

Digital economic and circulation industry--The mediator effect based on green technologic innovation

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Abstract. So as to explore the mediator effect of green technologic innovation on the impact of digital economic on circulation industry, based on the panel data of 30 provinces in China from 2011 to 2019, this paper constructs a panel fixed effect model and a mediator effect model for empirical analysis. The results show that the digital economic significantly boosts the advance of the circulation industry; through the mediator effect model test, it is found that the digital economic can boost the advance of the circulation industry through green technologic innovation, and the mediator effect is 57.28 %. Finally, from the aspects of strengthening green technologic innovation, talent support, improving digital economic infrastructure and policy support, this paper puts forward some suggestions on promoting the advance of circulation industry by digital economic.

1 Introduction

The world is undergoing new changes in industry and technology in recent years. China 's digital economic has also achieved rapid advance and is accelerating its penetration into the production and circulation fields. At the same time, the advance of China 's circulation industry has formed a diversified circulation system. By accelerating the advance of circulation industry, it can boost the upgrading of industrial structure. It is a bridge connecting production and consumption, which can not only improve people 's living standards, but also create a good environment for the domestic market. Therefore, it is very important to speed up the advance of circulation industry. With the proposal of China 's dual carbon target, environmental protection, energy conservation and emission reduction and green advance are particularly important. Green technologic innovation is also known as ecological technologic innovation. On January 23,2019, the Central Committee for Comprehensively Deepening Reform passed the " Guiding Opinions on Building a Market-oriented Green Technologic Innovation System, " which is defined as an emerging technologic to reduce pollution, improve ecology, boost ecological civilization construction, and achieve harmonious coexistence between man and nature. Therefore, China needs to continuously boost green innovation and economic structure optimization on the road to achieve high-quality green economic advance.

The contributions of this paper include two aspects. Firstly, combined with China 's provincial panel data, this paper empirically studies the influence of digital economic on China 's circulation industry, and provides empirical evidence for the high-quality advance of China 's circulation industry. Secondly, this paper studies the

mediator role of green technologic innovation in the influence process of digital economic on circulation industry for the first time. On the road of promoting the high-quality advance of the economic, it explores a new path for the digital economic to affect the circulation industry.

2 Literature Review and Hypothesis

2.1 Digital economic and circulation industry

Digital economic is mainly composed of digital information and knowledge. It is an economic form that optimizes fairness and efficiency through information network and information communication technology. In the " 14th Five-Year Plan for Digital Economic Development, " seven key industries of digital economic are mentioned, including e-commerce, intelligent logistics and finance. In recent years, the rapid advance of China 's digital inclusive finance has provided economic guarantee for the efficient transformation of the circulation industry.

First of all, in terms of enterprises, digital finance has established more convenient and efficient financing channels for enterprises, which is conducive to enterprises producing more kinds of products and bringing better experience to users. Gao Yuan (2019) found that the mechanism of digital inclusive finance on the advance of retail industry is mainly reflected in broadening new financing channels, innovating business services, stimulating new consumption points and gathering new resource elements, and the effect is significant [1]. Yin Yingkai et al. (2020) concluded that the influence of fintech on SME financing was first inhibited and then promoted [2]. Furthermore, on the consumer side, the

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purpose of inclusive finance is to achieve inclusiveness in financial services. Digital inclusive finance can markedly narrow the urban-rural consumption gap and boost the consumption level of residents (Jiang, 2020) [3]. It can also boost consumption through income, mobile payment, consumer credit and insurance (Zou Xinyue et al., 2020) [4]. Zhang Qiancheng et al. (2022) believe that digital finance can actively boost pro-poor growth by improving technologic innovation, urbanization rate and entrepreneurship [5]. Wang Mingyang (2021) found that digital inclusive finance is conducive to expanding household consumption from the perspective of income stratification [6]. The digital economic can provide assistance for the business promotion of financial institutions such as banks and insurance companies, and then boost the construction of circulation services. Digital economic service is a business model emerging in the new economic situation. With the support of digital technology, it can improve market activity, boost the advance of circulation industry, and bring more convenience to market transactions. The above literature provides strong theoretical support for studying the influence of digital economic on the circulation industry. Digital economic has a significant role in promoting consumption level and enterprise financing through digital finance. Therefore, digital economic boosts the transformation of circulation industry through digital finance and technologic intelligence, thus promoting the advance of circulation industry. Therefore, Hypothesis H1 is proposed :

H1: Digital economic can boost the advance of circulation industry.

2.2 The Intermediary Role of Green Technologic Innovation

Over recent years, the rapid advance of artificial intelligence, cloud computing, e-commerce and the increasing consumption demand of people are also promoting the circulation industry to carry out technologic empowerment and improve circulation efficiency. At present, there are few literatures on the influence of green technologic innovation on the circulation industry. Green advance is an indispensable part of achieving China's dual carbon goals and high-quality economic advance. Therefore, based on the previous research on the influence of technologic innovation on the advance of circulation industry, this paper seeks the mechanism of green technologic innovation on the advance of circulation industry. In response to the national policy of environmental protection and energy conservation, enterprises have improved some polluting and energy-consuming machines. However, on the one hand, enterprises need funds to change machines and develop green technologic. On the one hand, it is necessary to bear the cost of shutdown rectification in the transformation. The rapid advance of digital finance can solve the problem of funds for enterprises. Qiao et al. (2022) found that digital inclusive finance is more effective in promoting green advance of enterprises for heavily polluting industries [7]. At the same time, digital inclusive finance can reduce the inhibitory effect of foreign direct

investment on the advance of green economic (Wang Xia et al., 2022) [8].

While studying the influence of technologic innovation on the commercial circulation industry, Wang (2018) also discussed the influence of technologic innovation on the circulation industry under the empowerment of Internet advance, and finally found that the advance of the Internet can expand the influence of technologic innovation on the commercial circulation industry [9]. Technologic innovation is not only reflected in the convenience of the circulation process and the high quality of products, but also accelerates the modernization of the advance of the circulation industry. In the article of Li Panke (2020), he found that technologic innovation can markedly boost the high-quality advance of the logistics industry [10]. Tian Yahui (2020) found that green technologic innovation can boost the transformation of circulation industry by studying the coupling mechanism of green technologic innovation to circulation industry [11]. Through the above literature review, digital economic can boost green technologic innovation, and green technologic innovation can also boost the advance of circulation industry. It follows that the hypothesis H2:

H2: Digital economic can indirectly boost the advance of circulation industry through green technologic innovation.

3 Research Design

3.1 Sample selection and Data

Considering the availability of data, this paper selects data from 30 provinces in China (except Tibet Autonomous Region, Hong Kong, Macao and Taiwan) from 2011 to 2019. Among them, the Digital Inclusive Finance Index is released by the Digital Finance Research Center of Peking University. It is the current general data on digital inclusive finance research. The intermediary variable green technologic innovation selects the number of green patents granted as the measurement index. The data is from the Green Patent Database (GPRD) under the China Research Data Service Platform. The original data of the explained variables and control variables are from the 'China Statistical Yearbook' and the website of the National Bureau of Statistics. Descriptive statistical analysis of explanatory variables, explained variables, control variables and mediator variables, the results are shown in Table 1.

3.2 Variable Declaration

3.2.1 Explained variable: circulation industry (*Ich*)

This paper draws on Bao Zhenshan et al. (2022) to use the number of wholesale and retail industries as a measure of the advance level of China's circulation industry [12].

3.2.2 Explanatory variables: digital economic (*Sz*)

Based on the practice of Zhao Tao et al. (2020), the

comprehensive advance level of digital economic is measured from the aspects of Internet advance and digital financial inclusion [13]. The number of Internet broadband access users, the proportion of employees in computer services and software industry in urban units, the total amount of telecommunication services per capita, the number of mobile phone users in 100 people and the index of digital inclusive finance are selected.

3.2.3 Mediator variable: green technologic innovation (Tech)

The number of green patents is used as an indicator to measure this variable.

3.2.4 Control variable

So as to fully control the influence of the digital economic on the circulation industry and control the variables that may affect the advance of the circulation industry, the following control variables are selected : Regional people 's living standards (Enger),this paper uses the Engel coefficient to represent; Open is expressed as the ratio of total import and export to GDP; The urbanization rate (City) is expressed by the proportion of urban population in each region to the total population; Government intervention (Govern) is expressed by the ratio of government general budget expenditure to GDP; Human capital (Hum), the average years of education to examine the level of human capital in each province; Population aging (Old), using the proportion of people aged 65 and over to measure the degree of aging.

TABLE I. BASELINE REGRESSIVE RESULTS

Variable	(1)FE	(2)FE	(3)RE	(4)RE
Sz	82.31*** (7.715)	110.2*** (23.28)	83.14*** (7.754)	112.3*** (21.28)
Enger		115.3** (54.18)		94.46* (55.60)
Open		-86.10*** (17.45)		-41.77** (16.90)
City		210.9*** (80.21)		196.2*** (68.19)
Gov		-79.92 (52.77)		-224.5*** (42.82)
Hum		-22.10*** (7.265)		-16.91*** (6.179)
Old		-274.9*** (93.29)		-166.6* (90.40)
_cons	32.95*** (2.833)	151.1* (84.10)	32.66*** (9.906)	126.3** (62.54)
R2	0.323	0.426	0.326	0.392

3.3 Model Setup

This paper uses panel data of 30 provinces in China from 2011 to 2019, this paper studies the influence mechanism of digital economic on circulation industry. Therefore, this paper constructs the following model:

3.3.1 The benchmark regressive model is as follows:

$$Ich_{i,t} = \beta_0 + \beta_1 Sz_{i,t} + \beta_2 X_{i,t} + \mu_i + \varepsilon_{i,t} \quad (1)$$

In equation (1), ich is the explanatory variable circulation industry, Sz is the explanatory variable digital economic, and X is a series of control variables other than explanatory variables that affect the circulation industry. β_0 denotes the intercept term, μ_i denotes the unobservable individual fixed effect in i region; $\varepsilon_{i,t}$ denotes the random perturbation term. *i* and *t* represent province and time respectively.

3.3.2 mediator effect model

So as to explore the mediator role of green technology

innovation between digital economic and circulation industry, this paper constructs a model to test the mediator effect with reference to Wen Zhonglin et al. (2004) [14].

$$Ich_{i,t} = \beta_0 + \beta_1 Sz_{i,t} + \beta_2 X_{i,t} + \mu_i + \varepsilon_{i,t} \quad (2)$$

$$Tech_{i,t} = \alpha_0 + \alpha_1 Sz_{i,t} + \alpha_2 X_{i,t} + \mu_i + \varepsilon_{i,t} \quad (3)$$

$$Ich_{i,t} = \gamma_0 + \gamma_1 Sz_{i,t} + \gamma_2 Tech_{i,t} + \beta_3 X_{i,t} + \mu_i + \varepsilon_{i,t} \quad (4)$$

Formula (2) is the total effect model of the digital economic on the circulation industry, where β_1 is the total effect, and formula (3) the influence of the digital economic on the intermediary variable green technologic innovation. Equation (4) γ_1 is the direct effect of digital economic on circulation industry, and $\gamma_1 \alpha_1$ represents the indirect effect of digital economic on circulation industry through green technologic innovation.

4 Authentic Proof Analysis

4.1 Baseline regressive results

Before the regression of Model (1), the Hausman test is

first performed, and the results show that the fixed effect model is used for regression. At the same time, this paper uses the regressive results of the random effect model as a control. The results are shown in Table 1 : Column (1) and Column (2) are the regressive results of the influence of digital economic on the advance of circulation industry. Column (1) is the regressive results without introducing control variables. The results show that digital economic can markedly boost the advance of circulation industry. In order to avoid the influence of other factors on the circulation industry and ensure the reliability of the results, control variables are introduced. Through Column (2), it can be found that the digital economic shows a significant level of 0.01, and the regressive coefficient is 110.2, indicating that the influence of the digital economic on the circulation industry still has a very significant role in promoting. Column (3) (4) as a control, the results are consistent. It is proved that if H1 is established, the digital economic can markedly boost the advance of the circulation industry. Looking at the control variables, the influence of people 's living standards and urbanization rates on the circulation industry is positive and significant, indicating that the improvement of people 's living consumption level is the driving force for the advance of the circulation industry. The influence of opening up, human capital and aging on the circulation industry is negative and significant. In the short term, the introduction of foreign capital will cause certain pressure on local enterprises. In the long run, it will stimulate local enterprises to learn from foreign enterprises to a certain extent. Government intervention has inhibited the advance of the circulation industry. The reason for this situation may be that the circulation industry is mostly private enterprises. The government 's policies on these private enterprises are not targeted, resulting in not only not effectively solving the problems of some enterprises, but also limiting their advance space. Human capital has a negative effect on the advance of the circulation industry. The reason may be that the flow of talents is large and the

distribution of talents is very uneven.

4.2 Mediator effect analysis

This paper tests the mediator role of green technologic innovation in the influence of digital economic on the circulation industry. Stepwise regression was performed on model (2) (3)(4) to obtain table 2 results. Column (1) indicates the total effect of the digital economic on the circulation industry, which shows a significant level of 0.01, and the regressive coefficient is 110.2, the result is positive and significant. The direct effect of the digital economic on the circulation industry shows a significant level of 0.05, and the regressive coefficient is 47.08, which is positive and significant. The coefficient of green technologic innovation is 0.499, which is also markedly positive. However, after the mediator variable is added to Column (3), the coefficient of the digital economic is reduced, indicating that the digital economic has more than a direct influence on the circulation industry. The results in column (2), the digital economic, which shows a significant level of 0.01, and the regressive coefficient is 126.3, the influence on green technologic innovation is positive and significant, confirming that the digital economic can markedly boost green technologic innovation through capital and knowledge sharing. At the same time, it also suggests that green technologic innovation has a partial intermediary effect in the process of digital economic 's influence on circulation industry. The direct effect is 47.08, the total effect is 110.2, the indirect effect is 63.12, and the mediator effect of green technologic innovation is 57.28 %.

The above test results prove that there are two paths for the impact of digital economic on the circulation industry. The first is the direct positive promotion effect, followed by the indirect promotion of the advance of the circulation industry through green technologic innovation, assuming that H2 is established.

TABLE II. MEDIATOR EFFECT ANALYSIS

Variable	Ich(1)	Tech(2)	Ich(3)
Sz	110.2*** (23.28)	126.3*** (30.73)	47.08** (18.17)
Enger	115.3** (54.18)	186.1*** (71.52)	22.42 (41.43)
Open	-86.10*** (17.45)	-180.2*** (23.03)	3.874 (14.78)
City	210.9*** (80.21)	150.5 (105.9)	135.8** (60.72)
Gov	-79.92 (52.77)	-130.2* (69.65)	-14.93 (40.07)
Hum	-22.10*** (7.265)	-20.95** (9.590)	-11.65** (5.531)
Tech			0.499** (0.0374)
Old	-274.9*** (93.29)	131.1 (123.1)	-340.4*** (70.48)
_cons	151.1* (84.10)	108.3 (111.0)	97.02 (63.51)
R2	0.426	0.564	0.675

Note:*, **, *** are significant at the level of 10 %, 5 %, and 1 %, respectively; the t value is adjusted by the robust standard error in brackets.

5 Conclusions and Implications

This paper empirically tests the influence of digital economic on the development of circulation industry and the mediator effect of green technologic innovation through fixed effect model and mediator effect model. The following conclusions are drawn : First, the digital economic markedly boosts the advance of the circulation industry. Second, green technologic innovation has a mediator effect in the path of the influence of the digital economic on the circulation industry, and the mediator effect accounts for 53.3 % of the total effect. It shows that the digital economic itself has some influence on the circulation industry, and some of it affects the circulation industry through green technologic innovation.

Through the above research conclusions, two policy implications are proposed. First, strengthen the cultivation of new elements of digital economic and enhance the integration of digital economic and circulation industry. On the one hand, the government should vigorously support the intelligent upgrading of the circulation industry and encourage the self-upgrading and transformation of the circulation industry through policy support subsidies. On the other hand, the government should continue to improve new infrastructure and accelerate the implementation of ' Internet + circulation ' policy initiatives. Second, improve the level of green technologic innovation and advance. The influence of digital economic on the advance of circulation industry has two paths : the digital economic directly boosts the circulation industry; economic indirectly boosts the advance of circulation industry through green technologic innovation. The improvement of green technologic innovation can realize the transformation and upgrading of the circulation industry. Therefore, on the one hand, it is necessary to increase the policy investment in technologic research and advance of enterprises and encourage them. On the one hand, by cultivating a large number of highly skilled talents, the corresponding subsidy incentives are set for them. Finally, it is to implement a relatively open policy and encourage international exchanges and cooperation on green technologic innovation.

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