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The Impact of Low-Carbon Pilot Cities on the Development of Digital Economy: Empirical Evidence from 284 Cities in China

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Abstract: The launch of the low-carbon city pilot policy is of great significance to promoting China's economic structural transformation, especially for the development of the digital economy. This paper took the low-carbon city pilot policy as a quasi-natural experiment. By matching the panel data of 284 cities in China from 2007 to 2020, this paper studied the impact of the low-carbon pilot cities on the development of the digital economy by using the differences-in-differences(DID) method. The results show the following: (1) The low-carbon city pilot policy significantly promoted the development of the digital economy in the pilot areas, and the promotion effect was the most significant in the eastern region and the pilot areas of non-resource-based cities. (2) Through a mechanism analysis, it was found that government intervention and human capital play a mediating role between low-carbon pilot cities and digital economy development, while the mediating effect of industrial structure upgrading was not verified in this paper. (3) The mechanism of action is also heterogeneous in different regions; that is, the magnitude and direction of action vary across regions. This paper attempts to provide theoretical support for the green and sustainable development of the Chinese economy.

Keywords: low-carbon city pilot policy; digital economy; differences-in-differences (DID); mediation effect

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1. Introduction

Since the launch of the reform and opening-up policy, China's economy has experienced rapid growth. However, this growth has been driven by an extensive economic model that capitalizes on population expansion as a development dividend, consequently leading to China becoming the world's largest emitter of carbon dioxide. This kind of rapid economic development, achieved at the expense of severe environmental pollution, is unsustainable. What we should strive for is sustainable development, which encompasses not only the sustainability of capitalist profitability and accumulation but also the satisfaction of present needs without compromising the ability of future generations to meet their own needs while safeguarding the environment [1–3]. In order to cope with the increasingly severe environmental problems and achieve green, sustainable, and high-quality economic development, the Chinese government put forward a dual carbon target at the 2015 Paris Climate Change Conference. Therefore, governments at all levels have attached importance to the construction of low-carbon cities. In July 2010, the National Development and Reform Commission of China issued a notice to carry out low-carbon city pilot projects, which designated five provinces, including Guangdong and Yunnan, and eight cities, including Tianjin and Chongqing, as the first batch of low-carbon city pilot projects [4–6]. Subsequently, the second and third batches of low-carbon pilot areas were determined in 2012 and 2017, respectively, in order to alleviate the pressure of reducing carbon emissions and achieve the goal of economic green and sustainable development [7,8]. An economy's productive base includes not only its capital assets (stocks of manufactured, human, and natural capital and knowledge) but also its institutions (including its cultural coordinates) [3]. China's digital economy accounted for about 38% of GDP in 2020, according to the White Paper on China's Digital Economy, after the country implemented low-carbon pilot policies. The digital economy, developed on the basis of the Internet, big data, and other technologies, has widely penetrated and been integrated into every aspect of social production and life, and it has promoted the continuous transformation of the traditional manufacturing industry to digital production, gradually becoming a new driving force and new engine leading economic development [9,10]. As a broad and profound economic and social change, green and low-carbon city construction is bound to have an impact on many fields, such as government investment in science and technology, digital information infrastructure, digital technology innovation, regional science and technology personnel training, and industrial digital transformation. At present, many scholars have conducted in-depth studies on the impact mechanism of the digital economy promoting carbon emission reduction. For example, Lei Xiao ying et al., revealed the inverted U-shaped impact of the digital economy on China's carbon emissions, while Meng Zi yu et al., found that the digital economy significantly reduces urban carbon emissions by promoting industrial structure upgrading and green innovation [11,12]. From another perspective, the following urgent question is raised: does a low-carbon pilot city promote the development of the digital economy? Scholars have taken the development of the Internet as the core and added the idea of a digital transaction index into the measurement system. The digital economy is centered on the popularization of the Internet and the promotion of digital finance [13]. According to the China Statistical Yearbook released by the National Bureau of Statistics, China's telecom business revenue increased from CNY 2.999 trillion in 2010 to CNY 13.6763 trillion in 2020. The Internet penetration rate and the number of mobile phone users also increased from 34.3 percent and 859 million in 2010 to 70.4 percent and 1.594 billion in 2020, respectively. As we can see from the statistics, China's digital economy has developed rapidly in the past decade under the influence of many factors. During this development period, the low-carbon city pilot policy was also energetically popularized. So, are the low-carbon pilot cities one of the reasons for the promotion of the development of the digital economy? If the low-carbon pilot cities promote the development of the digital economy, what is the mechanism? In order to better answer the above questions, this paper conducts extensive studies on the digital economy, green and low-carbon development, and related content.

The remainder of this article is arranged as follows: Section 2 provides a literature review. Section 3 introduces the theoretical mechanisms and research hypotheses. Section 4 details the study design. Section 5 presents the results. Section 6 contains the discussion. Section 7 presents the conclusions and policy implications.

2. Literature Review

After combing the previous literature, it was found that the research closely related to this paper can be roughly divided into four categories.

2.1. On the Definition of the Digital Economy

In 1996, Don Tapscott, the father of digital economics, first proposed the concept of the digital economy, which attracted wide attention worldwide, but in the early stage, this concept was only considered a synonym of the Internet economy or information economy [14]. Peter believes that the digital economy is a kind of extensive economic activity involving production, sales, and service, integrating data and knowledge as production factors and taking modern cyberspace as the main scope of activities [15]. According to the White Paper on China's Digital Economy, the digital economy is a higher economic stage after the agricultural economy and industrial economy [16]. The digital economy takes digital knowledge and information as the key production factors, digital technology innovation as the core driving force, and modern information networks as important carriers, and, through the deep integration of digital technology and the real economy, the digital and intelligence levels of traditional industries are constantly improved, the reconstruction of economic development is accelerated, and the governance mode of the government takes on a new economic form [17].

2.2. Studies on the Effect of Low-Carbon City Pilot Policy

As a policy, the effects and externalities of the low-carbon city pilot policy include many aspects. At present, the research on the low-carbon city pilot policy is not limited to regional CO_2 emission reduction; an increasing number of studies focus on other positive externalities brought by the policy. Therefore, many scholars have gradually incorporated the positive externalities of promoting regional green technology innovation, industrial structure upgrading, digital economy development, scientific research, and development investment into the policy evaluation system of low-carbon pilot cities [18–20]. Generally speaking, the policy has two ways of influencing regional factors. The first is direct promotion. To reduce carbon emissions, we need to provide new technical support to traditional high-pollution production enterprises in the areas to reduce the carbon emissions of major enterprises at the production and processing end and the waste gas treatment end. Therefore, local governments will increase scientific research investment in related fields based on green technology innovation based on their reality, which directly promotes regional science and technology development [13]. In addition, as a policy tool, environmental regulation directly affects the production and management decision-making process in modern enterprises. Under the restriction of strict environmental protection regulation policies, high-polluting enterprises will face greater pollution costs, which forces them to change their original production and management processes in the direction of digitalization and greening [21]. The second is indirect guidance. Environmental regulations as specific policies guide enterprises to carry out scientific and technological innovation and eliminate backward production capacity, or they force high-polluting enterprises to move to areas with weak environmental regulations, and low-carbon city pilot areas will result in more low-polluting and clean enterprises, thus indirectly promoting the adjustment and upgrading of local industrial structure. In addition, pilot areas will also actively implement alternative renewable energy actions, vigorously develop new clean energy, such as solar, wind, and water, and reduce dependence on traditional energy [22].

2.3. Studies on the Influencing Factors of Digital Economy Development

As the new engine of economics, the digital economy has attracted the attention of many research institutions and scholars. For example, Wang, using the digital economy development data published by Tencent Research Institute, found that, at the national level, the government's investment in science and technology plays a leading role in the development of the digital economy and the improvement of the level of digital science and technology, the upgrading of industrial structure, etc., also play a role in promoting the development of the digital economy. At the local level, the development of the digital economy in different regions is affected by various factors. Specifically, infrastructure construction and digital information infrastructure have different degrees of influence [23]. Based on the relevant data of the Yangtze River Delta, Hu Yan et al. used a QAP correlation analysis and a QAP regression analysis to conduct research, and they found that per capita GDP, the number of Internet users, the development level of the tertiary industry, per capita science and technology expenditure, and the presence of cities nearby all have a significant impact on the development of the digital economy in the Yangtze River Delta [24]. Liu Jun et al., used the panel data of 30 provinces in China from 2015 to 2018 to measure the development level of China's digital economy and, at the same time, studied the factors driving the development of the digital economy. The research results found that regional economic growth, foreign investment dependence, government intervention, and human capital all significantly affect the development of the digital economy [25].

2.4. Studies on the Relationship between Carbon Dioxide Emissions and Digital Economy

At present, most academic studies on the relationship between carbon dioxide emissions and the digital economy focus on the impact of digital economy development on regional carbon emission intensity and its mechanism of action. Most scholars have discussed and verified how the development of the digital economy affects carbon dioxide emissions from theoretical and empirical perspectives. Most scholars believe that the development of the digital economy can reduce carbon emission intensity. On the one hand, the digital economy itself is environmentally friendly. Compared with traditional physical manufacturing enterprises, enterprises based on the digital economy, such as Internet and information service enterprises, consume less energy and have a lower carbon emission intensity while achieving the same economic benefits, and their economic greening degree is much higher than that of traditional manufacturing enterprises [26]. On the other hand, the digital economy can penetrate and be integrated into traditional industries, and it can be integrated with traditional production factors to change the production and operation mode of enterprises, stimulate the upgrading of low-end industries, reduce fossil energy consumption, and, thus, reduce the relative emissions of carbon dioxide [27,28].

In general, the existing literature mainly studies how the digital economy reduces carbon emissions, or it studies how the pilot policies of low-carbon cities promote regional technological innovation and promote high-polluting enterprises to move out and ultimately reduce regional carbon emissions. However, there is a lack of research on how the pilot policies of low-carbon cities affect the development of the digital economy and its mechanism. Therefore, the existing research results inspire thinking and provide a reference for this paper, but there is still room for further research. In view of this, this paper is based on the current relevant research and aims to expand on it by focusing on determining whether low-carbon pilot cities can promote the development of the digital economy. The possible innovations of this paper are as follows: First, this study starts with the pilot policies of low-carbon cities and discusses whether such pilot policies of low-carbon cities can promote the development of the digital economy from an empirical perspective. Second, this study attempts to reveal the influence mechanism of the low-carbon pilot cities promoting the development of the digital economy, and it verifies the mechanism through an empirical model to provide theoretical support for strengthening the construction of the digital economy. Third, this study examines the exogenous impact of the "low-carbon city pilot policy" and the application of this policy to establish whether the model has strong robustness.

3. Theoretical Mechanisms and Research Hypotheses

3.1. The Impact of Low-Carbon Pilot Cities on the Development of Digital Economy

After the conference in 1972 in Stockholm, most Western countries established special institutions and enacted laws and regulations in order to control or correct the vacancy caused by industrial behavior. The negative impacts of gas, soil, water, and other ecosystems resulted in the formation of environmental regulations [29]. The pilot areas use environmental regulations to reduce carbon intensity. On the one hand, from the perspective of the positive regulation of policies, in regions that implement pilot policies for low-carbon cities, local governments are bound to pay more attention to regional science and technology investment based on their actual conditions [30]. That is, local governments will encourage local enterprises to take the initiative to carry out scientific and technological innovation by means of financial subsidies, tax relief, and other incentives, thereby ultimately providing impetus for promoting the development of the digital economy in the region. On the other hand, from the perspective of the negative regulation of policies, low-carbon pilot cities put pressure on high-polluting and energy-consuming enterprises by means of carbon emission rights trading and the imposition of pollution fees, thus affecting the decision making of enterprises and forcing high-polluting enterprises to either transfer their industries or passively transform to low-pollution and digital production and operation modes so as to promote the development of the digital economy in the region [31]. Therefore, based on the above analysis, this paper proposes hypothesis H1, which is detailed below.

Hypothesis 1 (H1). *Low-carbon pilot cities can significantly promote the development of the regional digital economy.*

3.2. Low-Carbon Pilot Cities, Government Intervention, and Digital Economy Development

Government intervention is an important factor affecting the development of the digital economy and the development of the digital economy cannot be separated from government support [25]. The research conclusions of the existing literature on the effects of government intervention are not uniform; some scholars have affirmed that the financial allocation of the government plays a significant role in promoting the scale of economic development [32]. Some scholars have pointed out that direct intervention strategies based on the government's target assessment will lead to changes in the distribution of resources and the strategic innovation of enterprises, thus hindering the improvement of the quality of economic development [33]. Other scholars have suggested reducing the government's direct intervention in factor markets and emphasizing improving the level of market integration to promote high-quality economic development [34]. In this paper, it is argued that the pilot areas of the policy require a reduction in regional carbon emission intensity. Although there are no specific provisions on the measures that local governments should take, after the implementation of the policy, local governments will apply certain interventions according to the actual situation of the region and their own capabilities. The existing forms of government intervention are mainly manifested in increasing a series of government financial expenditures, such as science and technology expenditure, education expenditure, energy conservation and environmental protection expenditure, urban maintenance expenditure, and infrastructure construction expenditure, in the region. From the perspective of the intervention effect, on the one hand, it can enhance the overall scientific and technological level of the region and improve the research and development of digital-related core technologies [35]; on the other hand, it can enhance the level of regional infrastructure construction, including the construction of digital infrastructure, such as the construction of digital government platforms, digital traffic command platforms, and digital agricultural monitoring platforms. All of this will help to promote the development of the digital economy. Therefore, this paper proposes hypothesis H2, which is detailed below.

Hypothesis 2 (H2). *Government intervention is an important mechanism for low-carbon pilot cities to promote the development of the digital economy.*

3.3. Low-Carbon Pilot Cities, Industrial Structure Upgrading, and Digital Economy Development

The industrial structure is closely related to the development of the digital economy. In pilot areas, enterprises are required to change the traditional mode of production and management, that is, to upgrade the industrial structure and continuously transform in the direction of greening and digitalization [36]. In the pilot areas of low-carbon cities, local governments will influence the production and operation decisions of enterprises through a variety of market-oriented means, and the enterprises in the region will transform from traditional production enterprises to digital enterprises by relying on the Internet, cloud computing, and other technologies. To be specific, the industrial structure of low-carbon pilot cities will gradually transform from a traditional labor-intensive structure to a knowledge-intensive, technology-intensive, and capital-intensive structure, and the above industrial structure transformation mainly relies on the penetration and integration of the tertiary industry within the areas of digitalization and the digital economy as the main developmental body to the primary and secondary industries. Therefore, the development of industrial digitalization is influenced by the development level of the tertiary industry [37,38]. In general, this process of the continuous optimization of and increase in industrial structure, namely, the upgrading of industrial structure, promotes digital construction, and it will ultimately promote the development of the digital economy. Therefore, this paper proposes hypothesis H3, which is detailed below.

Hypothesis 3 (H3). *Industrial structure upgrading is an important mechanism for low-carbon pilot cities to promote the development of the digital economy.*

3.4. Low-Carbon Pilot Cities, Human Capital, and Digital Economy Development

Milgrom and Robert (1990) proposed that, under a production mode with high efficiency, there is complementarity among factors, and industry needs more than the input of a single key production factor. Therefore, in the digital economy industry, there is a rapid influx of information technology and capital, and the corresponding labor input is more inclined to high-skilled and high-quality talents. Therefore, in the process of digital economy development, the impact of talent team construction on economic growth should be more significant [39]. The low-carbon city pilot policy emphasizes that "it is necessary to strengthen the construction of low-carbon development capabilities and talent teams, focusing on the accumulation and training of talents in related fields." Therefore, in order to promote reductions in regional carbon dioxide emissions, local governments at all levels must strengthen the construction of local talent teams and increase investment in the training of scientific and technological talents so as to exchange relevant talents for the transformation of digital technology output that applies to the field of carbon emission reduction, thereby ultimately promoting the development of the local digital economy. At the same time, under the guidance of local policies, enterprises need to upgrade their technology, reduce carbon dioxide emissions, save production and operation costs, and improve the competitiveness of the industry, which will inevitably increase the demand for scientific and technological talents. Therefore, the low-carbon city pilot policy will increase the number of scientific and technological talents in the pilot areas [30]. The digital construction carried out by the pilot areas and local enterprises centering on the low-carbon goal needs to be supported by the construction of scientific and technological talents; that is, the higher the level of human capital, the faster the development of the digital economy based on digitalization in the region [40]. Therefore, this paper proposes hypothesis H4, which is detailed below.

Hypothesis 4 (H4). *Human capital is an important mechanism for low-carbon pilot cities to promote the development of the digital economy.*

Based on the formation mechanism of low-carbon city pilot policy and related research, the role mechanism of low-carbon city pilot policy in promoting the development of digital economy is determined, as shown in Figure 1.

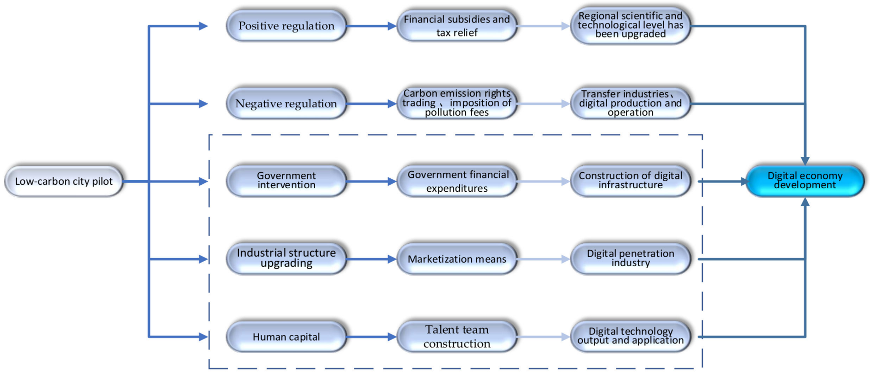

Figure 1. Map of the effects of low-carbon city pilot on the development of digital economy.

4. Study Design

4.1. Econometric Models

In this study, three batches of pilot policies of low-carbon cities were taken as a quasi-natural experiment. The multi-phase difference model (DID), which has been frequently used in the field of policy evaluation, was used to establish a benchmark model. The first, second, and third batches of low-carbon pilot cities were taken as the experimental group, while non-low-carbon pilot cities were taken as the control group, and the dummy variables for policy implementation were set. This study aimed to explore whether the low-carbon pilot cities can reverse the development of the digital economy. The benchmark measurement model is as follows:

$$Dig_{it} = \alpha_0 + \beta_0 DID_{it} + \varphi_0 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In the above model, α_0 is the intercept term. Dig_{it} represents the development level of the digital economy of city i in year t. DID_{it} is the dummy variable of the low-carbon city pilot policy, indicating whether city i implemented this policy in year t. If it was implemented, DID_{it} is 1; if it was not implemented, DID_{it} is 0. X_{it} represents the other control variables that may affect the development of the digital economy, including the level of economic development, technological innovation, urbanization, financial development, and trade openness. μ_i and λ_t represent the city fixed effect and the year fixed effect, respectively, and ε_{it} is a random disturbance term. In this model, the part that this study pays more attention to is β_0; that is, if β_0 is greater than 0 and passes the significance test, then it indicates that the low-carbon city pilot policy significantly promotes the development of the digital economy.

In order to further verify the mechanisms proposed by hypotheses H2, H3, and H4 above, the following mediation mechanism model is established in this paper:

$$W_{it} = \alpha_1 + \beta_1 DID_{it} + \varphi_1 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

$$Dig_{it} = \alpha_2 + \beta_2 DID_{it} + \theta_2 W_{it} + \varphi_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

In models (2) and (3) above, W_{it} represents the possible institutional variables, including government intervention, industrial structure, and human capital, with the rest being consistent with those in model (1). The presence of a mechanism variable can be demonstrated if β_1, β_2, and θ_2 are all significantly positive and if the β_2 coefficient decreases compared to model (1) β_0.

In order to test whether the parallel trend hypothesis is valid, this paper uses the practice of Beck [41] et al. The expression is shown in Equation (4):

$$Dig_{it} = \alpha_0 + \sum_{j=-6}^{6} \beta_j V_j + \varphi_0 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

Considering the large span of years before and after the implementation of the policy and the small number of samples in the first 6 years and the second 6 years after the implementation of the policy, this paper combines the data on the first 6 years of the implementation of the policy, as well as those on the second 6 years of the implementation of the policy. In equation (4) above, the subscript t is the year of the policy implementation, ranging from −6 to 6. A negative value represents before the policy implementation, while a positive value represents after the policy implementation. V_j is the dummy variable of the policy implementation, and V_{-j} represents the dummy variable of j years before the policy implementation. For the experimental group, the value is 1, and for the control group, the value is 0. V_j represents the dummy variable in the JTH year after the implementation of the low-carbon pilot policy. Similarly, if the city is in the experimental group, the value is 1, and the control group has a value of 0. In the formula, β_j represents the difference in the digital economy development in the t-year of policy implementation between the cities implementing low-carbon pilot programs and the cities not implementing low-carbon pilot programs, which is the focus of this part. The remainder of the formula is consistent with model (1).

4.2. Variable Selection

(1) Explained variable: digital economy development level (Dig). Based on the availability of relevant digital data within cities and the measurement ideas of Zhao et al., and Wei et al., this paper took the development of the Internet as the center of measurement [9,42]. The specific measurement method involved measuring the development level of the digital economy through a principal component analysis after the standardized dimensionality reduction processing of four indicators, namely, the Internet penetration rate, the number of employees in related industries, the output of related industries, and mobile phone popularity. In general, the actual contents of the above four indicators are as follows: the number of Internet broadband access users per 100 people, the proportion of computer and software employees in urban units, the total number of telecommunications services per capita, and the number of mobile phone users per 100 people at the end of the year.

(2) Core explanatory variable: low-carbon pilot city (DID). In this paper, the low-carbon pilot city was set as a dummy variable as the core explanatory variable of this study. If city i is approved as a low-carbon pilot city in year t, DID_{it} is 1; otherwise, DID_{it} is 0. As the low-carbon pilot cities were implemented in three batches in 2010, 2012, and 2017, some of the pilot cities had repeated approval. Therefore, this paper learned from the practice of Song et al. If a city had repeated approval, the first approval time of the city was set as the time of the implementation of the low-carbon pilot policy [43]. It should be noted that if a province is approved as a low-carbon pilot, all cities in that province are defined as low-carbon pilot cities.

(3) Control variables. Considering that other factors may also have an impact on the development of the digital economy, this paper also selected other control variables that may have an impact on the development of the digital economy. These mainly include the following: The financial development level (Fina): this is expressed by the logarithm of the annual deposit and loan balance of the financial institutions in each city. Openness: this is expressed by the logarithm of the total import and export volume of each city. The economic development level (GDP): this is expressed by the logarithm of the gross regional product. The technical innovation level (Inno): this is expressed by the logarithm of the number of authorized invention patents, utility model patents, and design patents in each year in the city added to the total. The urbanization level (Ur): this is expressed by the logarithm of the permanent population at the end of the year.

(4) Mechanism variable. In order to verify hypotheses H2, H3, and H4 proposed above, the following mediation variables were selected in this paper: Government intervention (Gov): the annual fiscal expenditure of the local governments in each city is used to represent the degree of government intervention in environmental governance and digital economy development. Industrial structure (IS): the proportion of the added value of the tertiary industry in GDP is expressed, which means that the low-carbon pilot city will affect the upgrading of industrial structure and, thus, the development of the digital economy. Human capital (Hum): this is used to verify the impact of changes in human capital on the development of the digital economy, expressed by the year-end numbers of research, technical service, and geological survey workers.

4.3. Data Sources and Descriptive Statistics

This paper used the panel data of 284 prefecture-level cities in China from 2007 to 2020. In view of the availability of data and regional economic and cultural differences, data on cities in Tibet, Hong Kong, Macao, and Taiwan were not included in the experimental group. Data related to the development of the digital economy in prefecture-level cities (the number of Internet broadband access users, the number of computer and software employees, the total amount of telecommunications business, and the number of mobile phone users at the end of the year), control variables, and mechanism variables were mainly from China City Statistical Yearbook. To fill in the small amount of missing data, this paper combined the Statistical Bulletin of National Economic and Social Development of each city and used the linear interpolation method. The descriptive statistics of all the variables used in this paper are shown in Table 1 below.

Table 1. Implication variables and descriptive statistics.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Variable Symbol	**Variable Name**	**Sample Number**	**Mean Value**	**Standard Deviation**	**Minimum Value**	**Maximum Value**
Explained variable	Dig	Digital economy development	3976	1.685	1.230	0.150	13.294
Core explanatory variable	DID	Low-carbon pilot city	3976	0.247	0.431	0.000	1.000
Control variable	Inno	Technological innovation level	3976	6.901	1.779	1.609	12.310
	GDP	Level of economic development	3976	7.167	0.991	4.124	10.564
	Fina	Financial development level	3976	7.907	1.185	4.607	12.477
	Open	Degree of opening up	3969	4.783	2.119	−2.904	10.459
	Ur	Urbanization level	3976	5.879	0.701	2.797	8.136
Mechanism variable	Gov	Government intervention	3976	351.425	597.22	3.594	8607.032
	Hum	Human capital	3976	1.244	4.133	0.3	71.710
	IS	Industrial structure	3976	40.114	10.044	8.580	83.870

5. Results

5.1. Baseline Regression Results

According to the benchmark regression model constructed in Formula (1) above, this section specifically analyzes the impact of low-carbon pilot cities on the development of the digital economy, and the benchmark regression results are shown in Table 2 below. Columns (1) and (2) of Table 2 list the regression results of the fixed effect of control time. No control variable is added to column (1), and no control variable is added to column (2). It can be seen that the differential coefficient is positive and significant. Columns (3) and (4) list the regression results of the fixed effect of the control individual, in which no control variable is added to column (3), and no control variable is added to column (4); furthermore, the differential coefficients are both positive and significant. Columns (5) and (6) list the regression results of control time and individual fixed effects. Column (5) shows the results without the addition of the control variables, and column (6) shows the results with the addition of the control variables. The coefficients of difference β_0 are 0.144 ($p < 0.05$) and 0.125 ($p < 0.05$), respectively. Although the coefficient and significance level of the differential term in the regression results decreased, all the estimation results show that the pilot policies of low-carbon cities played a positive role in promoting the development of the digital economy. Therefore, hypothesis 1 is valid; that is, the pilot policies of low-carbon cities have promoted the development of the digital economy.

Table 2. Baseline regression results.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	**Dig**	**Dig**	**Dig**	**Dig**	**Dig**	**Dig**
DID	0.165 ***	0.167 ***	0.802 ***	0.191 ***	0.144 **	0.125 **
	(0.0614)	(0.0604)	(0.0643)	(0.0578)	(0.0611)	(0.0593)
Inno		−0.0655 *		0.0317		−0.101 ***
		(0.0344)		(0.0339)		(0.0354)
GDP		0.245 ***		0.0786		0.179 *
		(0.0950)		(0.0889)		(0.102)
Fina		0.454 ***		0.541 ***		−0.0695
		(0.0838)		(0.0699)		(0.103)
Open		0.0711 ***		0.0249		−0.0108

Table 2. *Cont.*

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	**Dig**	**Dig**	**Dig**	**Dig**	**Dig**	**Dig**
		(0.0276)		(0.0328)		(0.0351)
Ur		−0.607 ***		−0.302		−0.0508
		(0.179)		(0.586)		(0.605)
Constant	1.034 ***	−0.0854	1.487 ***	−1.767	1.034 ***	1.259
	(0.0538)	(0.634)	(0.0159)	(3.360)	(0.0269)	(3.541)
Time fixed effect	Yes	Yes	No	No	Yes	Yes
Individual fixation effect	No	No	Yes	Yes	Yes	Yes
Observations	3976	3969	3976	3969	3976	3969
R-squared	0.455	0.442	0.162	0.412	0.455	0.459
Number of Id	284	284	284	284	284	284

Note: ***, **, and * represent 1%, 5%, and 10% significance levels. Parenthesis values are robust standard error of clustering to city. Values in brackets are robust standard errors for clustering to cities.

5.2. Parallel Trend Test

The prerequisite for the establishment of the differential model is to satisfy the parallel trend hypothesis of the experimental group and the control group. Figure 2 reports the results of the parallel trend test.

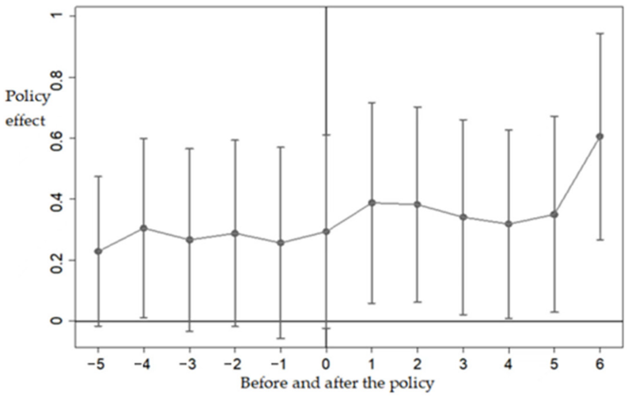

Figure 2. Parallel trend test.

As shown in Figure 2, before the implementation of the policy, most regression result coefficients were not significant, indicating that there is no significant difference in the development of the digital economy between the cities that implement low-carbon pilot programs and the cities that do not. In the year of the implementation of the policy, there was no significant difference. However, from the first year after the implementation of the policy, the pilot cities and non-pilot cities showed significant differences in the development of the digital economy, indicating that the effect of the pilot policies may have a certain lag. So, on the whole, the parallel trend test of the digital economy development was passed.

5.3. Robustness Test

5.3.1. Placebo Test

In the causal relationship between the low-carbon city pilot policies and the development of the digital economy, there may be other interference factors. Therefore, this section aims to exclude the influence of other possible random interference factors on the estimation results and ensure that the development of the digital economy is driven by the low-carbon city pilot policy. In this paper, 123 cities were randomly selected as virtual pilot cities, and the remaining 161 cities were selected as virtual non-pilot cities. Furthermore, repeated sampling was conducted 500 times for a placebo test. Since the experimental samples were randomly selected, the coefficients of the different factors of the placebo test should mostly approach 0 and not be significant. Figure 3 reports the estimated coefficients and their p-value distributions for the 500 replications of the placebo test. As shown in the distribution of the estimated coefficients in Figure 3, most of the estimated coefficients obtained via random sampling are near 0, and the *p*-values of most of the estimated coefficients are greater than 0.1, which meets the estimation expectations of the placebo test, indicating that the development of the digital economy is not caused by random interference factors. Therefore, the placebo test was passed, and the results obtained by the above benchmark regression are robust.

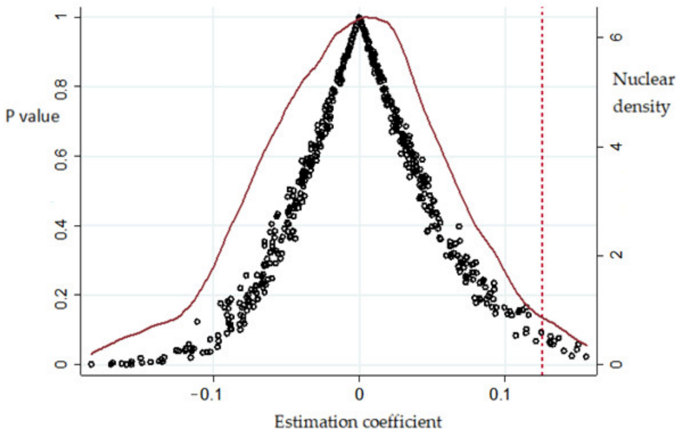

Figure 3. Placebo test.

5.3.2. Changing the Calculation Method of the Explained Variable

In order to further ensure the robustness of the benchmark regression results, a robustness test was carried out by changing the calculation method of the explained variables. In the baseline regression, the explained variable digital economy development (Dig) was measured using a principal component analysis. In this section, a new digital economy development index (Dig_2) was calculated after the standardized dimensionality reduction of the four indicators, namely, the Internet penetration rate, the number of employees in related industries, the output of related industries, and mobile phone popularity, using the entropy method, and then it was put into the benchmark regression model of formula (1) for estimation. The estimation results are reported in columns (1) and (2) of Table 3 below. As shown in columns (1) and (2) of Table 3, the coefficients of the differential terms are 0.00734 and 0.00661, respectively, and both of them pass the significance test level of at least 10%. Therefore, the conclusion obtained by combining the results of the baseline regression is robust.

Table 3. Robustness test.

	(1)	(2)	(3)	(4)	(5)
	Change the Explained Variable	**Change the Explained Variable**	**Tail Reduction Treatment**	**Tail-Breaking Treatment**	**Exclude the Municipalities Directly under the Central Government**
Explained Variable	**Dig_2**	**Dig_2**	**Dig**	**Dig**	**Dig**
DID	0.00734 *	0.00661 *	0.0987 **	0.0898 *	0.111 *
	(0.00402)	(0.00395)	(0.0479)	(0.0458)	(0.0589)
Inno		−0.00332 *	−0.0934 ***	−0.0931 ***	−0.0883 **
		(0.00201)	(0.0302)	(0.0304)	(0.0342)
GDP		0.0139 **	0.0752	0.0428	0.170 *
		(0.00570)	(0.0819)	(0.0774)	(0.100)

Table 3. *Cont.*

	(1)	(2)	(3)	(4)	(5)
	Change the Explained Variable	Change the Explained Variable	Tail Reduction Treatment	Tail-Breaking Treatment	Exclude the Municipalities Directly under the Central Government
Explained Variable	Dig_2	Dig_2	Dig	Dig	Dig
Fina		−0.000708	−0.0405	−0.0407	−0.0312
		(0.00634)	(0.0789)	(0.0771)	(0.101)
Open		0.000182	0.00792	0.0141	−0.00822
		(0.00192)	(0.0291)	(0.0280)	(0.0356)
Ur		−0.0465	−0.0995	0.00527	−0.105
		(0.0482)	(0.250)	(0.232)	(0.606)
Constant	0.0574 ***	0.262	1.864	1.363	1.271
	(0.00175)	(0.279)	(1.528)	(1.438)	(3.523)
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Individual fixation effect	Yes	Yes	Yes	Yes	Yes
Observations	3976	3969	3969	3811	3913
R-squared	0.405	0.412	0.543	0.545	0.461
Number of Id	284	284	284	282	280

Note: ***, **, and * represent 1%, 5%, and 10% significance levels.

5.3.3. Elimination of Extremes

Outliers may have an impact on the estimation results of the baseline regression. In order to eliminate this possible impact, this paper included the development of the digital economy to reduce and break the tail of the sample by 2%. The estimation method is the same as that of baseline regression. As shown in columns (3) and (4) of Table 3, the coefficients of the differential terms after the tail reduction treatment and tail-breaking treatment are all positive and pass the significance test level of at least 10%. Therefore, the conclusion obtained by analyzing the baseline regression results is robust.

5.3.4. Exclusion of Special Cities

The higher administrative level, special political status, and economic development level of the municipalities directly under the central government, as well as the greater differences in the economic development level, the technological innovation level, the degree of opening to the outside world, human capital, and other aspects compared with other ordinary prefecture-level cities, including the samples in the estimation, may lead to deviations in the estimation results. Therefore, this study excluded the samples of municipalities directly under the central government for re-estimation in order to verify the robustness of the baseline regression results. The estimation results are shown in column (5) of Table 3. After removing the sample data of municipalities directly under the central government, the estimation results of the differential terms were also found to be positive and significant, which further proves the robustness of the baseline regression estimation results.

5.3.5. Excluding the Influence of Other Policies at the Same Time

After sorting out the relevant policies, it was found that, while implementing the pilot policies of low-carbon cities, there are other policies that may affect the development of the digital economy. Among them, there are two policies that are most likely to affect the development of the digital economy, namely, the “smart city pilot” and the “wideband pilot” policies. In order to avoid the influence of the two policies on the low-carbon pilot cities, dummy variables of the two policies, namely, pilot city and pilot time, respectively, were added into the benchmark regression model, and regression was conducted for the interaction terms of the two variables. The estimation results are shown in columns (2) and (3) of Table 4. Column (2) of Table 4 reports the estimation results after adding the “smart pilot city” policy. As can be seen in the estimation results, the interaction term of the low-carbon pilot city is still positive and passes the significance test level of 5%, while the interaction term coefficient of the smart city pilot policy is positive but fails the significance test. Therefore, it is estimated that the pilot policies of low-carbon cities promote the development of the digital economy. However, whether the pilot policies of smart cities promote the development of the digital economy is not fully verified in this paper. In Table 4, column (3) reports the estimation results after adding the "wideband China pilot" policy. The estimated coefficient of the wideband China pilot policy is 0.269, and it is significantly positive, passing the significance test level of at least 1%, indicating that the wideband China pilot policy significantly promotes the development of the digital economy. At the same time, the estimated coefficient of the low-carbon pilot city is 0.118, which is decreased but still positive, and it passes the significance test level of 5%, indicating that both the broadband China pilot and the low-carbon city pilot policies are driving factors for the development of the digital economy, and the robustness of the conclusions obtained from the baseline regression estimation is further verified.

Table 4. Robustness test.

	(1)	(2)	(3)
	Dig	**Dig**	**Dig**
DID	0.125 **	0.128 **	0.118 **
	(0.0593)	(0.0586)	(0.0584)
Widehand			0.269 ***
			(0.0723)
Smart city		0.102	
		(0.0640)	
Inno	−0.101 ***	−0.0980 ***	−0.0797 **
	(0.0354)	(0.0356)	(0.0348)
GDP	0.179 *	0.167	0.150
	(0.102)	(0.101)	(0.0984)
Fina	−0.0695	−0.0687	−0.0648
	(0.103)	(0.104)	(0.103)
Open	−0.0108	−0.0127	−0.0144
	(0.0351)	(0.0351)	(0.0341)
Ur	−0.0508	−0.0492	−0.192
	(0.605)	(0.602)	(0.607)
Constant	1.259	1.316	2.145
	(3.541)	(3.533)	(3.560)
Time fixed effect	Yes	Yes	Yes
Individual fixation effect	Yes	Yes	Yes
Observations	3969	3969	3969
R-squared	0.459	0.461	0.470
Number of Id	284	284	284

Note: ***, **, and * represent 1%, 5%, and 10% significance levels.

5.4. Test of Mechanism of Action

According to the mechanism analysis above, low-carbon pilot cities may promote the development of the digital economy through government intervention, industrial structure upgrading, and human capital. In this section, the existence of these mechanisms is specifically tested based on models (2) and (3) established above.

5.4.1. Government Intervention

Government intervention (Gov) as an intermediary variable was brought into models (2) and (3) for regression. The regression results are shown in columns (1) and (2) of Table 5 below. Column (1) shows the impact of the low-carbon pilot program on government fiscal expenditure. The coefficient of the differential term is positive and passes the significance test, indicating that the low-carbon pilot program has significantly promoted the increase in government fiscal expenditure. However, in the estimation results in column (2), the coefficient of the differential item is no longer significant, but the estimated coefficient of the government fiscal expenditure item is still significantly positive, indicating that there may be a complete intermediary effect. That is to say, the impact of low-carbon pilot construction on the development of the digital economy is realized by promoting an increase in government fiscal expenditure. Hypothesis 2 is verified, indicating that government fiscal expenditure is the intermediary mechanism between low-carbon pilot cities and digital economy development, and the promotion effect of low-carbon pilot cities on digital economy development is realized through increasing government fiscal expenditure.

5.4.2. Upgrading of Industrial Structure

The industrial structure upgrading (IS) variable was brought into models (2) and (3) as an intermediary variable. The estimation results are reported in columns (3) and (4) of Table 5. In Table 5, column (3) lists the result of estimating industrial structure upgrading as the explained variable. As can be seen in the estimation result, although the coefficient of the pilot item of the low-carbon city is positive, it does not pass the significance test level, indicating that the low-carbon pilot city has not significantly enhanced the proportion of the tertiary industry. Therefore, hypothesis 3 is not valid. Industrial structure upgrading is not an intermediary mechanism between low-carbon pilot cities and digital economy development. However, according to the estimation results in column (4), the upgrading coefficient of industrial structure is significantly positive, indicating that the upgrading of industrial structure is one of the factors promoting the development of the digital economy. The higher the proportion of the tertiary industry in the total economic development, the higher the development level of the digital economy. However, the intermediary mechanism of industrial structure upgrading is not verified in this paper.

5.4.3. Human Capital

Human capital (Hum) was taken into the model as an intermediary variable for estimation. The estimation results are shown in columns (5) and (6) of Table 5 below. Column (5) takes human capital as the explained variable and the low-carbon pilot city as the core explanatory variable. It can be seen in the estimation results that low-carbon pilot cities significantly promote the growth of human capital. By observing the estimation results in column (6), we can see that the coefficient of differential coefficients of the low-carbon pilot cities is no longer significant, but the estimated coefficient of human capital is still positive and passes the significance test, indicating that there is a complete intermediary effect; that is, the development of the digital economy is completely realized through the promotion of human capital growth by the low-carbon city pilot policy. Hypothesis 4 is verified, indicating that human capital is the intermediary mechanism between low-carbon pilot cities and digital economy development.

Table 5. Test of mechanism of action.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Explained Variable	**Gov**	**Dig**	**IS**	**Dig**	**Hum**	**Dig**
DID	124.0 ***	0.0759	0.0758	0.124 **	0.574 ***	0.0596
	(38.56)	(0.0562)	(0.353)	(0.0592)	(0.178)	(0.0562)
Gov		0.000394 **				
		(0.000167)				
IS				0.00764 *		
				(0.00455)		
Hum						0.113 ***
						(0.0236)
Constant	−6606 ***	3.859	42.62 ***	0.934	−22.00 ***	3.755
	(2353)	(3.459)	(10.79)	(3.451)	(7.859)	(3.628)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Urban fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3969	3969	3969	3969	3969	3969
R-squared	0.397	0.480	0.786	0.460	0.135	0.494
Number of Id	284	284	284	284	284	284

Note: ***, **, and * represent 1%, 5%, and 10% significance levels.

5.5. Further Analysis

5.5.1. Urban Location Heterogeneity

The above study analyzed the overall impact of low-carbon pilot cities on the development of the digital economy, but this overall impact may cover up regional heterogeneity. China has a vast territory, and the various regions differ greatly in terms of economic development foundation, urban infrastructure, digital infrastructure construction, resource endowment and government emphasis, etc. All these differences may have a heterogeneous impact on the development of the digital economy. In view of this, this paper divided urban samples according to geographical location into four regions, namely, the eastern region, western region, central region, and northeast region. The four regions were analyzed to study the influence of regional factors on the development of the digital economy. The regression results are shown in Table 6. The estimation results show that the low-carbon pilot cities play a significant positive role in the development of the digital economy in the eastern region, while the low-carbon pilot cities do not play a significant role in promoting the development of the digital economy in the central and western regions. The possible reasons for this are that the eastern region has a relatively high level of economic development at its foundation, which can attract more innovative and entrepreneurial projects and talents. Meanwhile, the urban infrastructure and digital infrastructure are relatively complete, which can provide favorable conditions for the development of the digital economy. However, in the central and western regions and northeast China, where the economic development and urban infrastructure development levels are relatively low, low-carbon pilot cities do not significantly promote the development of the digital economy. Therefore, in contrast, low-carbon pilot cities can significantly promote the development of the digital economy in the eastern region.

Table 6. Bit heterogeneity analysis.

	Eastern	Central	Western	Northeastern
Explained Variable	**Dig**	**Dig**	**Dig**	**Dig**
DID	0.185 *	0.0459	0.149	0.141
	(0.108)	(0.100)	(0.109)	(0.168)
Constant	4.175	3.542	1.286	−3.797
	(17.36)	(2.534)	(3.243)	(5.485)
Control variable	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes
Urban fixed effect	Yes	Yes	Yes	Yes
Observations	1204	1120	1169	476
R-squared	0.898	0.714	0.772	0.764

Note: * represent 10% significance levels.

In addition, this paper also analyzed the heterogeneity of the mechanism in geographical location. The estimation results are shown in Tables 7 and 8 below. Table 7 reports the estimation results of government intervention as an intermediary mechanism. As can be seen in the estimation results, in the eastern region, the low-carbon city pilot policy promoted government fiscal expenditure, the increase in fiscal expenditure promoted the development of the digital economy, and the intermediary mechanism of government intervention was established. In the central and northeastern regions, the low-carbon city pilot policies did not lead to a significant increase in government fiscal expenditure, so the intermediary mechanism of government intervention was not established. In the western region, although the low-carbon city pilot policy promoted an increase in government fiscal expenditure, the fiscal expenditure did not promote the development of the digital economy, so the intermediary effect of government intervention was not established. In the eastern region, most of the pilot cities are located in the coastal areas, and industrial development occurred early and is complete, which promotes regional economic development. In the context of the national promotion of green, sustainable, and high-quality economic development, local governments are bound to increase fiscal expenditure year by year, thus providing a large number of digital infrastructure platforms for the digital development of regional industries and ultimately promoting the development of the regional digital economy. In the central and northeastern regions, most of the pilot areas have net population outflow from the cities and relatively slow economic growth, and the construction of public service infrastructure is not sound, so the government's financial expenditure for the construction of digital infrastructure is not significant. In the western region, the population is sparse, the primary industry accounts for a high proportion, and the economic growth rate in recent years is much higher than that in the northeast region, so the fiscal expenditure is relatively obvious but limited by the low-level industrial structure, the fiscal expenditure did not significantly promote the development of the regional digital economy.

Table 7. Heterogeneity analysis of mechanism of action.

	Eastern	**Eastern**	**Central**	**Central**	**Western**	**Western**	**Northeastern**	**Northeastern**
Explained Variable	**Gov**	**Dig**	**Gov**	**Dig**	**Gov**	**Dig**	**Gov**	**Dig**
Gov		0.0004 **		0.0016 **		0.000175		0.0014 **
		(0.00017)		(0.00065)		(0.00015)		(0.00054)
DID	130.2 *	0.132	8.031	0.0327	102.1 **	0.131	−11.38	0.157
	(75.76)	(0.104)	(40.02)	(0.0779)	(42.15)	(0.109)	(37.70)	(0.148)
Constant	−18,205 ***	11.46	−2665 ***	7.916 ***	−4358 ***	2.048	−4275 **	2.082
	(5788).	(19.49)	(943.7)	(2.167)	(1416)	(2.947)	(1805)	(3.641)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Urban fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1204	1204	1120	1120	1169	1169	476	476
R-squared	0.873	0.904	0.842	0.772	0.833	0.773	0.904	0.781

Note: ***, **, and * represent 1%, 5%, and 10% significance levels.

Table 8. Heterogeneity analysis of mechanism of action.

	Eastern	**Eastern**	**Central**	**Central**	**Western**	**Western**	**Northeastern**	**Northeastern**
Explained Variable	**Hum**	**Dig**	**Hum**	**Dig**	**Hum**	**Dig**	**Hum**	**Dig**
Hum		0.092 ***		0.591 ***		0.196 ***		−0.0344
		(0.024)		(0.193)		(0.0283)		(0.0947)
DID	0.585 *	0.131	0.148	−0.0415	0.372 **	0.0761	0.199 *	0.148
	(0.314)	(0.101)	(0.124)	(0.0863)	(0.174)	(0.102)	(0.113)	(0.161)
Constant	−69.00 ***	10.52	−6.015 *	7.099 ***	−17.30	4.671 *	−0.393	−3.810
	(20.54)	(18.33)	(3.332)	(1.928)	(14.56)	(2.705)	(5.613)	(5.471)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Urban fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1204	1204	1120	1120	1169	1169	476	476
R-squared	0.948	0.905	0.919	0.805	0.908	0.795	0.959	0.765

Note: ***, **, and * represent 1%, 5%, and 10% significance levels.

Table 8 reports the estimation results of a heterogeneity analysis using human capital as an intermediary effect. As the estimates show, the low-carbon city pilot policies have contributed to an increase in human capital in the eastern and western regions and, thus, to the development of the regional digital economy. Therefore, the intermediary effect of human capital only exists in the eastern and western regions and not in the central and northeast regions. In this paper, most pilot cities in the eastern region are economically developed and have a high level of urban development. There are many colleges and universities for talent training, and most college graduates and young people choose to settle in the eastern region because of the numerous development opportunities, thus promoting the construction of regional talent teams and further promoting the development of the regional digital economy. In the western region, although most of the pilot cities are vast and sparsely populated, in recent years, with the promotion of the western development strategy, there are quantitative talents in various fields flowing into the western region every year. In particular, in recent years, the construction of talent teams in the western region has promoted the automation and digitalization of regional agricultural planting and agricultural product processing, and the use of digital platforms for agricultural product sales has played a significant role in promoting the development of the regional digital economy.

5.5.2. Heterogeneity of Urban Development Types

The development of the different cities in China depends on different factors, that is, the economic base, infrastructure, and resource endowment of different regions. Therefore, the following question is raised: does the promoting effect of low-carbon pilot cities on the development of the digital economy vary among cities of different development types? According to the Notice of The State Council on Printing and Distributing the National Plan for Sustainable Development of Resource-Based Cities (2013–2020) issued by China in 2013, urban development in China can be divided into resource-based cities and non-resource-based cities. In view of this, this paper also analyzed the heterogeneity of cities with different development types, and the estimation results are reported in Table 9. As the estimates show, the low-carbon pilot cities did not promote the digital economy in resource-based cities, but they did in non-resource-based cities. The possible reason for this is that the development of non-resource-based cities is more dependent on knowledge-intensive and high-tech-intensive industries. After the implementation of the low-carbon pilot policy, the regional digital technology level was further promoted, and the application of digital technology was further promoted, thus promoting the development of the regional digital economy.

Table 9. Heterogeneity of urban development types.

	Resource-Based City	**Non-Resource-Based City**
Explained Variable	**Dig**	**Dig**
DID	0.0253	0.133 *
	(0.0545)	(0.0731)
Constant	3.553 ***	0.556
	(1.301)	(6.566)
Control variable	Yes	Yes
Time fixed effect	Yes	Yes
Urban fixed effect	Yes	Yes
Observations	1589	2380
R-squared	0.717	0.875

Note: ***, and * represent 1%, and 10% significance levels.

6. Discussion

This paper comprehensively studied the impact and mechanism of low-carbon pilot cities on the development of the digital economy. This paper took China as the research object; divided it into eastern, central, western, and northeastern regions to study the mechanism and location heterogeneity; and further divided it into resource-based cities and non-resource-based cities to study heterogeneity so as to obtain accurate conclusions. Compared with the previous studies on the influencing factors of digital economy development [13,20,21], this paper innovatively considered low-carbon pilot cities as an influencing factor. For China as a whole, the benchmark regression results showed that the pilot areas of low-carbon cities play a significant role in promoting regional digital economy development compared with non-pilot areas. In the mechanism test, only the mediating effects of government intervention and human capital were verified, similar to the research conclusions of many scholars [27,30,35]. In addition, the finding regarding the role of human capital in economic development is similar to that found by Partha Dasgupta, who mentioned that China's accumulation of human capital can promote sustainable economic development [3]. Although the intermediary effect of industrial organization upgrading was not proven, it was found through an analysis of the test results that the coefficient of industrial structure upgrading affecting the development of the digital economy was significantly positive, and the higher the proportion of the tertiary industry, the more obvious its promoting effect on the development of the digital economy, which is consistent with previous research conclusions [17–19]. At present, Chinese industries are undergoing transformation and upgrading. Compared with the primary and secondary industries, the tertiary industry accounts for a higher proportion of the use of digital technologies. Therefore, the industrial structure with a higher proportion of the tertiary industry plays an obvious role in promoting the development of the digital economy in the role of the low-carbon city pilot policy.

7. Conclusions and Policy Implications

7.1. Conclusions

(1) The development of the digital economy is significantly affected by the pilot policies of low-carbon cities; that is, the implementation of the pilot policies of low-carbon cities can significantly promote the development of the regional digital economy. Specifically, compared with cities that have not implemented low-carbon city pilot policies, after adding control variables and control bidirectional fixed effects to the policy pilot cities, the coefficients of the differential term β_0 were 0.144 ($p < 0.05$) and 0.125 ($p < 0.05$), respectively, and this hypothesis remained valid after a parallel trend test and a placebo test. The above conclusions validate research hypothesis H1, which also means that, after the implementation of the pilot policy of low-carbon cities in China, the positive guidance and negative guidance can indirectly promote the improvement of the digital economy level in the pilot areas.

(2) The influence of low-carbon pilot cities on the digital economy has regional heterogeneity. However, from the regional perspective, the pilot policy of low-carbon cities has a significant positive effect on the development of the digital economy in the eastern region, whereas it has a promoting effect on the development of the digital economy in the other regions, but it is not significant. This may be due to the high level of economic development and the relatively perfect digital infrastructure in the eastern coastal areas of China, which provide good conditions for the development of the digital economy.

(3) The low-carbon city pilot policy promotes the development of the digital economy through government intervention. Specifically, low-carbon pilot cities can promote the development of the digital economy through government interventions, such as increasing science and technology expenditure, infrastructure construction expenditure, and tax relief, which verifies research hypothesis H2 in this paper and demonstrates the mediating effect of government intervention. However, its mediating effect is only significant in eastern China, and although it exists, it is not significant in the other regions. This may be caused by the preferential implementation of the pilot policies in the economically developed cities in the east in recent years, the continuous intervention of the government, and the continuous increase in financial investment by the government.

(4) Low-carbon pilot cities can promote the development of the digital economy through human capital. Specifically, for the path of "low-carbon city pilot policy → human capital → digital economy development", the mediating effect of human capital is more significant in the eastern and western regions of China than in the other regions. In addition, hypothesis H4 in this paper was not verified in empirical studies, which may be due to the fact that China is currently in the process of upgrading its industrial structure, and the industrial use of digital technology is low, but it is certain that an advanced industrial structure can promote high-quality economic development.

7.2. Policy Implications

Based on the above research conclusions, the following policy recommendations are put forward:

First, it is necessary to evaluate the effects of policies in a timely manner, adjust policies according to the policy environment in different regions, and enhance the adaptability and pertinence of policies. In the implementation process of pilot policies, the concept of green development should be implemented, the overall level of digital technology should be promoted and applied in the region, and regional high-polluting enterprises should be guided to actively transform to the digital production and management mode so as to realize the rapid development of the regional digital economy.

Second, we should conduct appropriate government interventions, respect the objective laws of market development, and intervene in line with market trends. The government should focus on the internal driving forces of regional economic development, not limited to the micro level of guidance to production enterprises, and it should actively promote the construction of regional digital infrastructure at the macro level to provide the impetus for the overall transformation to digital policy pilot areas, thereby achieving a win–win situation of digital economic development and regional carbon emission intensity reduction.

Third, it is necessary to coordinate industrial planning and promote the digitalized tertiary industry to actively penetrate and integrate into the primary and secondary industries. To carry out the strategy of sustainable development, traditional high-pollution production enterprises should optimize their production and management mode by combining digital technology, giving full play to the advantages of digital technology in the whole process of production and management, and realizing the green production and management of enterprises. The low-carbon city pilot policy has really become a powerful driving force promoting the development of traditional industries in the direction of digitization.

Fourth, we should rely on the pilot policies of low-carbon cities, strengthen the construction and training of digital technical talents, intensify the reform of the household registration system, accelerate the accumulation of high-tech human capital in cities, and provide a sufficient foundation for technical and human resources for the development of the regional digital economy and the overall digital economy.

7.3. Limitations and Future Research

On the basis of previous studies, this paper innovatively puts forward the influence and mechanism of low-carbon city pilot policies on the development of the digital economy for the first time and provides empirical evidence. However, there are still some limitations, as well as room for further research involving several aspects. Firstly, it is necessary to pay attention to the impact mechanism of low-carbon city pilot policies on micro-enterprises' digital transformation. Secondly, the level of regional digital development could be measured, and the influence of the level of digital development on the development of the regional digital economy could be explored.

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