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Risk Assessment and Coping Strategies for The Coordinated Development of Digital Finance and Green Finance

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Abstract: In the contemporary era characterized by rapid technological advancements, the digital economy has emerged as a pivotal force reshaping the global economic landscape. Based on the digital economy development index meticulously measured through principal component analysis, this paper undertakes an in - depth exploration. It makes use of the panel data of municipal samples spanning from 2011 to 2020. The core objective is to rigorously test the impact and underlying mechanisms of the digital economy on regional green technology innovation. Specifically, the research delves into this relationship from two crucial perspectives: industrial structure and educational human capital. The industrial structure perspective focuses on how the digital economy reconfigures traditional industrial frameworks, fostering new forms of production and resource allocation that are conducive to green technology innovation. Regarding educational human capital, it examines how the digital economy influences the cultivation and utilization of high - quality human resources, which in turn drive the development of green - tech innovation in regions. This comprehensive analysis is expected to provide valuable insights for promoting sustainable development in the digital age.

Keywords: Digital economy; green technology innovation; education and human capital; industrial structure rise.

1. Introduction

Ever since the reform and opening up policy was carried out, China has made stunning economic strides. It has climbed to the position of the world's second - largest economy. But the flip side of this fast - paced economic development is a set of environmental headaches. Problems such as high - level emissions, excessive energy consumption, and severe pollution have come to the fore. which have affected the sustainable economic development. The party's 20th annual report clearly points out that accelerating shift the development model to an eco - friendly one and promote green, low - carbon economic and social development are the key links in achieving high-quality development. Green technology innovation, as an interwoven point of green development and innovation drive, has been upgraded to a national action plan. Braun And Wield proposed that green technology refers to the process or production and products to reduce the consumption of energy and raw materials, Featuring both green and innovative elements, it places greater emphasis on the win - win situation of environmental and economic benefits. At present, China has entered a new stage of development. Striving for the attainment of the "dual-carbon" objective and the realization of green and sustainable development of the economy and society, it is necessary to lead the transformation of the economic mode through green technology innovation.

2. Theoretical Analysis and Research Hypothesis

2.1. How the digital economy influences and impacts green technology innovation

The digital economy's impact on green technology innovation is mainly shown in three aspects. First, it has built a favorable external environment for the smooth progress of green technology innovation. In the production links of enterprises, for instance, the utilization of advanced technologies like the Internet of Things and artificial intelligence can quickly integrate information resources, accurately control the production tasks,It has changed the previous extensive and inefficient production mode, greatly reduced the production cost of enterprises, improved the production efficiency, provided favorable conditions for the smooth development of green technology innovation activities, and promoted the development of the industry in the direction of intelligent and green. Digital technology, on the other hand, also plays a huge role in enterprise management, use, intelligent system or equipment can reduce enterprise management level, promote enterprises in the direction of flattening (xin-zhi liu, 2022), improve the efficiency of internal management and collaboration, green technology innovation activities for the enterprise provides a good environment. Second, the development of digital technology enables different innovation subjects to participate in green innovation activities. Digital technology has broken the time and space limit, overcome the previous barriers of cross-regional or transnational communication, especially in the event of an epidemic, wars and other adverse circumstances, saved a lot of time for in-depth research, and effectively strengthened the spillover effect of green technology innovation. In addition, the spillover and sharing characteristics of digital technology make the green technology innovation of leading enterprises more rapid and overflow to other enterprises in the industry, further improving the overall level of green technology innovation of the industry. Third, the digital economy has a forcing effect to encourage enterprises to make green technology innovation. Aaron And Jason (2016) pointed out that the knowledge spillover effect of digital economy forces the manufacturing cost within the industrial system, and pays attention to ecological environment governance and resource protection

in the process of technological innovation. With the continuous improvement of China's environmental regulation policies, the cost of environmental protection is also increasing. Green technology innovation can reduce pollution emissions from the source. Under the condition of open and transparent market environment and environmental protection policies, enterprises must continue to carry out green innovation activities if they want to gain competitive advantages in the market. Accordingly, the following research hypotheses are proposed:

Research Hypothesis 1: The expansion of the digital economy has the potential to drive forward the improvement of green technology innovation level.

2.2. How the development of the digital economy impacts regional green technology innovation in terms of its functional mechanism

The digital economy influences green technology innovation by improving educational human capital. From the demand side, the rapid development of digital economy has spawned a large number of new digital industries. Under the development of new business forms, the labor force is required to have corresponding skills and digital literacy. On the supply side, the widespread use of digital technology enables the workforce to improve their skills. First, the professional training of digital technology directly enables the labor force, and enriching intelligent digital resources and services are conducive to the improvement of the digital skills and comprehensive quality of the labor force, such as online education, artificial intelligence simulation and other learning activities on digital platforms, to improve the level of human capital in education. Second, the digital economy and technology is set to propel the optimization and elevation of the employment structure of the labor force. The establishment of employment information service platform and online recruitment software has effectively alleviated the information asymmetry between enterprises and employees, cracked the shackles of the mismatch of educational human capital elements in the past, greatly improved the matching degree between supply and demand in the labor market, and promoted the change of labor employment structure.

At the same time, the improvement of educational human capital also drives green technology innovation. Jiang Fuxin et al. (2013) confirmed the significant positive impact of educational human capital on green technology innovation. On the one hand, the discussion and communication between different professionals in the agglomeration system is conducive to the acquisition of knowledge technology, the spark of innovation, and thus expand the radiation scope of knowledge overflow. In addition, in order to improve the competitiveness of the new formats, many labor through "middle school" and "re-education" way to learn advanced technical skills, improve the production boost the enterprise's efficiency and technological innovation, and steer the enterprise towards green development, energy conservation, and emissions reduction consensus, promote enterprises to realize technology accumulation and environmental technology innovation, drive regional green innovation level. High quality education, on the other hand, human capital pay more attention to the quality of life, environmental protection, knowledge, green consumption consciousness, for green low carbon way of life and green consumption demand, guide the whole society consumption structure change, make more energy saving and environmental protection industry into this field, thus forcing twin enterprise continuously green technology innovation. Accordingly, the following research hypotheses are proposed: Research Hypothesis 2a: Digital economy influences green technology innovation through educational human capital.

Digital economy affects green technology innovation by optimizing the industrial structure and upgrading it. Digital economy is characterized by high synergy, low cost and high permeability, which can have exerts a positive impact on the evolution of the industrial structure. Once the industrial structure evolves, it can effectively drive regional green technology innovation. To begin with, the expansion of the digital economy promotes labor force and capital from industries with low productivity to new industries with high productivity, and then improves the efficiency of resource allocation, creating a good basic condition for the improvement of urban green innovation ability. Second, The digital economy has the power to dig deeper into the relationships among industries. It enables the seamless cooperation of upstream and downstream industrial chains, making them develop in a coordinated way. With the digital economy booming has unique advantages, which can build a diversified and large-scale digital ecological network, and accommodate many enterprises in the upstream and downstream of the industrial chain. Enterprises can tap and use their own comparative advantages in the digital ecological network, and form extensive interaction and cooperation with other users and enterprises. Based on the theory of agglomeration economy, the degree of industrial correlation in different regions and different categories is continuously improved, which makes the connection between backward industries and advanced industries more and more close, and jointly promotes the coordinated development of industries and green technology innovation. Accordingly, the following research hypotheses are proposed: Research Hypothesis 2b: Digital economy affects green technology innovation by optimizing industrial structure and upgrading.

3. Research Design

3.1. Measurement model setting

Benchmark model construction. In order to study the role of digital economy on green technology innovation, the benchmark measurement model constructed based on the sample of prefecture-level cities in 2011-2020 is as follows:

$$Green_innoi,t=\alpha0+\alpha1Digitali,t+\alpha2Zi,t+\mu i+\delta t+\varepsilon i,t \quad (1)$$

In the formula _ _ (1), i=1, 2,3,..., N indicates the sample region, t=1, 2,3,..., T is the sample period; Green_innoi, Area i, t represents the green technology innovation level in the t period, Digitali, Area t indicates i in the digital economy development index during t, Zi, And t represents a set of control variables. These variables mainly consist of financial development level (Finance), permanent resident population (People), foreign direct investment (Fdi) and the proportion of scientific research and technical personnel (Ratio _ sci); μ I shows an individual fixed effect, δ t shows the time-fixed effect, εi, T is a random interference term; α 0 is the intercept term, α 1 and α 2 are the coefficients of each variable.

Analysis of the conduction mechanism. According to

mentioned above, the upgrading of industrial structure and educational human capital are the intermediary variables between digital economy and green technology innovation. On the basis of the significance of the coefficient (1) the influence of the Digital Economy Development Index on Green Technology Innovation,the following transmission mechanism models are constructed to determine whether the intermediary effect exists. The details are as follows: To construct the transmission mechanism model of industrial structure upgrading as an intermediary variable:

$$Stru_indi_{,t} = \omega 0 + \omega 1 Digitali_{,t} + \omega 2 Zi_{,t} + \mu i + \delta t + \varepsilon i_{,t} \quad (2)$$

Construct the transmission mechanism model of educational human capital as an intermediary variable:/

$$Educai,t = \omega 0 + \omega 1 Digitali,t + \omega 2 Zi,t + \mu i + \delta t + \varepsilon i,t \quad (3)$$

3.2. Variable selection and data description

In this paper, the samples of prefecture-level cities in China were selected as the research object, and the samples with serious data missing were excluded. Given the release of the data of digital economy statistical indicators since 2011, the sample range is set for 2011-2020. The data are from China Statistical Yearbook and China Science and Technology Statistical Yearbook,explained variables. Green Technology Innovation (Green _ inno): Whether in cities or enterprises, the most intuitive achievement of green technology innovation is the number of green patent applications or licenses. Therefore, this paper combines the measurement method of existing literature, uses the number of green patent applications in prefecture-level cities as the measurement standard of green technology innovation in this region, and carries out logarithmic treatment.

Core explanatory variables. Digital economy (Digital): this paper is based on the number of digital circulation the Chinese core journals to overview trade economy core journals 123 word economic characteristics, give priority to with application type and development level, combined with wang jun (2021), Yang Huimei and Jiang Lu (2021) research, from the digital technology development level, digital and digital industrialization three dimensions selected 31 indicators, using the principal component employ an analytical approach to gauge the development level of the digital economy in China. Table 1 shows the specific indicator definitions.

Table 1. Digital economy level indicators.

Level 1 dimension	Secondary dimension	Three dimensions	Indicator attributes
Development level of digital technology	infrastructure	Number of Internet broadband access ports	+
		Number of Internet broadband access users	+
		Number of Web sites per thousand people	+
		Number of base stations per thousand people	+
		Number of IPv4's	+
		The number of websites per 100 enterprises	+
		Number of computers used per hundred people (units)	+
		Penetration	+
		R&D funds	+
	ambient level	Software and information technology service personnel	+
		Technology market Number of technology contracts	+
Industrial digitization	Agricultural digitization	Rural broadband access users / ten thousand households	+
		Value value of agriculture, forestry, animal husbandry and fishery	+
		The proportion of administrative villages that open Internet broadband services	+
	Industrial digitization	value added	+
		The ratio of the amount of national patent applications granted to the full-time equivalent of R & D personnel of industrial enterprises above designated size	+
		New products of industrial enterprises above designated size	+
	Digital service industry	Per capita expenditure on transportation and communications consumption	+
		Per capita cultural, education and entertainment consumption	+
		Express volume	+
		The Digital Financial Inclusion Index	+
		Value-added value of the tertiary industry	+
Digital industrialization	Telecom industry scale	Total telecom business	+
		Telecom long-distance optical cable line length	+
		Telecom's main business income	+
	Scale of the electronic information manufacturing industry	Main business income of communication equipment, computer and other electronic equipment manufacturing industry	+
		Total assets of communications equipment, computers and other electronic equipment manufacturing industries	+
		The average number of workers in communication equipment, computer and other electronic equipment manufacturing industry / 10,000 people	+
	Software and information technology services	Total software business revenue	+
		E-commerce sales volume	+
		Number of information system integration service enterprises	+

Metavariable. Industrial structure upgrading (Stru _ in): According to the di-Clark law, combined with relevant

literature, in this paper, we use the ratio of the output value of the tertiary industry to that of the secondary industry for analysis. Educational human capital (Educa): This paper selects the per capita years of education to measure educational human capital. The specific calculation method is (the regional sample including the population with primary school education * 6 + middle school * 9 + high school * 12 + junior college or above * 16) / the sample population of areas over 6 years old.4. Control variables. To comprehensively analyze the impact of green finance on high - quality economic development, we'll explore it from data, cases, and policy aspects. the following control variables are selected: financial development level (Finance): the balance of the year, the resident population (People): the resident population; foreign direct investment (FDI): the balance of the amount of foreign direct investment; the proportion of scientific research and technical personnel (Ratio _ sci): the proportion of practitioners specializing in scientific research and technical research. Descriptive results are presented in Table Table 2.

Table 2. Descriptive statistics of the variables.

Type of variable	Variable name	Variable symbol	Sample size	Mean value	Standard deviation	Minimum	Max
Explained variable	Green technology innovation	Green_ino	2.750	5.235	1.648	0	10.45
Explanatory variable	digital economy	Digital	2.750	0.076	0.056	0.01	0.569
Metavariable	upgrading of an industrial structure	Stru_edu	2.750	0.025	0.072	0.014	0.535
Metavariable	Education of human capital	Educ	2.750	1.798	2.031	0.005	12.764
Metavariable	Financial development level	Finance	2.750	1.018	0.629	0.118	9.622
Controlled variable	permanent resident population	People	2.750	5.908	0.862	3.775	8.074
Controlled variable	foreign direct investment	FDI	2.750	0.994	1.089	0.009	15
Controlled variable	The proportion of scientific research and technical personnel employed	Ratio_sci	2.750	0.256	1.022	0.002	0.49

4. Empirical Results and Analysis

4.1. The benchmark regression results and analysis

As can be seen from Table 3, the coefficient of the digital economy shows a significantly positive value at the 1% level regardless of whether relevant variables are controlled or not, and the digital economy can significantly promote green technology innovation, which verifies the hypothesis 1 of this paper. From the perspective of control variables, we obtained that the estimated coefficient of the financial development level shows an obvious positive relationship at a significance level of 1%, indicating that vigorously developing capital market can promote green technology innovation and progress; the regression coefficient of permanent population is significantly positive at 1%, indicating that population factors have important influence on the significant growth of green technology innovation; the regression coefficient of foreign direct investment is significantly positive, indicating **tha**t the opening up and the injection of more funds can significantly improve the level of green technology innovation.

Table 3. Benchmark regression results of digital economy affecting green technology innovation.

Variable	(1)	(2)
	Green_ino	Green_ino
Digital	12.219***	8.865***
	-0.533	(0.547)
Finance		0.519***
		(0.039)
People		1.795***
		(0.254)
Fdi		0.045***
		(0.014)
Ratio_sci		(0.015)
		(0.014)
Digital	4.305***	-7.022***
	(0.043)	(1.486)
Obs	2750	2750
R2	0.175	0.258

4.2. Mechanism of action test

Upgrading of the industrial structure. Table 4 results (1) with the baseline regression. Column (2) and column (3) respectively test studying the digital economy's impact on industrial structure upgrading and their combined effect on

green tech innovation, results show the digital economy's coefficient and industrial structure are significantly positive. Therefore, the mediation effect of industrial structure upgrading was verified, and hypothesis 2a was verified.

Education of human capital. As above, the results showed that the coefficient of digital economy and the coefficient of educational human capital were significantly positive at the level of 1% respectively, so the intermediary effect of educational human capital was verified, and hypothesis 2b was verified.

Table 4. Mechanism testing.

	(1)	(2)	(3)	(4)	(5)
variable	Green_ino	Stru_ind	Green_ino	Educa	Green_ino
Digital	8.865***	4.286***	5.159***	3.110***	8.135***
	(0.547)	(0.234)	(0.542)	(0.310)	(0.561)
Stru_ind			0.865***		
			(0.044)		
Educa					0.297***
					(0.036)
Control	Y	Y	Y	Y	Y
Constant	-7.022***	-0.651	-6.459***	7.716***	-9.275***
	(1.486)	(0.635)	(1.382)	(0.829)	(1.494)
Obs	2,750	2,750	2,750	2,740	2,740
R2	0.258	0.346	0.359	0.095	0.279

4.3. Robustness test

Robustness test of the tail-reduction treatment. In order to control for the influence of outliers on the estimated results, the explanatory and explained variables were "tailed", where all observed values less than 1% quantile or greater than 99% quantile were removed, and the results passed the robustness test.

Robustness test for the lagged explanatory variables. The lag phase and lag two periods of the digital economy index are selected to return to the green technology innovation index, so as to avoid the endogenous problems caused by reverse causality to some extent. The results passed the robustness test.

4.4. Analysis of heterogeneity

Heterogeneity between eastern and Midwest regions. The results show that The digital economy drives green tech innovation. Compared with the east, in the west, the digital economy's incomplete part gradually enhanced, play table 1 digital economy index table 2 variables descriptive statistics Digital Circulation table 3 digital economy impact green technology innovation benchmark regression results note: brackets for standard error said respectively in 10%, 5%, 1% level.similarly hereinafter.124 Business economy Research issue 12,2024 plays a more significant role. Possible reasons are as follows, one is the eastern digital economy development earlier, the corresponding digital infrastructure construction is relatively complete, at the same time, compared to the central and western regions, the eastern region has advantages in human capital and industrial structure, enabling its digital economy to drive green tech innovation. In contrast, the central and western regions, hampered by low - level economies and development conditions, show weaker green tech innovation growth despite digital economy progress. Due to inherent differences, the digital economy has a more active and significant impact on these areas.

Heterogeneity between central cities and non-central cities. The results show that the impact of digital economy in both central cities and non-central cities on green technology innovation is significantly positive, but the influence coefficient of non-central cities is significantly greater than that of central cities. According to the reasons, the geographical location and economic development level of central cities are much higher than those of non-central cities, which have significant advantages in terms of resource endowment, industrial structure, talent and technology.

Heterogeneity between first and second tier cities and third and fourth tier cities. The tier cities are comprehensively divided by the dimensions of commercial resource agglomeration and future plasticity, which has the characteristics of "acquired efforts" compared with the division of central cities. The results show that digital economy has a significant positive role in promoting green technology innovation in all tier cities, but the influence coefficient have significant advantages in economic, resource and technological development, while the development foundation of the third-and fourth-tier cities is relatively weak.

5. Study Conclusions and Policy Recommendations

We should strengthen the Internet and information technology infrastructure, construction efforts, make up for the shortcomings in broadband and other aspects, make full use of digital technology to achieve the interconnection of everything, and better promote green technology innovation. In addition, we should establish and improve the market mechanism, improve the refined development of supply chain and industrial chain, accelerate the deep integration of digital economy and real economy, help enterprises complete digital transformation.

Improve human capital in education and stimulate the

effect of green technology innovation. We will increase support for personnel training, increase spending on personnel input, and accelerate the promotion of human capital for innovative and skilled education. At the same time, we should increase the introduction of economic and technical talents at home and abroad, actively learn from advanced talent management concepts, and regularly organize expert discussion meetings on digital economy, improve the professional core quality, gradually form an inter-regional talent lending mechanism, organize assistance and mutual assistance work, and narrow the regional green technology innovation and development gap.

We should pay attention to the balanced development of regional digital economy and effectively improve the level of regional green technology innovation. It is necessary to adopt classified measures according to local conditions, and implement differentiated digital economy development strategies. For small and medium-sized cities, we should actively give full play to their comparative advantages, actively expand and undertake industrial transfer projects, promote the in-depth integrated development of regional competitive industries and digital economy.

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