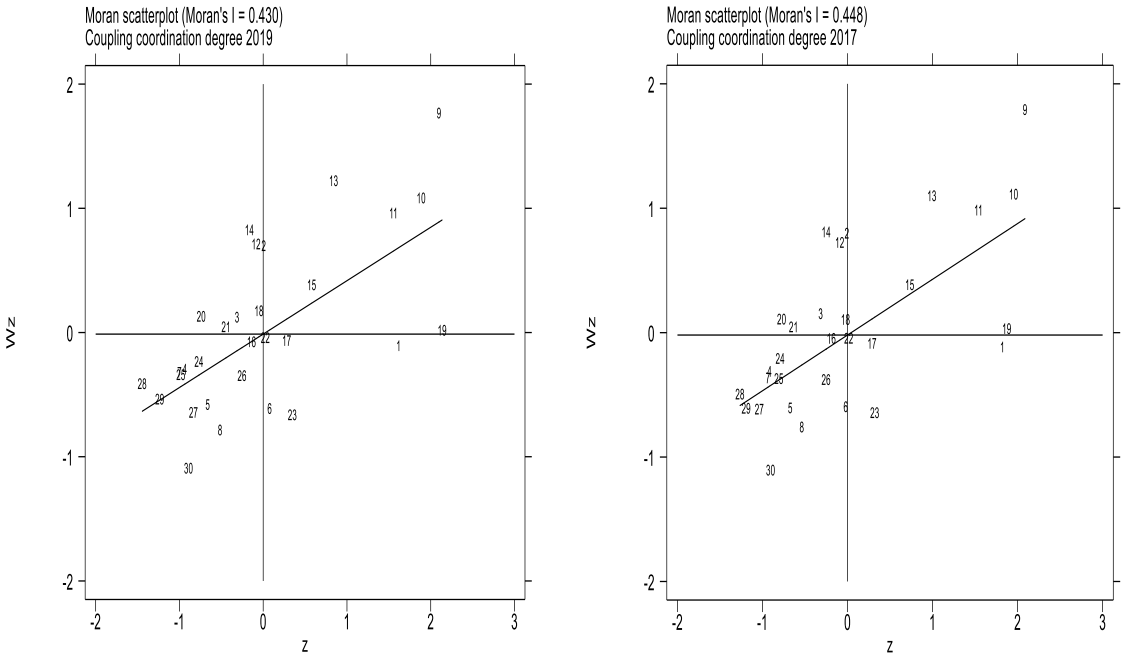

To further examine the spatial relationships among different provinces, four representative years, namely 2011, 2014, 2017, and 2019, were selected.Their corresponding local Moran's I scatter plots are displayed in Graph 5 and Table 3 shows the distribution of the corresponding local Moran's I region. Overall, the local spatial autocorrelation indices of the coupling coordination degree between digital economy and economic growth efficiency are distributed in all four quadrants. Most of them are located in the first and third quadrants, indicating the presence of "high-high" and "low-low" agglomeration areas with significant positive spatial correlation. There are fewer provinces in the second and fourth quadrants, representing "low-high" and "high-low" agglomeration areas, respectively, suggesting that regions with high and low values of coupling coordination tend to cluster at the extremes. In general, during the study period, only a few provinces transitioned to adjacent regions, while most provinces showed no significant transition changes, indicating a high level of spatial stability. At the same time, the degree of imbalance in the development of digital economy and economic growth efficiency coupling coordination remains significant, which is difficult to reconcile in the short term. Specifically, the "high-high" (H-H) agglomeration areas are mainly concentrated in the eastern and central regions, dominated by Beijing, Tianjin, and Shanghai. The "low-low" (L-L) agglomeration areas are primarily found in the northwest regions such as Inner Mongolia, Jilin, and Heilongjiang, as well as in the southwestern regions of Yunnan and Guizhou. These regions have lower levels of digital economy development and are geographically remote. The "low-high" (L-H) agglomeration areas are mainly located in the central regions, such as Hebei, Jiangxi, and Henan. The "high-low" (H-L) agglomeration areas are mainly distributed in provinces like Liaoning and Hubei. It can be observed that regions with higher economic development levels are generally distributed in the "high-high" (H-H) agglomeration areas and "high-low" (H-L) agglomeration areas. Furthermore, most provinces are in the "low-low" (L-L) agglomeration areas, such as the southwestern and northeastern regions, indicating that there is still significant room for improvement in the development of China's digital economy and economic growth efficiency. Therefore, accelerating the coordinated development of digital economy and economic growth efficiency in various provinces and cities, reducing coordination disparities, and promoting technological innovation is the necessary path to achieve rapid social transformation and structural upgrading.

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Table 3 The distribution of local Moran's I values for the coupling coordination degree between digital economy and economic growth efficiency.

年份	高-高（H-H）	低-高（L-H）	低-低（L-L）	高-低（H-L）
2011	北京、天津、上海、江苏、浙江、福建、山东、安徽	河北、江西、河南、湖南、广西、海南	山西、内蒙古、吉林、黑龙江、重庆、贵州、云南、陕西、甘肃、青海、宁夏、新疆	辽宁、湖北、广东、四川
2014	天津、上海、江苏、浙江、福建、山东、安徽	河北、江西、湖南、广西、海南	山西、内蒙古、吉林、黑龙江、河南、贵州、云南、陕西、甘肃、青海、宁夏、新疆	北京、辽宁、湖北、广东、重庆、四川
2017	上海、江苏、浙江、福建、山东、广东	天津、河北、安徽、江西、湖南、广西、海南	山西、内蒙古、辽宁、吉林、黑龙江、河南、重庆、贵州、云南、陕西、甘肃、青海、宁夏、新疆	北京、湖北、四川
2019	上海、江苏、浙江、福建、山东、广东	天津、河北、安徽、江西、湖南、广西、海南	山西、内蒙古、吉林、黑龙江、河南、贵州、云南、陕西、甘肃、青海、宁夏、新疆	北京、辽宁、湖北、重庆、四川

4. Conclusion and Recommendations

This paper selects panel data of the comprehensive index of the digital economy and economic growth efficiency for 30 provinces and cities from 2011 to 2019 and analyzes and measures the results from two perspectives: time series and regional differences. It constructs an index evaluation system for the digital economy and an index evaluation system for economic growth efficiency based on three dimensions: capital productivity, labor productivity, and total factor productivity, and explores the impact of overall economic growth efficiency. The above research results show that: firstly, the development of the digital economy has a positive promoting effect on economic growth efficiency, and the improvement of economic growth efficiency also provides a source of momentum for the development of the digital economy. Secondly, the trend of changes in the coupling coordination degree between the digital economy and economic growth efficiency in the eastern, central, and western regions of China from 2011 to 2019 is basically the same, showing a synchronous and stable upward trend. Thirdly, the regional difference analysis results show that since 2011, there has been a significant difference in the coupling coordination degree between the digital economy and economic growth efficiency in China, but it shows a trend of convergence. The difference between the western region and the eastern region is relatively large, and the differences among the three regions of the east, central, and west are also showing a trend of convergence.

Based on the above analysis, this study provides the following three feasible suggestions to promote the development of the digital economy and improve economic growth efficiency:

First, explore strategies and policies for the simultaneous positive development of the digital economy and economic growth efficiency. Overall, the coupling coordination degree between the digital economy and economic growth efficiency in China is relatively low. Except for the eastern region, most provinces in the central and western regions are still in the stage of moderate to low coordination. Even in the eastern region, only a few provinces have achieved a high level of coordination, while most are at a moderate level. This indicates that as the economic and social development progresses, the interdependence and mutual constraint

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between the digital economy and economic growth efficiency in China are increasing, but there is still room for improvement. It is necessary to strengthen regional infrastructure construction, especially the construction of digital economy infrastructure, and improve the economic growth efficiency of underdeveloped regions through the coupling coordination between the digital economy and economic growth efficiency.

Second, formulate appropriate measures based on the development reality of each region. Provinces like Jiangsu, Zhejiang, and Guangdong are in a highly coordinated or extremely coordinated stage, with a relatively developed economic foundation. It is necessary to enhance their radiation effects on neighboring provinces, expand their radiation scope, and strengthen their interconnection and interaction with neighboring provinces, thereby promoting the development of the digital economy and economic efficiency growth in more provinces. Provinces adjacent to highly coordinated areas, such as Anhui, Shandong, and Fujian, have started to undergo economic structural transformation. They can take advantage of their proximity to highly coordinated areas and actively introduce advanced technologies for digital economy development. By leveraging the advantages in capital, technology, and talents of highly coordinated areas, they can improve economic growth efficiency, break through the bottleneck of coupled development, and achieve highly coordinated and balanced development between the digital economy and economic growth efficiency.

Third, accelerate the development of central and western regions to reduce the imbalance between the development of the digital economy and economic growth efficiency. The levels of digital economy development and economic growth efficiency in the central and western regions are lower compared to the eastern region. It is necessary to expedite policy support for these underdeveloped regions, address the coordination weaknesses in the coupling development of the digital economy and economic growth efficiency in the central and western regions, and promote the coordinated development of the digital economy and economic growth efficiency in all provinces and cities in China. This can be achieved by promoting technological innovation and leading the economic development in the central and western regions.

References

[1] Bai Xuejie, Song Pei, Li Lin, Liao Sainan. Can the digital economy promote the transformation of China's industrial structure-- From the perspective of efficiency based technological progress [J]. Journal of Xi'an Jiaotong University (Social Sciences Edition), 2021 (06): 1-15.

[2] Du Chuanzhong, Zhang Yuan. Research on the Mechanism of the Impact of Digital Economy Development on Enterprise Productivity Growth [J]. Securities Market Introduction, 2021 (02): 41-51.

[3] Duan Xiufang, Xu Chuanang. Research on the Coupling and Coordination Mechanism of China's Digital Economy and High Quality Economic Development [J]. Business Economics, 2021 (06): 3-8.

[4] Jing Wenjun, Sun Baowen. Digital Economy Promotes High Quality Economic Development: A Theoretical Analysis Framework [J]. Economist, 2019 (02): 66-73.

[5] Li Le, Zhou Linyi. Research on Promoting Regional Production Efficiency through Digital Inclusive Finance [J]. Journal of Shandong University of Technology (Social Sciences Edition), 2018 (04): 5-9.

[6] Li Xiaohua. New characteristics of the digital economy and the formation mechanism of new driving forces in the digital economy [J]. Reform, 2019 (11): 40-51.

[7] Li Xiaolong, Ran Guanghe. How does the development of digital finance affect the quality of technological innovation? [J] Modern Economic Exploration, 2021 (09): 69-77.

[8] Li Xuesong, Zhang Yudi, Sun Bowen. Does regional integration promote economic growth efficiency—— Empirical Analysis Based on the Yangtze River Economic Belt [J]. China Population, Resources and Environment, 2017 (01): 10-19.

ISSN: 2710-0170

[9] Li Yuxin, Zheng Liang. Research on Economic Growth Efficiency and Influencing Factors in Western Provinces: Empirical Analysis Based on SFA Model [J]. Ecological Economy, 2019 (03): 57-62.

[10] Qin Hanqi Empirical Study on the Coupling and Coordination of Digital Economy and Economic Growth in China [D]. Jiangxi University of Finance and Economics, 2021.

[11] Li Yuxin, Zheng Liang. Research on Economic Growth Efficiency and Influencing Factors in Western Provinces: Empirical Analysis Based on SFA Model [J]. Ecological Economy, 2019 (03): 57-62.

[12] Qin Hanqi Empirical Study on the Coupling and Coordination of Digital Economy and Economic Growth in China [D]. Jiangxi University of Finance and Economics, 2021.

[13] Song Changqing, Li Zilun, Ma Fang. Regional Differences and Convergence Analysis of China's Economic Growth Efficiency [J]. Urban Issues, 2013 (06): 46-51.

[14] Wang Shujia, Kong Wei, Ren Liang, Zhi Dandan, Dai Binting. Misunderstandings and corrections of domestic coupling coordination degree models [J]. Journal of Natural Resources, 2021 (03): 793-810.

[15] Wang Yong, Du Pengfei. Factor Endowment, Economic Growth Efficiency, and Regional Gap: A Threshold Effect Analysis Based on the Yangtze River Delta Urban Agglomeration [J]. Statistics and Decision Making, 2020 (21): 125-128.

[16] Wei Zhenxiang, Shi Xiangguo. Analysis of the Coupling Relationship between Ecological Sustainability and High Quality Economic Development: An Empirical Study Based on Inter provincial Panel Data [J]. East China Economic Management, 2021 (04): 11-19.

[17] Yu Zhiqian, Zhu Ning. Digital Economy, Inclusive Finance, and Economic Growth [J]. Jinan Journal (Philosophy and Social Sciences Edition), 2021 (11): 51-61.

[18] Yuan Qingmin, Qiu Jing, Feng Dong. A study on the economic growth efficiency of three major urban agglomerations in China based on the SBM Undesirable model [J]. Resources and Environment of Arid Areas, 2015 (09): 7-12.

[19] Zhang Teng, Jiang Fuxin, Wei Zhentao. Can the digital economy become a new driving force for promoting high-quality economic development in China? [J] Exploration of Economic Issues, 2021 (01): 25-39.

[20] Zhang Weidong, Ding Junchao. Research on the Technical Efficiency and Influencing Factors of Economic Growth: A Case Study of Sichuan Province [J]. Economic Research Guide, 2014 (10): 1-5.

[21] Zhang Weidong, Zhao Shihong, Long Haixia, Liu Meiru. Economic Growth Efficiency Based on SBM Method and Total Factor Productivity Decomposition: A Case Study of Sichuan Province [J]. Financial Science, 2015 (08): 100-111.

[22] Honohan,P.Financial Development,Growth and Poverty:How Close are the Links?[NJ.Palgrave Macmillan,London,2004:1-37.

[23] Basu,S.,&.Fernald ,J.Information and Communications Technology as a General-purpose Technology:Evidence From US lndustry Data[J].German Economic Review,2007,8(2):146-173.

[24] Romer P.Increasing Return and Long-run Growth [J].Journal of Political Economy,1986,(94).

[25] Lucas R E. On the Mechanics of Economic Development [J] .Journal of Monetary Economics,1988,(1).

[26] HARRIS T F,IOANNIDES Y M.Productivity and metropolitan density[R].Department of Economics,Tufts University,2000.

[27] YOUNG A.The razor's edge:distortions and incremental reform in thePeople's Republic of China[J].Quaterlyjournal of economics,2000,115(4):1091-1135.