

Has the Advancement of the Digital Economy Improved the Well-being of the Population?

--Empirical Study Based on Chinese Provincial Panel Data

Wenjing Peng^{1, #}, Fengbin Xie^{2, *, #}, Jinke Shi^{3, #}

¹School of Economics, Henan University, Henan, China, 475004

²School of Mathematics and Statistics, Guangdong University of Foreign Studies, Guangzhou, Guangdong, 510006

³College of Humanities and Development Studies, China Agricultural University, Beijing, China, 100091

* Corresponding Author Email: 15280400986@163.com

#These authors contributed equally.

Abstract. Promoting the long-term prosperity of a country by exploring the relationship between the digital economy and residents' happiness holds great significance. This research quantifies the extent of digital economy progress through the utilization of the Critic approach. The investigation assesses the evolution in disparities in digital economy development levels across various provinces. Since happiness is a discrete ordered response variable, this paper utilizes an ordered probit model to investigate the impact relationship, incorporating individual characteristic variables. Furthermore, this study takes the sense of social justice as the mediating variable to test whether the development level of digital economy has a mediating effect on residents' happiness. The empirical results imply that the disparity in digital economy development levels among provinces gradually decreases over time, and boosting digital economy development positively make contributions to improving residents' happiness. The impact effect comprises both direct and indirect effects; specifically, digital economy development directly affects residents' happiness and indirectly influences it by enhancing their sense of social fairness. Based on these conclusions, this paper offers relevant recommendations to promote national prosperity and enhance residents' happiness.

Keywords: Digital Economic Development, Residents' Happiness Index, Mediation Effect

1. Introductory

Residents' happiness is an important measure of national and social livelihood development^{[1][2]}. In recent years, with the rapid development of digital economy technologies, including big data, Internet of Things and blockchain, the digital economy has become an increasingly significant driving force for national economic growth, which has profoundly changed the development power and development mode of the world economy. The ultimate goal of promoting the country's high-quality development is to achieve the happiness and well-being of the people, and the digital economy is the key to high-quality development. By studying whether the digital economy enhances residents' happiness and the specific path of influence, it helps to understand how the digital economy upgrades people's life quality, optimises the allocation of social resources and promotes human well-being.

Specifically, for the digital economy, the most widely used approach is to define the digital economy in terms of measurement. For example, OECD constructs a digital economy satellite account and tries to compile a supply and use table to comprehensively and systematically measure the digital economy. At present, some scholars and institutions have already established some measurement systems, such as Liu Jun et. al. developed an evaluation index system for China's sub-provincial digital economy, which was constructed based on three key dimensions: informatisation development, Internet development, and digital transactions^[3]; Sun Xiaoqiang et al set up 9 second-level indicators as well as 34 third-level indicators for measurement^[4]. Zhao Tao and colleagues employed principal component analysis to gauge the comprehensive level of digital economy

development, focusing on aspects such as internet growth and digital financial inclusion^[5]. As for residents' happiness, scholars have conducted rich theoretical and empirical research on its influencing factors. Some research focuses on economic factors affecting happiness^{[3][6]}, and non-economic factors, such as external environmental factors^[6], as well as the residents' intrinsic traits, including gender, education and health status^{[6][8]}. The advancement of the digital economy provides people with a more convenient way of life and rich employment opportunities, and also reduces the threshold of entrepreneurship. Through the digital economy technology, the government can provide public services more efficiently to meet people's needs. Scholars have already studied residents' happiness in terms of digital government, digital integration^[9], and Internet use^[6], while some researchers have studied that the digital economy can affect residents' happiness and thus the consumption structure by influencing residents' happiness. Residents' consumption structure, there are fewer researches on the mechanism of the digital economy's impact on residents' happiness.

In summary, this paper provides an empirical study on the mechanism of the influence of the digital economy on residents' happiness. The contributions of this paper are mainly: firstly, it provides a new critic measure for the extent of digital economy growth, and uses the coefficient of variation method to find out that the difference in the level of digital economy development between provinces is decreasing year by year. Secondly, by using the ordered probit model, it is proved that the level of digital economic development has both direct and indirect influence mechanisms on residents' happiness. In the realm of indirect effects, digital economic progress can indirectly impact the happiness of residents by shaping their perception of social equity. Ultimately, with a digital economic development perspective, drawing from the findings of empirical research, this paper presents pertinent policies and recommendations to foster the nation's high-quality development and elevate residents' well-being.

2. Theory and Methodology

2.1. Background and hypothesis of the study

On the one hand, with the improvement of the development level of the digital economy, people's lives can become more prosperous. Conversely, digital economy advancement can contribute to the prosperity of the populace. The digital economy possesses efficient capabilities for transmitting and processing information, which provides impetus for enterprise innovation and promotes enterprise industrial upgrading and transformation. The wide application of enterprise digital technology can improve the operational efficiency of enterprises and create more social wealth. On the other hand, the emergence of the digital economy has greatly facilitated people's lives, there are a lot of convenient digital platforms such as Internet hospitals, remote medical consultations, live online classes and so on. Based on the above analysis, Hypothesis 1 posits a connection between the level of digital economy development and residents' happiness.

H1: The development of the digital economy can significantly improve the well-being of the population.

The digital economy has an inclusive effect that can promote a fairer and more reasonable distribution of social wealth. On the one hand, the development of digital economy can promote the equalisation of social services. The promotion of digital technology can optimise government functions and supplement the provision of public services in backward areas through digital government platforms. On the other hand, digital economic development can narrow the income gap between urban and rural areas. The equalisation of social services and the reduction of the urban-rural income gap can directly affect the residents' sense of social equity. In summary, this paper proposes Hypothesis 2.

H2: Suggests that there is a link between the degree of digital economy development and the happiness of residents.

Individual traits, including gender, age, education, marital status and household income, have a certain impact on people's sense of well-being. Gender is different in terms of happiness due to

differences in physiological, psychological and social roles^[7]; age also affects happiness due to differences in life experience and psychological maturity; education level affects people's knowledge of life and work and thus affects happiness; marital status affects people's stability and emotional support of life and thus affects happiness; and family income affects residents' living standards and affects happiness. Therefore in summary, this paper proposes Hypothesis 3

H3: Personal characteristics can influence the well-being of the population.

2.2. Research Methodology

The level of digital economy development has multi-dimensional attributes, so it is necessary to construct an evaluation system to measure based on its connotation attributes. Combining the connotation of the level of digital economic development and considering the availability of data, we refer to the approach of Zhao Tao et al[5]. We extracted five core measurement elements to measure the level of digital economy development in 31 provinces and municipalities across the country. Considering the correlation between variables, this article uses the CRITIC objective assignment method to standardize the relevant data of the five indicators, The weights for each indicator are established by assessing the strength of comparison and conflict among the sub-indicators employed to evaluate the level of digital economic development. The specific indicators are outlined in Table 1.

Table 1. Indicator system for measuring the development level of the digital economy

main indicator	number	Level 1 indicators	Secondary indicators	causality
Digital Economy Development Index	1	Internet penetration	Percentage of Internet users in the resident population	+
	2	Number of people working on the Internet	Percentage of people employed in computer services and software	+
	3	Internet-related outputs	Telecommunications services per capita	+
	4	Mobile phone penetration rate	Mobile phone penetration rate	+
	5	Digital financial development	Digital Inclusive Finance Index	+

There are m evaluation provinces, n evaluation indicators of digital economic development, and the raw data are X_{ij} , $i=1,...,m, j=1,...,n$. Firstly, the dimensionless normalisation is carried out, and the formula is as follows:

$$X'_{ij} = \frac{X_{ij} - \min\{X_j\}}{\max\{X_j\} - \min\{X_j\}} \quad (1)$$

where $\max\{X_j\}$, $\min\{X_j\}$ are the maximum and minimum values of the j indicator respectively, and X'_{ij} is the processed data. Calculate the mean value of the evaluation data under the j indicator:

$$E(X'_j) = \frac{1}{m} \sum_{i=1}^m X'_{ij} \quad (2)$$

Calculate the standard deviation for the j indicator:

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^m (X'_{ij} - E(X'_j))^2}{m-1}} \quad (3)$$

Calculate the conflicting nature of the evaluation indicators:

$$R_{j1} = \sum_{j_2}^n (1 - \rho_{j_1 j_2}) \quad (4)$$

where $\rho_{j_1 j_2}$ is the Pearson's correlation coefficient for the two evaluation indicators j_1 and j_2 , and R_{j1} is the conflicting nature of the j_1 evaluation indicator. Calculate the amount of information for the j indicator:

$$I_j = \sigma_j \cdot R_j \quad (5)$$

Calculate the weights of the indicators at j :

$$w_j = I_j / \sum_{j=1}^n I_j \quad (6)$$

according to formula (2) (3) (4) (5) (6), the weights of the secondary evaluation indicators of the extent of digital economy growth in 31 provinces were calculated.

Table 2. Weights of indicators for the level development of the digital economy

norm	w_1	w_2	w_3	w_4	w_5
Weighting	27.324	21.725	2.957	18.279	29.715

Since happiness is a discrete ordered response variable, it is estimated using an ordered probit model, which is specifically designed to handle data where the explanatory variable is ordinal. Referring to Wei Haixiang's^[2] approach, the following econometric model:

$$happiness_{ijt} = \beta_0 + \beta_1 Dige_{jt} + \gamma Micro_{ijt} + \delta Macro_{jt} + \delta_j + \mu_t + \varepsilon_{ijt} \quad (7)$$

where $happiness_{ijt}$ denotes the happiness of the i th sample in the j th region in year t . $Dige_{jt}$ denotes the level of digital economic advancement of the j th region in year t , $Micro_{ijt}$ is the individual characteristic variable of the i th respondent of the j th region in year t , $Macro_{jt}$ is the province characteristic variable of the j th region in year t , β_1 represents the parameter to be estimated, δ_j represents the province fixed effect, μ_t represents the time fixed effect, and ε_{ijt} is the model residual term. Secondly, this paper further illustrates whether the degree of digital economic development will affect residents' happiness through the mediating effect of social equity variables^[2]. This paper intends to construct the following mediation effect model for testing:

$$happiness_{ijt} = \beta_0 + \beta_1 Dige_{jt} + \gamma Micro_{ijt} + \delta Macro_{jt} + \delta_j + \mu_t + \varepsilon_{ijt} \quad (8)$$

$$Fairness_{ijt} = \beta_0 + \beta_1 Dige_{jt} + \gamma Micro_{ijt} + \delta Macro_{jt} + \delta_j + \mu_t + \varepsilon_{ijt} \quad (9)$$

$$happiness_{ijt} = \beta_0 + \beta_1 Dige_{jt} + \beta_2 Fairness_{ijt} + \gamma Micro_{ijt} + \delta Macro_{jt} + \delta_j + \mu_t + \varepsilon_{ijt} \quad (10)$$

3. Empirical Analysis

3.1. Data sources and description

The measurement data in the level of development of digital economy comes from the China Statistical Yearbook and the China Digital Financial Inclusion Index (CFI) compiled by the Digital Finance Research Centre of Peking University and Ant Gold Service Group. In this paper, four periods of CFPS data in 2014, 2016, 2018, and 2020 were selected to analyse the relationship between the digital economy and residents' well-being. The CFPS was launched in 2010 by the Institute of Social Science Investigation (ISSS) at Peking University. Furthermore, the study employs a multi-stage

probability sampling procedure. This approach ensures national representativeness, encompassing 162 counties or districts (referred to as counties) across 25 provinces in mainland China, which collectively account for 95% of China's total population. In the initial survey wave, CFPS conducted interviews with 33,600 individuals residing in 14,798 households. These individuals are re-interviewed every two years. At CFPS, the well-being of residents has been documented since the 2012 wave. During the sample selection process, the paper treated the data as follows: samples with outliers in the variable data and samples with two or more consecutive years of missing data were excluded, and samples with small fluctuations in residents' well-being over the four periods of time were excluded in order to reduce bias caused by self-censorship.

The indicator used in this paper to measure the happiness of the population is selected from the subjective attitude question in Section M of the GFPS: "How happy do you/do you feel?" This is a fill-in-the-blank scoring question, where 0 represents the lowest and 10 the highest. For the explanatory variables, the Critic measure was chosen from the indicator system in Table 1. For control variables: individual characteristic variables include age, gender, life satisfaction, marital status, and household income; provincial level control variables are emission of Pm2.5, number of hospital beds, land area of administrative area, and house price.

3.2. Descriptive statistical analyses

For the level of development of the digital economy, we measured the data from 2011 to 2020. The results show that the development level of digital economy in each province has steadily improved. Specifically, as Table 2 describes the statistical results, the mean value of the subjective well-being of our residents is 5.170, indicating that the overall level of the well-being of our residents is in the middle of the range. The average value of the digital economic development indicator is 0.364, with a maximum of 0.975, a minimum of 0.014, and a standard deviation of 0.973. This variation in the level of digital economic development underscores significant regional disparities.

Table 3. Main variables and descriptive statistics

variable name	average value	(statistics) standard deviation	minimum value	maximum values
Happiness of residents	5.170	2.706	0	10
digital economy	0.364	25.973	0.014	0.975
Pm2.5 emissions	48.719	17.303	12.593	118.842
Number of hospital beds	2869.588	2176.134	196.000	10923.000
Land area of administrative districts	1801.801	1972.206	20.000	14059.000
cost of housing	47561	2243.760	2256	120457
(a person's) age	50.763	14.582	19.000	95.000
distinguishing between the sexes	0.473	0.499	0	1
Life satisfaction	6.791	2.503	0	5
marital status	0.862	0.345	0	1
household income	36883	1549	0	125764

3.3. Tests of Difference

Changes in the development of the digital economy in each province are shown in the following figure: Figure 1 shows that the development level of digital economy in each province has improved significantly from 2011 to 2020, the eastern region has a higher level of development than the western region, and the gap between different provinces in the level of digital economy development has narrowed. Meanwhile, in order to verify the objectivity of our evaluation method, we did a convergence analysis and calculated the coefficient of dispersion between provinces in each year. The

figure 2 show that the coefficient of dispersion between provinces gradually decreases with the growth of the years and has convergence:

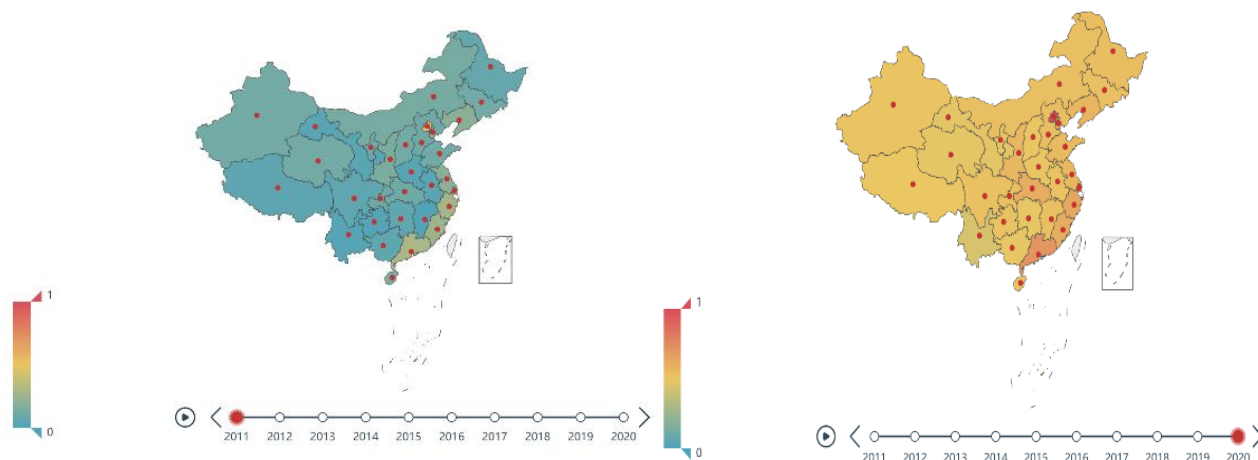


Figure 1. Combined digital economy scores by province, 2011 and 2020

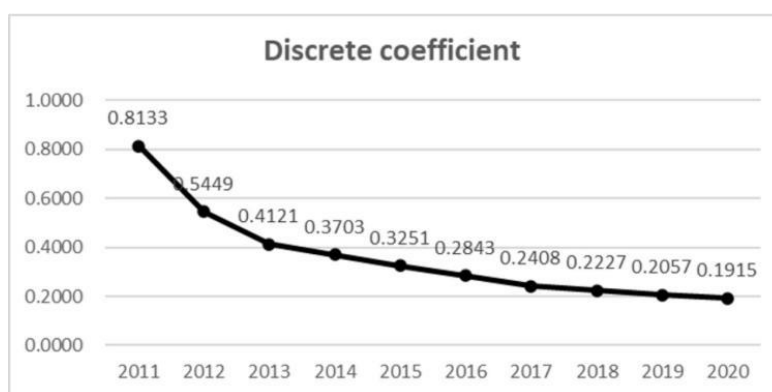


Figure 2. Variation of discrete coefficients

3.4. Analysis of impact mechanisms

The year fixed-effects model is widely used in economics to analyze the influence of different years on economic growth. By introducing year fixed-effects, we can control for factors that are present in all years, such as long-term economic policies and institutional factors. This allows us to more accurately assess the impact of other factors, such as macroeconomic fluctuations, external shocks, or policy changes, on economic growth. Analyzing year fixed-effects helps us determine which years experienced economic growth beyond the long-term trend and which years were negatively affected. This aids policymakers and researchers in gaining a better understanding of the fluctuations in economic growth and in formul.

The digital economy variable exhibits a notably positive influence on residents' happiness, with a regression coefficient of 0.0074947, and it passes the significance test at the 0.001 level. The digital economy can promote the development of society as a whole, affect all aspects of people's lives, promote the industrial upgrading and transformation of enterprises, facilitate the lives of residents, and promote common prosperity, so it can significantly affect the happiness of residents.

Table 4. The results of digital economy development, sense of fairness and residents' happiness

variable name	total effects model	multivariate modelling	
	sense of well-being	sense of fairness	sense of well-being
Digital Economy Index	0.0074947** (0.003)	237.9251*** (16.103)	0.0063921** (0.002)
sense of fairness			0.00001*** (0.000)
Interprovincial control variables	be	be	be
individual control variable	be	be	be
distinguishing between the sexes	0.0046 (0.0024)		
(a person's) age	0.0077 (0.0017)		
matrimonial	0.0082 (0.0005)		
educational attainment	0.0054 (0.0027)		
household income	0.0037 (0.0018)		
Year fixed effects	be	be	be
Interprovincial fixed effects	be	be	be
observed value	21320	21320	21320
R ²	0.084	0.822	0.086

The interim findings from the mediation effect analysis suggest that the digital economy has a significantly positive impact on residents' happiness, with a regression coefficient of 237.9251. Several individual characteristic variables do not have a significant effect on residents' happiness. The gender variable has no significant effect, with a regression coefficient of 0.0046, and the age variable also has no significant effect, with a regression coefficient of 0.0077; the marriage variable has no significant effect on residents' happiness, with a regression coefficient of 0.0082; the education level has no significant effect on residents' happiness, with a regression coefficient of 0.0054; and the income of the family has no significant effect on residents' happiness, with a regression coefficient of 0.0037. Individual characteristic variables have no significant effect on residents' happiness. The regression coefficient is 0.0037. Individual characteristic variables have no significant effect on residents' happiness.

After including the variable of sense of fairness in the regression model (10), the digital economy still has a significant positive effect on residents' happiness, and the sense of fairness also has a significant positive effect on residents' happiness. Based on the mediation effect test step, it can be seen that the sense of fairness plays a partial mediating role in the relationship between the digital economy affecting residents' happiness. The digital economy can promote social fairness, such as the continuous popularisation and application of digital technology, people can obtain more information through smart devices and improve their knowledge of society, thus enhancing the sense of fairness, which affects residents' social happiness. However, the sense of social fairness plays a partially mediating role, and the digital economy does not fully affect the residents' sense of well-being by influencing the sense of fairness.

4. Conclusions and recommendations

The development of digital economy offers a new impetus for economic expansion. As economic development is closely related to people's well-being, since economic development is closely related to residents' happiness, this paper empirically examines the promotion effect of digital economy development on residents' happiness from the perspective of residents' happiness. It is found that the level of digital economy development in each province has increased steadily from 2011 to 2020, and the degree of inter-regional differences is decreasing, and digital economy development contributes to the improvement of residents' happiness. It is further revealed that the development of the digital economy will increase residents' happiness by improving their sense of social equity. These findings have the following implications:

First, improve the construction of digital infrastructure and create a favourable environment for the development of the digital economy. On the one hand, it is to increase the strength of infrastructure such as advanced network and data intelligence, accelerate the pace of transformation and upgrading, and consolidate the foundation for development. On the other hand, it is to encourage enterprises to carry out digital transformation and foster the combination of the digital economy and real industries, so as to promote the transformation and upgrading of enterprises, improve the operational efficiency of enterprises and increase social wealth. Secondly, we should plough deeply into the theoretical connotations of the report of the twentieth CPC National Congress on Chinese-style modernisation, and promote the realisation of the common wealth of all the people, so as to better enhance the people's sense of accessibility and fairness. The affluence we seek is not the affluence of some people, but the affluence of all the people, and reducing the wealth disparity is a crucial element in augmenting the citizens' perception of social equity.

For the benefit of the people is the essential requirement of the party for the public and ruling for the people.

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