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# RETRACTED: Digital economy enables common prosperity: Analysis of mediating and moderating effects based on green finance and environmental pollution

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This study aims to explore the impact of the digital economy on common prosperity. For this reason, a bidirectional fixed effect model based on panel data of 30 provinces (cities and autonomous regions) in China is empirically tested. The results show that the digital economy can significantly improve the level of common prosperity, and has a positive impact on green and sustainable economic activities such as promoting environmental improvement, coping with climate change and resource conservation and efficient utilization, which is still valid after a series of robustness tests. It also demonstrates the role of green finance as a partial intermediary in the process of shared prosperity and as a negative regulator of environmental pollution. Analysis of regional heterogeneity shows that the enabling effect of the digital economy on common prosperity is more significant in eastern and central provinces, but not significant in western provinces. The results of this study have some reference significance for some countries, where the gap between rich and poor has widened during the epidemic, to narrow the income gap and provide ideas for the parties that made commitments at the Glasgow Climate Summit (COP26) to curb warming and reduce CO<sub>2</sub> emissions. That is, continuous improvement of digital infrastructure; emphasis on the intermediary role of green finance and the negative regulating role of local environmental pollution levels; following the relative comparative advantages of regions and formulating differentiated policies for the development of the digital economy, etc.

## KEYWORDS

digital economy, common prosperity, green finance, environmental pollution, carbon emission reduction, COP26

## 1 Introduction

“Narrowing the gap between rich and poor and promoting common prosperity” is the essential demand of people all over the world. Since 2020, the world has been severely impacted by the COVID-19 epidemic, the economic situation and structure have become chaotic and complex, the income gap of people at all levels has further widened, and the distribution of social welfare has been uneven for a long time (Binns and Low, 2021). How to improve social welfare and promote equitable social distribution has become an urgent issue for governments around the world. Since the reform and opening-up, China’s national policy has shifted from

the traditional simultaneous prosperity to a part of getting rich first, while driving common prosperity. In terms of policy orientation, it is “Efficiency First, Consideration to Fairness.” As a result, China’s economy has grown rapidly. Meanwhile, the gap between the rich and the poor in China continues to widen with a Gini coefficient of about .45, which measures the gap between the rich and the poor, exceeding the United Nations’ warning line of .40. The income gap between different groups exists for a long time and is at a high level, and there is a risk of falling into the “middle-income trap” (Liu et al., 2022). In recent years, China has gradually entered the era of digital economy. The concept of “Common Prosperity” and a series of measures to narrow the gap between rich and poor has been formally proposed to promote equitable distribution. Even under the influence of the epidemic, these policies have also achieved remarkable results. Therefore, the various measures and experiences of the Chinese government on how to guide the healthy development of the domestic economy and promote the process of common prosperity are undoubtedly worth learning from all countries in the world.

In 2021, President Xi Jinping, as China’s most authoritative leader, once again emphasized the urgency of achieving common prosperity and the importance of finance as the core of the modern economy at the Central Finance and Economics Commission. The Central Finance and Economics Committee is known to be an important institutional arrangement for the Chinese Party Central Committee to lead the economic work and has important guidance on the direction and policies of economic development, and the themes of the meetings have basically become the focus of subsequent economic work. As an extension and breakthrough of the traditional financial system, the digital economy has effectively alleviated the shortcomings and drawbacks of the traditional Chinese financial system and has become an important part of the modern financial system. The White Paper on Digital Ecological Industry Boosting the Development of Common Prosperity pointed out that “developing digital economy is a feasible path to achieve common prosperity.” China’s entry into the stage of common prosperity coincides with the era of the digital economy (Xia and Liu, 2021). The innovation effect, spillover effect, synergy effect, and inclusive effect caused by the digital economy provide a sharing mechanism for balanced development and promote the whole society to share the dividend of the digital economy (Rihui, 2022). It can be seen that the digital economy provides a feasible way to transform the national economic structure, and it is considered an important basis for achieving the goal of common prosperity. In this context, an in-depth exploration of the impact of China’s digital economy development on common prosperity and related issues will not only help to deeply tap the value and potential of the digital economy in the process of promoting common prosperity, and promote the high-quality development of the digital economy but also have an important reference significance for countries around the world that have been widening the gap between rich and poor in the epidemic to narrow the income gap and achieve common prosperity for all.

## 2 Literature review

In recent years, the digital economy, including AI, Quantum Information, Blockchain, IoT, and 5G mobile network, has played an increasingly important role in the national economy with the development of the Internet. The continuous integration of digital

technology and the real economy has spawned many new models, but also led to the upgrading of the industrial structure (Su, et al., 2021) and the transformation of the economic development mode (Ahn, 2020). Numerous studies have conducted relevant research mainly in the following directions: first, in economic finance, Wang and Zhang (2022) used a mediating effects model, a threshold regression model and a spatial Durbin model to demonstrate that the digital economy is an important path for environmental regulation to strengthen the high-quality development of the economy, and the two together promote high-quality economic development. Xu et al. (2022) argued that the synergistic development of manufacturing and information and communication services has a significant positive impact on economic resilience. Wang et al. (2022)’s study is based on panel data of 121 countries from 2003 to 2019, and the results show that financial risk has a significant negative impact on the digital economy. Secondly, in energy research, Qu and Hao (2022) found that the digital economy has a significant mitigating effect on energy poverty, and there are regional differences, with the mitigation effect being more pronounced at high levels of digital economy development. Again, in terms of curbing climate warming, the carbon reduction effects of the digital economy and renewable energy have been confirmed by many studies (Chen, 2021; Li Z et al., 2021; Shang et al., 2022), especially in the context of climate warming and the recent signing of the Glasgow Climate Convention. Finally, the poverty reduction effect of the digital economy has also attracted a lot of attention. On the one hand, using digital information technology can enhance social capital from social networks, social participation, and social trust, and provide diversified financial services, thus reducing multidimensional poverty (Liu et al., 2021). On the other hand, the digital economy provides financial services for different groups at affordable costs, which improves the willingness of long-tail customers to use finance, making vulnerable groups benefit from it, thus alleviating poverty (Huang et al., 2019a).

Meanwhile, many studies have focused on common prosperity. For example, Li et al. (2022) built a measurement index system of the digital economy and shared prosperity, and demonstrated the coordination between the digital economy and shared prosperity through empirical research, which is of great significance for narrowing the regional economic gap. Zhang et al. (2022) constructed a micro common prosperity index from the three dimensions of material wealth, spiritual wealth, and social sharing, and found that digital economy and inclusive finance are important ways to narrow the gap between urban and rural areas and promote common prosperity by using the two-way fixed effect model. Based on the new economic geography perspective, Zhou (2022) included the digital economy in the core marginal model. His research shows that the digital economy provides solutions to alleviate the imbalance and disharmony of regional development, and promotes the process of common prosperity to a certain extent.

It can be seen from the above that the development of the digital economy plays an important role in achieving common prosperity. Firstly, the digital economy itself reflects a strong growth potential. The integrated application of digital technology, the promotion of digital industrialization, and industrial digitalization have become important guarantees for achieving the accumulation of material wealth for common prosperity. The digital economy with AI, Big Data, Cloud Computing, Blockchain, etc. as its core has spawned a large number of new industries and new models (Hukal et al., 2020), and is increasingly becoming a new engine for economic growth

(Hjort and Poulsen, 2019; Yang, 2022). According to the data in the White Paper on China's Digital Economy Development (2021), China's digital economy will reach 39.2 trillion yuan in 2020, accounting for 38.6% of GDP, and still maintain a high growth rate of 9.7% under the impact of the epidemic. Secondly, the development of the digital economy is playing a huge role in resource allocation, employment, income distribution, urban-rural gap, public services, and many other aspects, involving the increase of social wealth, improvement of social welfare, fair distribution of society and many other fields (Zhou et al., 2021), and directly related to the benefits of reform and development achievements to most people. In short, the digital economy provides a new driving force and a feasible path for achieving common prosperity.

Since the concept of common prosperity was first proposed by China, Chinese scholars pay more attention to its conceptual analysis, influential effects, and measurement of common prosperity indicators, while scholars from other countries focus more on the role of the digital economy in poverty alleviation, resource allocation, employment, and income distribution. To sum up, although the existing literature has made relatively rich research results, there are still areas to be expanded: First, the current literature is more unilateral research on the digital economy or common prosperity, and there is no good unified framework; Second, as the second largest economy in the world, China's experience in narrowing the income gap and promoting common prosperity can be used for reference by other countries, especially developing countries. However, at present, there are few empirical studies on the development of China's digital economy and the level of common prosperity, mainly focusing on theoretical analysis, lacking sufficient credibility, and unable to accurately describe the specific role of the digital economy in promoting common prosperity; Third, since the 2021 Glasgow Climate Conference (COP26), the concepts related to green development have gradually come into the public's view. The question of whether green finance and the level of environmental pollution play a certain role in the impact path of digital economy enabling common prosperity and what role they play is one of the fields rarely covered by scholars at present.

Based on this, this paper establishes an empirical model based on China's provincial panel data to specifically explore the impact between the digital economy and common prosperity. The possible marginal contributions are as follows: ① Based on the development level of the digital economy, this paper constructs an impact model of China's digital economy on the level of common prosperity from a more comprehensive perspective, expands existing research, and provides some ideas and methods for other countries to promote social equity and narrow the gap between rich and poor. ② This paper confirms the positive role of digital economy in green economic activities of environmental improvement, climate change response and resource conservation and efficient utilization, analyzes the impact of the digital economy on promoting common prosperity, and uses its green characteristics, discusses the intermediary role of green finance as a variable and the regulatory role of local environmental pollution level, and uses empirical analysis to verify it, deepening the existing literature. ③ Based on the geographical location, this paper explores the heterogeneous effect of China's digital economy on common prosperity. ④ Digital economy, common prosperity, green finance, and environmental pollution are placed in the same framework in this paper, referring to the methods of other scholars, starting from the mathematical model, and using comparative analysis to deduce and verify their relationship.

## 3 Theoretical mechanism analysis

### 3.1 Digital economy enables common prosperity

First of all, the integrated application of digital technology has greatly liberated and developed productivity, provided new impetus for regional economic growth and high-quality economic development (Yang, 2022), and digital platforms have provided great potential for the global economy and society (Bonina et al., 2021). At the same time, digital governance escorts the economic model of the new digital industry (Hukal et al., 2020), so as to consolidate the foundation of common prosperity. However, the deep integration of the digital economy and the real economy has not only promoted general macroeconomic growth but also significantly improved the quality of economic development (Shen et al., 2022), which means that there is strong momentum support for achieving common prosperity. In addition, the digital economy has inherent advantages and essential characteristics of increasing marginal revenue, high innovation, high growth, strong diffusion, wide coverage, and low cost, etc. (Rihua, 2022), which have an all-round and subversive impact on the economy and society. Compared with the traditional agricultural economy and industrial economy, the digital economy can release more economic development dividends, showing a strong "making bigger cakes" dynamic mechanism.

Secondly, with the popularization of digital technology and the expansion of application scenarios, the inclusiveness of the digital economy is gradually revealed, and digital dividends benefit most people and help achieve balanced growth. Additionally, the digital economy is the endogenous power to achieve inclusive growth and regional coordinated development. The spillover effect and synergy effect of digital economy development have significant income growth effect and poverty reduction effect (Ai and Tian, 2022; Lechman and Popowska, 2022), which has a negative direct effect on the regional gap and greatly reduces the urban-rural development gap (Chen and Wu, 2021). Therefore, the development of the digital economy helps to solve the problem of unbalanced development and promotes equal development opportunities in different dimensions such as regions, people, and urban-rural areas, which has a sharing mechanism of "dividing the cake" (Xiang et al., 2022).

### 3.2 Mediating effect of green finance

Green finance refers to economic activities that can promote environmental improvement, cope with climate change and save and use resources efficiently, which can also be understood as financial services provided for projects in the fields of environmental protection, energy conservation, clean energy, green transportation, green architecture, carbon emission reduction, etc. Common prosperity is an ideal state in which social wealth generally increases, the gap between rich and poor continues to narrow, and all people share the achievements of development.

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wealth generally increases, the gap between rich and poor continues to narrow, and all people share the achievements of development. The basic premise for green finance to promote common prosperity includes three aspects: ①green finance can improve productivity and promote income level; ②green finance is inclusive and friendly to underdeveloped regions and low-and-moderate-income groups, thus narrowing the gap between rich and poor; ③green finance is conducive to all people sharing the achievements of development. Zheng et al. (2022) summarized the mechanism of green finance to improve the level of common prosperity: On the premise of comprehensive consideration of the impact and role of government regulation and market resource allocation, the subjective initiative of the participants is fully exerted through the division of division effect, distribution effect of green elements, green technology effect, employment effect, and inclusion effect, so as to realize the expansion of the green financial market scale, improve the productivity level, promote the income level, narrow the gap between the rich and the poor, share the development achievements, and ultimately achieve common prosperity. Among them, the role of government regulation is embodied in an environmental regulation system, green assessment mechanism, green fiscal and tax policies, income distribution system, etc.; The role of market resource allocation is reflected in the competition mechanism and price mechanisms, such as affecting the energy consumption and carbon emission reduction of enterprises through the carbon trading mechanism, optimize the production and manufacturing process, and explore the feasible path of low-carbon transformation of enterprises (Xuan et al., 2020). Therefore, as one of the important branches of the digital economy, it is assumed that green finance has undertaken some mediating effects in the process of promoting common prosperity, which will be verified in the next part.

### 3.3 Moderating effect of environmental pollution level

For a long time, most literature has paid more attention to the relationship between environmental pollution and economic growth, mainly focusing on the study of the Environmental Kuznets Curve (Rao and Yan, 2020). In the early stage of economic development, pollution has risen rapidly; When the economic growth crosses a certain point, the environmental pollution shows a downward trend. However, with the improvement of residents' income levels and the widening gap between the rich and the poor, the relationship between pollution and the income gap has also come into everyone's sight. Most scholars believe that the greater the income gap, the less conducive to environmental protection. The widening income gap in a country is generally not conducive to the improvement of environmental quality. Some scholars believe that the level of common prosperity is related to the "inverted N" of industrial wastewater, carbon dioxide emissions, smoke, and dust emissions. In the process of moving towards high income, the widening of the income gap is not conducive to environmental protection and pollution control (Wang and Zhang, 2021). Moreover, the income gap between urban and rural areas has a negative externality of malignant cumulative effect. The larger the income gap, the greater the impact of environmental pollution on common prosperity (Lan et al., 2021). For example, Huang and Ye (2022) used panel data from 30 provinces in the Chinese Mainland from 2002 to 2019 to prove that environmental pollution has a significant negative impact on the income gap and common prosperity. In addition, there is no doubt that the digital economy can improve the

level of environmental pollution (Deng and Zhang, 2022; Li and Zhou, 2021; Li Y et al., 2021). To sum up, there is reason to speculate that the variable of environmental pollution level may play a moderating role in the process of the digital economy boosting common prosperity, and specific research will be shown in the next part.

## 4 Model construction, indicator selection, and data source

### 4.1 Model specification

Considering the availability of data, this paper uses panel data of 30 provinces in China (excluding Hong Kong, Macao, Taiwan, and Tibet) from 2011 to 2019 as samples to build a bidirectional fixed effect model to examine the impact of digital economy development on the level of common prosperity. This model is mainly used for panel data analysis, in which bidirectional fixation refers to the simultaneous control of time and provinces to reduce the impact of relevant missing variables or other factors on the study, making the results of this paper more reliable and robust. The mathematical model is as follows:

$$cp_{it} = \alpha + \alpha_1 de_{it} + \alpha_2 control_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (1)$$

Here,  $i$  represents the Province,  $t$  represents the Year,  $cp$  represents the Common Prosperity Level, and  $control$  represents a set of control variables in the equation, which includes foreign direct investment (FDI), opening level (open), financial development level (finance), human capital level (redu), and innovation capability (innovation). In addition, in order to alleviate the endogenous problem of missing variables, this paper uses  $\mu_i$ ,  $\varphi_t$  to control the fixed effect of province and year, and  $\varepsilon_{it}$  is the random error.

In order to test the mediating effect of green finance (green), referring to the method proposed by Wen and Ye, 2014, Eqs. 2, 3 on the basis of Eq. 1 have been constructed to test the mediating effect, as follows:

$$green_{it} = \beta + \beta_1 de_{it} + \beta_2 control_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (2)$$

$$cp_{it} = \gamma + \gamma_1 de_{it} + \gamma_2 green_{it} + \gamma_3 control_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (3)$$

According to the test method of Wen and Ye (2014),  $\alpha_1$  represents the total effect of the digital economy enabling common prosperity. In Eqs. 2, 3,  $\beta_1$  and  $\gamma_2$  represent the mediating effect of green finance.  $\gamma_1$  represents the direct impact of the digital economy on common prosperity in the dimension of green finance. Based on the significance of  $\alpha_1$ , if  $\beta_1$  and  $\gamma_2$  are significant, then when  $\gamma_1$  is significant, it is considered that green finance has a partial mediating effect; if  $\gamma_1$  is not significant, it is a complete mediating effect. If at least one of  $\beta_1$  or  $\gamma_2$  is not significant, the Bootstrap test is performed, and if the test passes, it indicates that partial mediating effects exist.

At the same time, in order to test the moderating effect played by the environmental pollution level (poll), an interactive term ( $de * poll$ ) between the environmental pollution level and the digital economy has been constructed. Through the significance of interaction items to verify whether there is a regulatory effect, this study will further establish the following moderating effect Eq. 4:

$$cp_{it} = \eta_0 + \eta_1 de_{it} + \eta_2 poll_t + \eta_3 de_{it} * poll_{it} + \eta_4 control_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (4)$$

TABLE 1 System of common prosperity indicators.

Index	Sub-index	Weights	Attributes
Common prosperity level	Urban <i>per capita</i> disposable income (Yuan)	0.22	+
	Rural <i>per capita</i> disposable income (Yuan)	0.25	+
	Per Capita GDP (Yuan/person)	0.27	+
	Average wage of urban unit employees (Yuan/person)	0.26	+

TABLE 2 System of digital economy development level indicator.

Index	Sub-index	Description	Attributes
Digital economy development level	Internet penetration rate	Number of Internet broadband access users among 100 people	+
	Information on internet-related practitioners	The proportion of employees in the computer service and software industry in urban units	+
	Internet-related outputs	The total amount of telecommunications services <i>per capita</i>	+
	Mobile phone penetration	Number of mobile phone users among 100 people	+
	Development of digital inclusive finance	China digital inclusive finance index	+

## 4.2 Variable measure and description

### 4.2.1 Explained variable

Common prosperity level (cp). Starting from the connotation of common prosperity, based on the conclusions published by Zheng in 2022, combined with the availability of provincial-level data, a common prosperity evaluation index system, which conforms to China's actual situation, has been constructed as shown in Table 1.

### 4.2.2 Core explanatory variable

Digital economy development level (de). There is no unified approach to measure the level of digital economy development at the provincial level. Considering the availability of data and drawing on the views of Zhao et al. (2020), this paper measures the level of the digital economy in each province from the aspects of Internet development and digital inclusive finance. For the measurement of Internet development, refer to the method of Huang et al. (2019b), four indicators have been adopted: Internet penetration rate, information on Internet-related practitioners, Internet-related outputs, and mobile phone penetration. The actual contents of these four indicators are the number of Internet broadband access users among 100 people, the proportion of employees in the computer service and software industry in urban units, the total amount of telecommunications services *per capita*, and the number of mobile phone users among 100 people. For measuring the development of digital inclusive finance, China Digital Inclusive Finance Index is adopted, which is jointly prepared by the Digital Finance Research Center of Peking University and Ant Financial Services Group (Guo et al., 2020). Individual missing values are supplemented by linear interpolation, and the data of the above five indicators are standardized and reduced by principal component analysis to obtain the development level of the digital economy. The weights

of principal components at all levels are listed in descending order, which is 0.713, 0.139, 0.090, 0.046, and 0.012 (Table 2).

### 4.2.3 Mediating variable

Green financial level (green). In the current literature, there are generally two kinds of methods to measure green finance: the comprehensive indicator system and the capital allocation indicator, both of which have advantages and disadvantages. In theory, the comprehensive indicator system can more comprehensively measure the development of green finance, but the construction of the indicator system itself has the uncertainty of weight measurement and the risk of missing sub-indicators, which is difficult to support effective econometric analysis. The capital allocation index can better overcome the problem of insufficient sample size, and in many theoretical models, it can keep consistent with the theoretical connotation of the core variables of the model, but this indicator inevitably gives up the comprehensiveness of the green financial measurement (Wen et al., 2022). Considering all factors comprehensively, this paper refers to the method proposed by Dong in 2020, and constructs a more reasonable green financial indicator system from the perspective of credit, investment, insurance, and government intervention (Table 3). For some missing values, the 5-years average method is used to calculate.

### 4.2.4 Moderating variable

Environmental pollution index (poll). In recent years, China's rapid economic development has caused certain damage to the ecological environment. Based on the actual situation and taking full account of the availability of information and data on various environmental pollutants, this paper quotes the calculation results published by Fu and Peng (2020) as the moderating variable, which selects five kinds of pollutant indicators: total wastewater, chemical

TABLE 3 System of green financial indicator.

Index	Sub-index	Description	Attributes
Green finance	Green credit	Interest expenditure of six high-energy-consuming industries/Total industrial interest expenditure	-
	Green investment	Investment in environmental pollution control/GDP	+
	Green insurance	Agricultural insurance income/Total agricultural output value	+
	Government support	Financial expenditure on environmental protection/General budget expenditure	-

oxygen demand in wastewater, sulfur dioxide, smoke and dust, and solid waste. The comprehensive index of environmental pollution is constructed by the entropy method. The larger the index value is, the worse the environmental quality is; On the contrary, the better the environmental quality is.

### 4.2.5 Control variables

In order to more comprehensively explore the impact of digital economy development enabling common prosperity, this paper refers to the ideas and principles for selecting control variables such as Kakwani et al. (2022); Zha and Fang (2022); Zhu et al. (2022), and then selects the following control variables: 1) Foreign direct investment (FDI), measured by the total investment of foreign-invested enterprises registered at the end of the year; 2) Openness index (open), measured by the ratio of the total import and export volume of foreign trade to the GDP of the year; 3) Financial development level (finance), measured by the ratio of the loan balance of financial institutions to GDP of the year; 4) Human capital level (redu), measured by the average years of education per capita in each province; 5) Innovation ability (innovation), measured by the ratio of internal expenditure of research and experimental development (R&D) funds of each province to the GDP of the year.

### 4.3 Data source and description

Based on the data of the China Statistical Yearbook, China Statistical Yearbook on Environment, China Statistical Yearbook on Science and Technology, Yearbook of China's Insurance, the website of the National Bureau of Statistics, statistical yearbooks of each province, China Stock Market and Accounting Research Database (CSMAR), and relevant reports on digital economy development over the years, the panel data of 30 provinces, cities and autonomous regions (excluding Tibet, Hong Kong, Macao, and Taiwan) in China has been collated and calculated and taken as statistical samples. Among them, individual missing values are supplemented by the advanced interpolation method; At the same time, in order to mitigate the heteroscedastic interference caused by data fluctuations, some data are processed by logarithmization. Some missing values are supplemented by linear interpolation; At the same time, in order to mitigate the heteroscedastic interference caused by data fluctuations, some data are logarithmized. In addition, in order to avoid pseudo regression between variables due to correlation, the variance inflation factor (VIF) was tested. The test result shows that the mean value was 5.14, which can be considered that there is no serious multicollinearity in the selected indicator data. Descriptive statistics of variables are shown in Table 4:

TABLE 4 Descriptive statistics of variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Cp	270	0.313	0.123	0.133	0.846
De	270	0.750	1.155	-1.027	6.614
Green	270	0.185	0.108	0.062	0.793
de* poll	270	0.191	0.339	-0.535	2.187
Lnfdi	270	6.570	1.366	3.432	9.777
Open	270	0.270	0.304	0.013	1.548
finance	270	3.139	1.071	1.568	7.607
Redu	270	9.172	.893	7.474	12.782
innovation	270	1.636	1.116	0.411	6.315

## 5 Empirical test

### 5.1 Benchmark regression

The benchmark regression results of digital economy development enabling common prosperity are shown in Table 5. Column (1) shows the direct impact of digital economy development on common prosperity without adding control variables and fixed effects. The regression coefficient is positive, and it has passed the significance level test of 1%, indicating that digital economy development can promote common prosperity. Columns (2) and (3) are the results of gradually controlling the fixed effects of time and province after adding control variables. The R-squared values are higher than that in column (1), and the regression coefficient is still significantly positive at the level of 1%, which indicates that the digital economy has a significant positive effect on common prosperity when considering the differences in the impact of innovation capacity, financial development, openness index, and other factors in different provinces. In general, for every unit of increase in the development level of the digital economy, China's level of common prosperity will increase by 0.043 units.

It can be seen from the value in column (3) that, in terms of control variables, the coefficient of FDI is significantly negative, which may be the "U" relationship proposed by Nie and Zhe (2020), that is, in the initial stage of FDI inflow, the regional income gap continues to expand due to the location choice and industrial choice of FDI, and the demand for skills of the labor force increases with the gradual improvement of the inflow quality of FDI, so the urban-rural income gap has been further expanded. The coefficient of the openness index is significantly negative, which may be because foreign trade is mainly concentrated in developed regions, and the

TABLE 5 Benchmark regression of digital economy and common prosperity.

	(1)	(2)	(3)
	cp	cp	cp
de	0.094*** (0.002)	0.064*** (0.007)	0.043*** (0.008)
Lnfdi		-0.003 (0.004)	-0.017*** (0.005)
open		-0.100*** (0.013)	-0.161*** (0.015)
finance		-0.013*** (0.004)	-0.016*** (0.004)
redu		0.023*** (0.006)	0.017*** (0.006)
innovation		0.043*** (0.007)	0.033*** (0.007)
_cons	0.242*** (0.009)	0.045 (0.056)	0.223*** (0.063)
Provincial fixed effect	No	No	Yes
Year fixed effect	No	Yes	Yes
Observations	270	270	270
R-squared	0.910	0.968	0.972

Standard errors are in parentheses \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

“polarization effect” attracts labor from backward regions to gather in cities, which is not conducive to promoting common prosperity. The coefficient value of the financial development level is significantly negative, indicating that it has aggravated social inequality to a certain extent (Brei et al., 2018; Zhang, 2021). The coefficient of human capital level is significantly positive, indicating that the higher the level of education, the more conducive to improving the income level, increasing the proportion of middle-income groups, and promoting common prosperity. The coefficient of innovation capability is significantly positive at the level of 1%, indicating that technological innovation has improved total factor productivity and is conducive to improving income levels, and its diffusion effect and scope economy effect are conducive to the sharing of development achievements by all people.

## 5.2 Analysis of mediating effect and moderating effect

### 5.2.1 Mediating effect

In this section, green finance is used as a mediator between the digital economy and common prosperity to establish a mediating effect model, and the regression results are shown in Table 6 with reference to the stepwise test method of Wen and Ye, (2014):

**Step 1.** Test the total effect of the digital economy on common prosperity by using the Eq. 1. The results are shown in Column (1) of

Table 6, that the higher the level of the digital economy, the higher the level of common prosperity of the province, which is significantly positively correlated, and  $\alpha_1 = 0.043$  is the total effect of the independent variable on the dependent variable.

**Step 2.** Use Eq. 2 to test whether the digital economy has a significant impact on green finance. As shown in column (2) of Table 6,  $\beta_1 = 0.033$  is at the level of 1%, which shows that the development of the digital economy in each province has a significant role in promoting green finance, and has a positive impact on green economic activities such as controlling carbon dioxide emissions, promoting energy transformation and curbing climate warming. This result is the same as that of Tian et al. (2022). They discussed the impact of the digital economy on the efficiency of green financial investment in China and found that its application in green finance can reduce the imbalance of regional economic development.

**Step 3.** Since the coefficient has been verified in the first two steps that both  $\alpha_1$  and  $\beta_1$  are significant, the independent variable and the mediator are put into Eq. 3 to test whether their influence on the dependent variable is significant and analyze whether the mediating variable has completely or partially mediating effect. As shown in Column (3) of Table 6, the digital economy and green finance are both at the level of 1% and significantly positively correlated with the level of common prosperity, indicating that green finance has played a partial mediating effect in the process of enabling the digital economy to achieve common prosperity, and its value is the product of  $\beta_1$  and  $\gamma_2$  ( $0.033 * 0.481 = 0.016$ ).  $\gamma_1 = 0.027$  represents that under the dimension of green finance, the direct impact of the digital economy on common prosperity decreases by 0.016 compared with the total effect of 0.043, which is the same as the intermediary effect results calculated earlier, which again shows the correctness of the model.

TABLE 6 Regression results of mediating effect and moderating effect model.

	(1)	(2)	(3)	(4)
	cp	green	cp	cp
de	0.043*** (0.008)	0.033*** (0.009)	0.027*** (0.007)	0.040*** (0.008)
green			0.481*** (0.052)	
de*poll				-0.025*** (0.006)
poll				0.024 (0.023)
Control variable	Yes	Yes	Yes	Yes
Provincial fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	270	270	270	270
R-squared	0.972	0.849	0.979	0.974

Standard errors are in parentheses \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

TABLE 7 Robustness test.

	(1)	(2)	(3)	(4)	(5)	(6)
	cp	cp	cp	cp	cp	cp
dige	0.976*** (0.086)	0.453*** (0.076)				
de			0.085*** (0.008)	0.034*** (0.008)	0.074*** (0.014)	0.044*** (0.011)
_cons	0.079*** (0.012)	0.140** (0.063)	0.234*** (0.004)	0.196*** (0.062)	0.234*** (0.005)	0.230*** (0.075)
Control variable	No	Yes	No	Yes	No	Yes
Provincial fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	270	270	270	270	180	180
R-squared	0.946	0.972	0.950	0.972	0.925	0.955

Standard errors are in parentheses \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

## 5.2.2 Moderating effect

Further analysis shows the regression results of the mathematical model with the environmental pollution level as the moderating variable in Column (4) of Table 6. Both the digital economy (de) and the interaction of the digital economy and environmental pollution index (de \* poll) have a significant impact on the level of common prosperity at the level of 1%. The coefficient of the former is positive, while the coefficient of the latter is negative, indicating that environmental pollution has a negative regulatory effect on the development of common prosperity, which is similar to the research results of He et al. (2022). They found that there is a strong spatial correlation between the ecological environment level and the relatively poor areas, and formulating effective environmental protection policies is the key to controlling climate change, promoting green development and common prosperity.

## 5.3 Robustness test

### 5.3.1 Replace core explanatory variables

Zhao et al. (2020) used the principal component analysis method to calculate the weight of the digital economy indicators in the previous section, but now, using Miao et al., 2022 method for reference, the entropy weight method is used to calculate the digital economy level (dige) and then conduct regression. As shown in Column (1) and Column (2) of Table 7, the results are significant at the level of 1% regardless of whether control variables are added, which is basically consistent with the benchmark regression results.

### 5.3.2 Winsorize

In order to eliminate the adverse effects of abnormal values and non-randomness on the measurement results, the variables in the model (1) above were winsorized by 1% up and down and then regressed again. As shown in Columns (3) and (4) of Table 7, whether control variables are added or not, the regression results are significant at the level of 1%, fully verifying the robustness of the empirical study.

### 5.3.3 Shorten sample cycle

In order to investigate whether the impact of the development level of the digital economy on common prosperity is affected by the duration of the study, referring to the method of Luo and Liu (2022), the sample interval has been shortened to 2013–2018 and then regresses again. Therefore, the total number of samples is reduced from 270 to 180. As shown in Columns (5) and (6) of Table 7, the regression results are still significant at the level of 1%, which shows the reliability and preciseness of this study.

## 5.4 Endogenetic treatment

Although the bidirectional fixed effect model adopted in this paper can effectively solve the endogenous problems caused by missing individual changes or time changes, it cannot effectively solve the endogenous problems caused by causality. Therefore, the instrumental variable method will be adopted to conduct the endogenetic test, using the lag term of the development level of the digital economy and the interaction term of the number of fixed phones per hundred people in each region in 1984 and the number of Internet users in the previous year is taken as the instrumental variables of the development level of the digital economy in each region, and the two-stage least square method (2SLS) is used to conduct the test. Columns (1) and (2) of Table 8 report the regression results of two tool variables in detail, showing that the promotion effect of the digital economy on common prosperity is significant at the level of 1%, indicating that the basic conclusion is still stable after considering endogenous issues. In addition, the  $p$  values corresponding to the LM statistics of Kleibergen Paap rk are .000 and .006 respectively, significantly rejecting the original hypothesis, indicating that there is no problem of insufficient identification of tool variables. At the same time, Cragg Donald's Wald F statistics are greater than the critical value (16.380) of the Stock-Yogo weak identification test at the 10% level, indicating that it is reasonable to select the lag term of the development level of the digital economy, the interaction term between the number of fixed phones per 100 people in 1984 and the number of Internet users in the previous year as the tool variable.

TABLE 8 Two-stage least squares (2SLS) regression.

	(1)	(2)
	cp	cp
de	0.046*** (0.017)	0.259*** (0.065)
Control variable	Yes	Yes
Provincial fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Kleibergen-Paap rk LM Statistics	29.642 (0.000)	7.478 (0.006)
Cragg-Donald Wald F Statistics	167.42 {16.380}	20.482 {16.380}
Observations	240	270
R-squared	0.966	0.879

Note: Values in ( ) are *p* values, and values in { } are critical values at the 10% level of the Stock-Yogo weak identification test.

TABLE 9 Heterogeneity analysis.

	(1)	(2)	(3)
	Eastern	Central	Western
	Cp	cp	Cp
de	0.066*** (0.013)	0.031** (0.012)	0.001 (0.006)
_cons	0.571*** (0.150)	0.150** (0.064)	0.178*** (0.033)
Control variable	Yes	Yes	Yes
Provincial fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Observations	99	72	99
R-squared	0.981	0.993	0.996

Standard errors are in parentheses \*\*\**p* < 0.01, \*\**p* < 0.05, \**p* < 0.1.

### 5.5 Heterogeneity analysis

There are obvious regional differences in the development degree and policy support of the digital economy and common prosperity in different regions of China. Therefore, in order to further explore whether there is regional heterogeneity in the promotion effect of the digital economy on common prosperity, the sample will be divided into eastern, central, and western regions for re-testing. As shown in Table 9, the regression coefficient of the digital economy in the central and eastern regions is significantly positive, indicating that the development of the digital economy has significantly promoted the process of common prosperity in this region, but not in the western regions. At the same time, the spillover effect intensity of the digital economy shows “East > Central > West”. It can be concluded that the impact of China’s digital economy on common prosperity has regional heterogeneity. The digital economy in the eastern region plays a stronger role in promoting common prosperity, followed by the

central region, and the western region is the weakest. The reason for this difference may be that compared with the western region, the eastern region has an earlier and higher level of digital economy development, and the dividend of digital inclusive finance is more fully released. However, due to the constraints of traditional financial foundation, resource talent and ideas, the application level of digital technology and financial services in the central and western regions is relatively low, resulting in the inability to fully release the dividend of the digital economy in the western regions.

## 6 Conclusion and recommendations

### 6.1 Conclusion

Since 2020, the world has been severely impacted by the COVID-19. The economic situation and structure have become chaotic and complex. The income gap of people at all levels has further expanded. The distribution of social welfare has been uneven for a long time. How to improve social welfare and promote social fair distribution has become an urgent problem for governments around the world. In this context, based on China’s provincial panel data in 2011–2019, this paper conducts an empirical study on the impact mechanism of the digital economy enabling common prosperity through the panel fixed effect model, mediating effect model, moderating effect model, and other methods. The main conclusions are as follows:

First, the basic facts show that the development of the digital economy has obviously promoted the level of common prosperity in China, not only playing a role in “making the cake bigger” on the overall level but also playing a role in “dividing the cake better” in terms of distribution. The regression coefficients passed the 1% significance test before and after adding the control variables and bidirectional fixed effects on time and provinces. In general, the level of common prosperity in China will increase by 0.043 units every time the level of digital economy development increases by one unit. The results of endogenous and robust tests show that this result is highly reliable.

Second, the result of intermediary effect shows that the development of digital economy has a significant role in promoting

green finance, and it is significant at the level of 1%. It has a positive impact on green economic activities such as controlling carbon dioxide emissions, promoting energy transformation and curbing climate warming.

Third, the analysis of the transmission mechanism shows that the digital economy not only has a direct promoting effect on common prosperity but also can have a significant positive impact through green finance, that is, the digital economy can indirectly promote social fair distribution and narrow the gap between rich and poor by promoting green finance. At the same time, the level of local environmental pollution will have a negative regulating effect on the process of common prosperity.

Fourth, the contribution of the digital economy to shared prosperity is more pronounced in central and eastern China, significant at the 5% and 1% levels respectively, but not in the western provinces, reflecting some regional heterogeneity.

## 6.2 Recommendations

The above research conclusion have important reference significance for some countries that have widened the gap between the rich and the poor during the epidemic to narrow the income gap, promote fair distribution, achieve common prosperity for all, and provide empirical evidence for governments to give full play to the dividend advantage of digital economy enabling common prosperity. It also provides some ideas for relevant parties who made commitments at the Glasgow Climate Summit (COP26) to curb climate warming and reduce CO<sub>2</sub> emissions. Based on this, we propose the following recommendations:

- (1) Continue to develop the digital economy, improve the digital infrastructure, focus on expanding the coverage of digital inclusive finance, and give play to the carbon emission reduction effect of digital finance. The main crux of the significant differences in the development of the digital economy among regions is the uneven infrastructure. Therefore, the deep integration and development of digital technology and the real economy should be paid attention to, so as to improve the level of the digital economy and narrow the gap between rich and poor.
- (2) Attach importance to the mediating role of green finance to promote common prosperity with “green development”. Especially at the moment of officially signing the Glasgow Climate Convention, the inclusive nature of the digital economy should be active to promote green and sustainable development and steadily advance the process of common prosperity. At the same time, the negative adjustment of the local environmental pollution level should be fully considered, so as to strengthen environmental governance, balance the environmental pollution costs borne by residents of all levels, and reduce the negative impact on the environment. As a result, the ecological compensation mechanism and environmental protection laws and regulations will be improved according to

the idea of “whoever pollutes shall govern, whomever gains shall compensate.”

- (3) Follow the regional comparative advantages and formulate differentiated digital economy development policies. The digital economy empowering common prosperity has significant regional heterogeneity, and the digital economy empowering effect in the central and eastern regions is more significant. Therefore, while improving the digital infrastructure, the central and eastern regions should focus on the layout of digital industries to avoid convergence and low-level duplication of construction; Give full play to the leading edge of digital technology, focus on breaking through the research and development of core and key digital technologies and pay attention to the integration of digital resources. In the relatively backward regions of various countries, the government should actively popularize the inclusiveness of the digital economy, promote residents to adapt to digital financial services, narrow the digital gap between regions, and promote the realization of the goal of the common prosperity of the country.

## Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by JZ. The first draft of the manuscript was written by JZ and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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