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Threshold effect of financial development on water resources utilization

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ABSTRACT

The role of financial development in enhancing water resources and its utilization is imperative for attaining the country's sustainable development. This paper used different stages of financial development indices and their resulting impact on water resource utilization in order to examine the threshold effect in China by using panel data from 2004 to 2015. This study put forward the threshold effect hypothesis by establishing a general equilibrium model. Further, the study employed the panel threshold model and panel fixed effect model to test the above hypothesis empirically. The results show that the single threshold effect exists in the relationship between financial development and water resource utilization. The impact of financial development on water resource utilization is not a simple linear relationship. When the growth rate of financial development is lower than the threshold value, there is a certain "threshold effect". Spatial heterogeneity affects the relationship between financial development and water resource utilization. Finally, the study found financial development in coastal areas with abundant water resources is relatively higher.

Keywords: Financial development; Water resources utilization; Threshold effect

1. Introduction

Water resource utilization is closely related to human survival that can be affected by financial development in varied paths. Under certain conditions, there are two ways for financial development to have an impact on the utilization of water resources. On the one hand, financial development reduces the consumption of water resources by guiding investment capital from industries with high pollution and high energy consumption to environmentally friendly industries and indirectly adjusting the industrial structure. On the other hand, according to the endogenous growth theory, financial development improves the utilization and treatment technology of water resources by identifying enterprises with technological progress and improves the profit of water resources by financing water treatment enterprises directly. This paper further reveals the relationship between financial development and water resource utilization, which provides new insight for improving environmental quality and water resources utilization, and a new perspective for promoting green economic transformation and upgrading.

Sustainable development is becoming aware of the threshold effect of financial development increasingly. This research on the threshold effect of financial development can be traced back to two research branches. One of the branches is based on the empirical hypothesis of the effect of the Kuznets curve (EKC) on financial development and its environmental relevance. It has been proposed that there is a correlation between financial development and the environment. And it also has been confirmed that the EKC between financial development and environment exists in some regions. However, due to the different data and perspectives, the results are not consistent. For example,

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Alam et al. [1] found energy consumption has a negative correlation with financial development in Asian countries (such as Malaysia). Al-Mulali et al. [2] studied that there is a two-stage correlation between financial development and energy consumption in African countries. Financial development can only reduce air pollution in the long term. Abid [3] examined the comparative analysis of EKC between Middle East & African and the European Union. There are different conclusions, even for the research of financial development and the environment in China. Some researchers believe that financial development is negatively related to the environment, reducing carbon emissions, and improving environmental relations [4]. Other research thinks that there is a positive correlation between them. Increasing carbon emissions cannot improve the environmental relationship.

The other branch is at the foundation of the resource curse hypothesis of financial development and water resources. The resource curse hypothesis holds that natural resource endowment has a negative correlation with economic growth. And the economic growth in the rich resource area is far behind that in the poor resource area. The United States as an example has been analyzed that rich regions in natural resources will promote financial development [5]. Over-dependence on natural resources has an impact on productivity. And mainly bank development can reduce the resource curse effect [6]. As the same, financial development has an impact on carbon emissions by renewable energy consumption [7,8]. The resource curse hypothesis holds that the quantity development of natural resources cannot promote the economic development of regions with rich resources. Furthermore, it will bring a series of negative effects and drag down economic development due to excessive resources [9].

These research on the basis of the two branches explain and verify the interaction of natural resources, environment, and financial development from different perspectives, as well as the existence of financial development threshold. In the above research, the main objects of environmental pollution include CO_2, electricity consumption, oil, and its equivalents. Water as a resource closely related to environment and production has been not neglected in this researches. However, due to different perspectives and different use of data, these studies tend to emphasize the impact of energy consumption and energy income, ignoring the consumption and utilization of water resources, resulting in the unclear threshold transmission mechanism of water resources and financial development.

The impacting path of financial development on water resources utilization mainly comes from two aspects. Firstly, financial institutions and capital markets can provide water resources treatment departments with capital (lend capital to the water resources sector) and generate loans (equity financing). By screening technology of the financial sector, high-tech enterprises can apply water treatment technology to improve the utilization efficiency of water resources. In 2017, there are 132 water treatment enterprises have been traded in the new over-the-counter market, 3 enterprises in Shanghai, 32 enterprises in Shenzhen market, and 1 enterprise in the Small and Middle-Size Enterprise Board of Shenzhen Stock Exchange. The distribution of the capital market of water treatment related enterprises and supply chain is shown in Fig. 1.

Secondly, with the increasing proportion of monetary and non-monetary instruments in the total economic volume, financial development promotes the industrial structure characterized by the modern service industry. Water resource consumption industry and water pollution enterprises are gradually replaced by technology-intensive enterprises. Therefore, financial development indirectly affects the efficiency of water resources utilization from the external environment.

For a further supplement of current literature and development of the actual situation, the main contributions of this paper are as follows: (1) revealing the influence mechanism of financial development on water resources utilization and nonlinear relationship between financial development and water resources utilization; (2) using threshold model to empirically test the factors affecting the relationship between financial development and water resources utilization; (3) putting forward reasonable water resources utilization policies.

2. Literature reviewing

2.1. Financial development

Financial development is critically important for China to develop renewable energy [10]. As an important instrument, financial development has become an influential factor in economic growth [11,12]. In terms of measuring instruments, financial development is mainly used to measure the development degree of financial intermediaries and

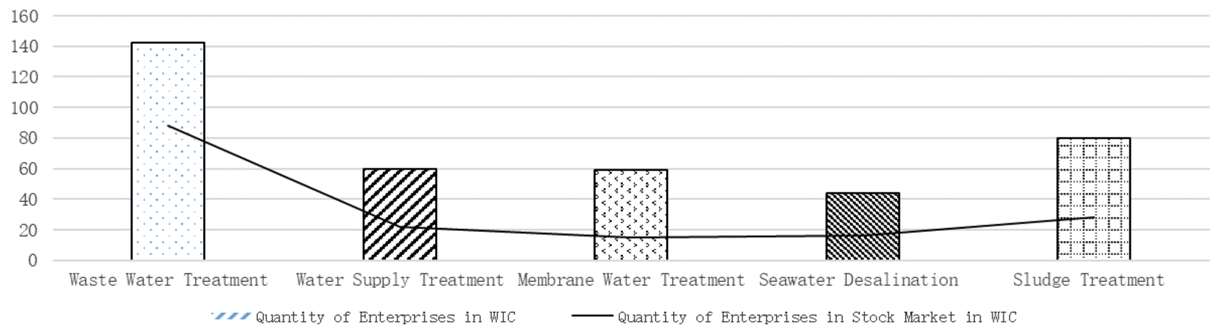

Fig. 1. Distribution of capital market of water treatment supply chain.

financial instruments in the whole economy. The commonly used variables are the proportion of the amount of bank credit relative to Gross Domestic Product (GDP) [13].

There has been abundant research on financial development related to water resources. Existing researches believe that water resources are in the process of financialization, mainly focusing on the micro-areas such as financialization effect, asset pricing accounting, and financial support of water resources engineering. For example, Bayliss [14] discussed the financialization trend of the water resource management sector from the perspective of private enterprises' investment in water resource consumption and believed that private enterprises' investment played a promoting role in water resource transportation and consumption. In the context of climate change, Pike and Pollard [15] discussed the geographical uneven distribution of financialization and financial derivatives on natural resources. Nazer et al. [16] analyzed the process of water resource utilization from the perspective of financial life cycle theory and analyzed the financial products and their effects that should be adopted at each stage. Schmidt and Matthews [17] discussed the coupling mechanism between financialization and the water-energy-food-climate system and proposed the great significance of intergovernmental financial cooperation for water resources management from the perspective of global financial network cooperation.

2.2. Financial development and water resources

Existing empirical studies have proved that the relationship between financial development and water resources exists. Some research indicated that the financial industry has a negative correlation with the total water consumption, and private enterprises have more opportunities for financing on water. Zaman et al. [18] analyzed the time series of 1975–2009 in Pakistan and found that financial development has an indirect impact on water consumption. Vörösmarty et al. [19] pointed out that the protection of freshwater needs to be aware of the global to the local overall threat. The study found that rich countries compensate for the pressure of water shortage by investing heavily in water technology through spatial methods, while poor countries maintain the vulnerability of water resources. Jalil and Feridun [11] analyzed the impact of China's financial development on energy consumption from 1953 to 2006. The negative correlation between financial development and energy consumption pollution shows that China's financial development did not sacrifice the environment.

Some research clarifies the positive relationship between financial development and natural resources. Such as Shahbaz et al. [20] confirmed the long-run relationship among natural resources financial development, and other variables on the cost of environmental degradation in the USA economy. Anser et al. [21] also testified there is a positive relationship between domestic credit to the private sector and CO_2 emissions & Greenhouse Gas emissions in Saudi Arabia for the period of 1975–2018. Xu and Tan [22] found financial development has the same positive impact on natural resource use efficiency by using the robust generalized least squares method and spatial measurement methods of 2006–2018 provincial panel data in China. Bekhet et al. [23] explore the relationships among financial development, energy consumption, and other impactors in Gulf Cooperation Council Countries. They had proved there exists a difference in a long-term relationship and short-term among variables by the autoregressive distributed lag bounds testing approach for the period of 1980–2011. Asif et al. [24] used time-series data from 1975 to 2017 to assess the 'resource curse' hypothesis in Pakistan.

However, the impact is uncertain in different regions and stages. Yin [25] found that financial development can improve water quality, reduce sulfur dioxide emissions, and improve environmental quality in financial developed areas by using 2007–2014 urban panel data and regression results. Ren and Zhu [26] pointed out that the scale efficiency and technical efficiency mechanisms that financial development affects the environment are not the same. Ouyang and Li [27] believed that the conclusions of different studies were biased due to differences in financial development indicators and environmental indicators.

Some scholars believe that there is a non-linear relationship between the use of natural resources and financial development. For example, Acemoglu et al. [28] discussed technological progress under environmental constraints based on the endogenous growth model. Muller [29] analyzed the financial debt of stockholders in water resource investment and financing enterprises and the distribution of project income. Charfeddine and Khediri [7] found that the relationship between financial development and carbon emissions was an inverted "U" curve, that is, carbon emissions increased first and then decreased as financial development deepened. Abbasi and Riaz [30] took Pakistan as the research object and found that only when the financial development was at a high level could the financial development promote the reduction of carbon emissions. Similar studies were conducted by Liu et al. [31], Javid and Sharif [32], and Salahuddin et al. [33].

In order to further clarify the relationship between China's financial development and water resource utilization, this paper first constructed a local equilibrium model, that incorporated the water resource sector into the endogenous impact framework. Secondly, this paper used a financial deepening index to measure the level of China's financial development, and used industrial water, domestic water, and ecological water to measure the degree of water resource utilization. And the relationship between financial development and water resource utilization is preliminarily determined based on descriptive statistical analysis. Thirdly, the panel threshold model and nonlinear fixed effect model are used to empirically test and analyze the above hypothesis. Finally, the paper puts forward the same conclusions on Organization for Economic Co-operation and Development (OECD) and America. This paper proposed some suggestions on financial development and water resources.

An assessment of the related literature indicated that most researches have focused either on the single linear nexus of financial development and water resources utilization or of financial development and other environmental pollutants, but only a limited number of researches has examined these two nonlinear relationships of in the same framework.

The main motivation of this paper is as follows: (1) based on the local equilibrium model, this paper discusses the path of financial development affecting the environment, establishes the theoretical framework of financial development affecting water resource utilization, and expounds the effect of financial development on water resource utilization. (2) Panel threshold model and nonlinear fixed effect model were used to empirically study the non-linear relationship between China's financial development and water resource utilization, providing a new perspective for studying the impact of financial development on environmental pollution.

3. Theoretical model

Based on the Segerson and Tietenberg [34] model, this paper constructs a theoretical model including the final product sector, water resources sector and financial sector, and solves the optimization problem by general equilibrium analysis method.

3.1. Final product department

The final product department produces the final product. In each period, the final product is composed of labor and water input, and production is organized according to the following production function.

$$Y_t = L^{1-\alpha}\int_0^1 \delta_{i,t}^{1-\alpha} w_{i,t}^{\alpha} d_i \tag{1}$$

where $w_{i,t}$ refers to the water input of the industry in year t under the level of efficiency coefficient. It can be indicated as the variable of water resource utilization. L is the human input.

3.2. Water resources department

Under the condition of complete competition, the final product is used as the pricing unit, so the price of water resources input is equal to the marginal product, namely:

$$p_{i,t} = \alpha\left(\frac{\delta_{i,t}}{w_{i,t}}\right)^{1-\alpha} \tag{2}$$

Among them, the price of water resources in year t (due to the difference of water pricing power in different regions, the fixed price of water resources here can be understood as the cost of water resources per unit of water use), is the utilization efficiency coefficient of water resources, whose value is between 0 and 1, reflecting the level of water conservation and water pollution treatment technology. When the demand for water is constant, the higher the price cost of water resources, assuming that the marginal exploitation cost C of water resources is fixed, and the total cost of total water consumption in year t, the total revenue of total water consumption in year t is the smaller.

$$\text{TNB}_t = \int_0^{w_t} \alpha\left(\frac{\delta_{i,t}}{w_{i,t}}\right)^{1-\alpha} dw_{i,t} - cw_{i,t} = \alpha(\alpha-1)\delta^{1-\alpha} w_{i,t}^{\alpha-2} - cw_{i,t} \tag{3}$$

In addition, the efficiency coefficient of water resource utilization is affected by financing constraints, where is the interest rate. If the total amount of resources is less than the demand, the optimal allocation of resources must meet the following constraints, equivalent to the marginal user cost. If the total amount of exploitable water resources is, the optimal dynamic optimization problem of resources in N years is as follows:

$$\text{Max}_{w_t} \sum_{i=1}^{n} \frac{\alpha(\alpha-1)\delta^{1-\alpha} w_{i,t}^{\alpha-2} - cw_{i,t}}{(1+r)^{i-1}} + \lambda\left(Q - \sum_{i=1}^{n} W_i\right) \tag{4}$$

The constraints are:

$$\frac{\alpha(\alpha-1)\delta^{1-\alpha} w_{i,t}^{\alpha-2} - cw_{i,t}}{(1+r)^{i-1}} - \lambda = 0 \tag{5}$$

$$Q - \sum_{i=1}^{n} W_i = 0 \tag{6}$$

$$\gamma = \delta^{\phi} \tag{7}$$

The above model can be solved by optimization conditions.

3.3. Financial sector

when the financial sector identifies water-saving and water pollution technologies through financing tools, according to the direction of technological progress, financialization helps to improve the direction of technological progress and improve the utilization efficiency of water resources at any time to the level of efficiency at any time, which indicates the probability that the financial sector identifies the technological progress of water resources. Sum up the water consumption of each industry and get the following function form:

$$\delta^* = \frac{\mu^{f^*}}{g+\mu^{f^*}},\ \delta_t = \begin{cases} \delta_t, \ldots u_t^f \\ \delta_{t-1}, \ldots 1-u_t^f \end{cases} \tag{8}$$

$$x_t = \mu_t^f + (1-\mu_t^f)\frac{x_{t-1}}{1+g} \tag{9}$$

$$\frac{\partial \delta^*}{\partial \mu^{f^*}} \succ 0 \quad \frac{\partial^2 \delta^*}{\partial (\mu^{f^*})^2} \prec 0 \tag{10}$$

From this, we can preliminarily infer the non-linear relationship between finance and water use efficiency.

4. Theoretical logic and preliminary statistical observation

4.1. Economic development and theoretical logic of water resources

The logic of the influence of financial development on water resource utilization efficiency is presented in Fig. 2. According to financial theory, the financial industry has the

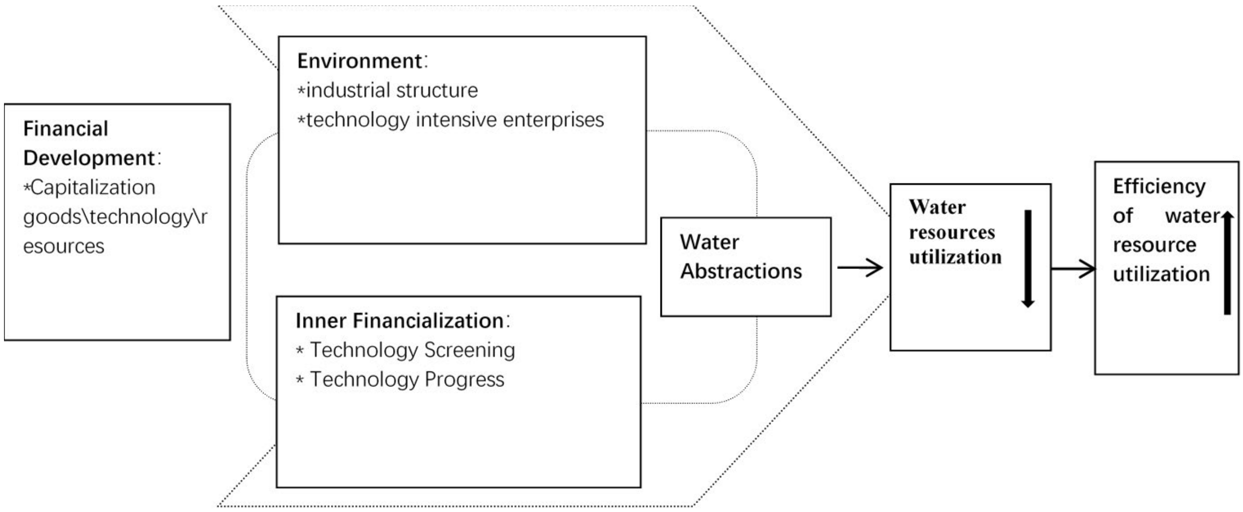

Fig. 2. Mechanism analysis logic diagram.

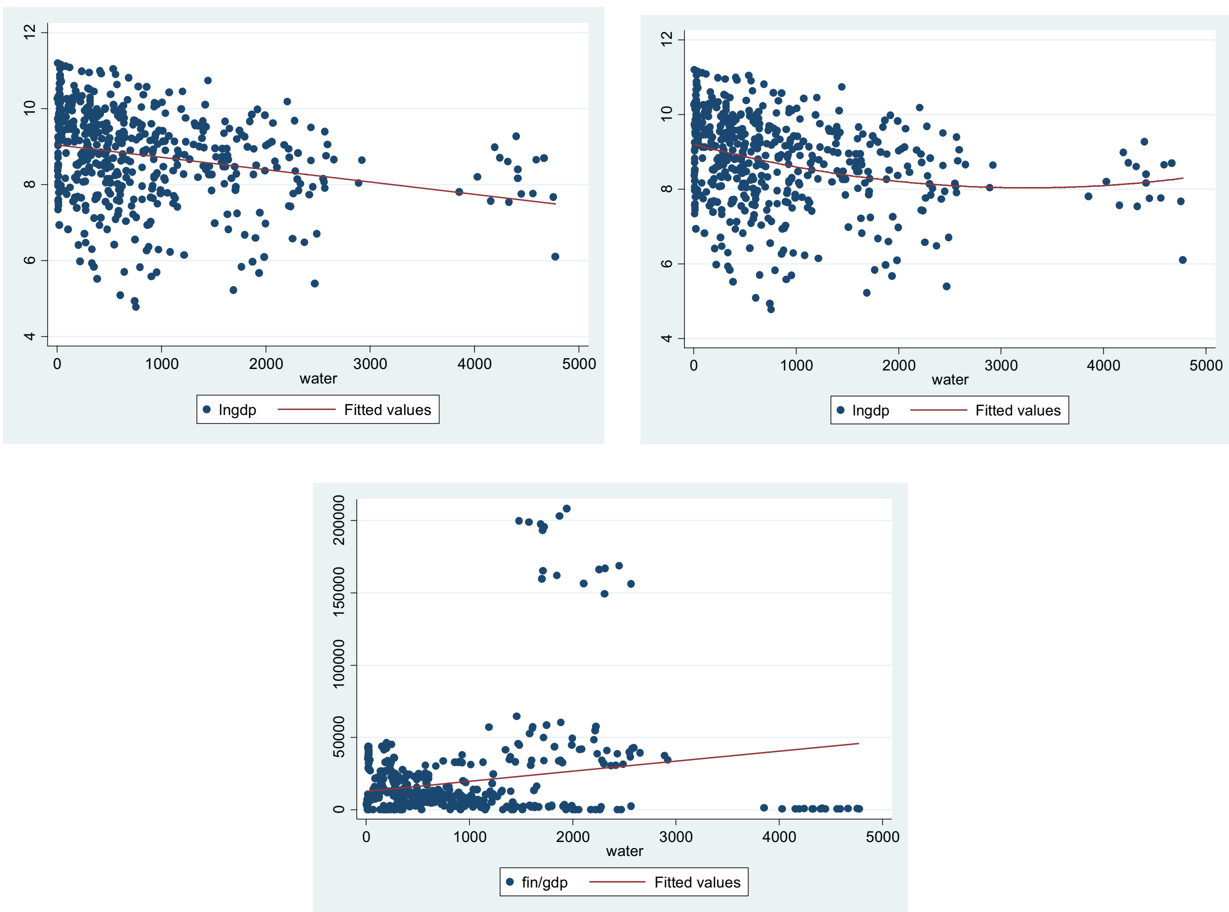

Fig. 3. Preliminary statistical observation.

function of screen technology [35]. Similarly, the financial industry can also identify water-saving and water pollution technologies. According to the direction of technological progress, financial development can help reduce the cost of technological progress [35], promote the spillover and diffusion of technologies including water-saving and water pollution control technologies, improve the efficiency of water resources utilization and reduce water resources utilization. Technological progress itself is conducive to improving the utilization efficiency of financialized water resources, reducing the utilization intensity of water resources per unit product production, and reducing the total utilization of water resources. On the other hand, due to the rebound effect of water resources and the economic growth effect of technological progress, the effect of financial development on the decrease of total water resources utilization may be weakened. Therefore, technological progress is one of the ways that financialization affects the utilization efficiency of water resources.

Existing literature shows that the influence of financial development on water resource utilization is inverted U-shaped. Early-stage of economic development, agriculture, and the light industry in the industrial structure are higher, the total water resource utilization is higher. While entering the stage of industrialization, the industrial structure of low-end manufacturing and traditional services is higher, will consume a large amount of water. But when the modern service industry represented by the financial industry dominates the industrial structure, the total amount of water resource utilization tends to decrease. Therefore, financial development has an impact on the total utilization of water resources. Areas with a high degree of financial development are mainly engaged in the production of technology-intensive products and the provision of modern services, which can help improve the efficiency of water use and reduce the total water use. Hence the industrial structure is the second way that financial development affects the utilization efficiency of water resources. Its logical structure is as follows.

4.2. Interprovincial financial development and water resources in China

According to the theoretical derivation and logic of the previous part, it can be known that water resource utilization and financial development are non-linear. From the perspective of natural resources, although the central and western regions of China are relatively rich in natural resources reserves, their economic growth lags behind. Therefore, in reality, we find that the "inverted U-shaped curve of water resources and financial level" is more likely to exist in China's provinces (Fig. 3).

Preliminary observations on China's interprovincial financial development and water resources are shown in the figure.

5. Research design and data

5.1. Data source and variable selection

This study employs the panel data of 30 provinces in China. Following are the list of variables that are used for assessment, that is, water resource utilization (ln wtotal) served as a dependent variable, while explanatory factors consist of financial development level (lnf), physical capital input (LNK), human capital input, the status of industrial structure, per capita water resource ownership and regional dummy variable.

As an input factor in production, Water resource utilization means gaining more output with less water input. Water use utilization is the ratio of total water consumption to GDP. The larger the value is, the lower the efficiency is. The more GDP per unit water consumption is, the higher the water use efficiency is. Industrial, agricultural, and ecological water use efficiency are respectively represented by industrial water consumption/GDP, agricultural water consumption/GDP, and ecological water consumption/GDP. The data of total water consumption, agricultural and industrial water consumption, as well as the total GDP of each province and agricultural and industrial GDP are from China Statistical Yearbook and water resource Bulletin of each year.

The independent variable is the financial development level (lnf), which refers to the financial depth index adopted by King and Levine. Financial development indicators use the ratio of balance of deposits and loans, the amount of stock-raising, and premium income to GDP. This variable is the key research variable in this paper. These data come from the Regional Financial Operations Report the Database of the National Bureau of Statistics of China.

Other control variables are as follows: (1) LNK represents physical capital input, which is an important factor in improving water resource utilization and is represented by regional social fixed asset investment. (2) LNL represents human capital input. In this paper, the number of college students is used to measure human capital input. (3) Structure variable represents the status of industrial structure. According to the principle of resource utilization, the improvement of water resource utilization efficiency tends to be a typical manifestation of industrial structure upgrading. Therefore, the upgrading coefficient of industrial structure is adopted, and its formula is the added value of the primary industry, twice the added value of the secondary industry, three times the added value of the tertiary industry, and divided by the total output value. (4) Wcpa variable represents per capita water resource ownership, indicating the impact of resource endowment on water resource utilization. (5) Dummy represents the regional dummy variable. In this paper, coastal and inland regional dummy variables are set to investigate water resource content in different regions. These data come from the database of the National Bureau of Statistics of China and have been integrated as indictors.

5.2. Model design

5.2.1. Panel threshold model

The threshold regression model of panel data is one of the main types of nonlinear regression models of panel data. Hansen (inference in TAR models, 1996) proposed the estimation and test of the threshold autoregressive model (TAR) of time series and proposed the use of bootstrap to test the significance of the threshold effect. Then Hansen introduced the econometric analysis method of the threshold regression model of static panel data with individual fixed effect. Based on the Hansen model, the following is set up in this paper:

$$W_{it} = \mu_{it} + \theta\omega_{it} + \beta_1 \text{FIN}_{it} I_{it}\left(\text{FIN}_{it} \le \gamma_1\right) + \beta_2 \text{FIN}_{it} I_{it}\left(\text{FIN}_{it} \succ \gamma_2\right) + \varepsilon_{it} \quad (11)$$

Among them, ω_{it} is a control variable that affects the efficiency of water resources. FIN_{it} is the level of financial development and threshold dependent variables and threshold variables are set. $I(\cdot)$ is the indicator function. γ is the threshold value to be estimated, ε_{it} is a random disturbance term.

5.2.2. Nonlinear panel regression model

In this paper, the following nonlinear panel regression model is established to test the nonlinear relationship between the two variables with the quadratic term of the dependent variable. The model is as follows:

$$\ln \text{w total}_{it} = \alpha_{it} + \beta_{it} \ln f_{it} + \eta \ln f_{it}^2 + \lambda z_{it} + \mu_{it} \quad (12)$$

6. Empirical results and analysis

6.1. Test of the threshold model

Firstly, the number of thresholds is determined in order to determine the form of the model. This paper estimates the efficiency of water resources utilization under the assumption of the single threshold, double threshold and triple threshold in turn, and obtains F statistics and P values, as shown in Table 1.

This paper finds that the single threshold effect of the financial industry is very significant, and the corresponding P-value is 0.000, which is significant at the 0% significance level. Therefore, this paper believes that the financial development level has a single threshold for water resource efficiency. Next, it will analyze based on the single threshold model. The estimated value of the single threshold and corresponding 95% confidence interval are shown in Table 1.

The estimated value of the threshold parameter refers to the value of γ when LR is 0. $\gamma = 1.8424$ is calculated by using stata14 software in Table 2. According to the threshold, the regional financial development level can be divided into two types a lower level and a higher level.

6.2. Regression model under the condition of financial development threshold

Next, this paper further discusses the impact of the financial development threshold on China's inter-provincial water resource utilization and seeks solutions to improve the use of water resources. Here, this paper respectively adds the financial development (LNF), the second term of financial development (Lnflnf), human capital (L), material capital investment (K), the level of economic foundation (LNG), the cross term of industrial structure and financial development (Struff), per capita water resources (WCPA), regional virtual variables (dummy2) for regression analysis. First, take the logarithm of the above data. The regression results are as follows in Table 3:

The regression results of the threshold panel model of 30 provinces in China from 2004 to 2015 (Table 3) show that the impact of financial development on water resources utilization is not a simple linear relationship, but there is a certain "threshold effect". When the growth rate of financial development is lower than 1.8424, the influence coefficient of financial development on water resources utilization is 0.0188, that is to say, when the level of financial development is improved, water resources utilization can be restrained; when the financial development is higher than 1.8424, the inhibition effect of financial development on water resources utilization is weakened. The above phenomena show that the inhibition intensity of financial development on water consumption shows a "V" trend. With the identification of advanced technology by financial development, when the technology of water treatment enterprises is improved, the dependence on water resources in the production process is reduced and the water consumption is reduced due to water-saving technology progress, water-saving facilities construction and other measures.

Although after the industrial and agricultural production efficiency is improved, driven by the economic benefits, the production scale is expanded, resulting in the reduction of the inhibition effect of production efficiency on water consumption, but after further improving the production efficiency, its inhibition effect on water consumption is strengthened again. It can be seen that financial development promotes the progress of industrial structure and production efficiency, which is an effective way to reduce agricultural water consumption.

6.3. Further test of nonlinearity

The regression results of the nonlinear tests are shown in Table 4.

From other control variables, the first-order variable coefficient of financial development (LNF) is negative, indicating that the higher the degree of financial development in

Table 2
Threshold estimation results

	Estimated value	95% confidence interval
Gamma	1.8424	(1.8313, 1.8556)

Table 1
Effect test of financial development threshold

	F-value	P-value	Critical value		
			10%	5%	1%
Single	4,212.46	0.0367	2.60E+03	3.60E+03	6.30E+03
Double	20.85	0.3467	450.5584	638.9696	1.20E+03
Triple	–308.43	0.9800	176.9515	325.6506	557.08

Table 3
Regression results of the panel threshold model

	Dependent variable ln wtotal			
	Coefficient	P-value	95% Conf. Interval	
LNF	0.8044***	0.0000	0.4728	1.1361
Lnflnf	–0.5453***	0.0000	–0.7524	–0.3382
L	0.0144	0.2760	–0.0115	0.0404
K	–2.14E-07	0.5050	–8.46e-07	4.18e-07
LNG	–0.9307***	0.0000	–0.9617	–0.8997
Struff	0.0055***	0.0000	0.0027	0.0082
WCPA	1.47E-07	0.9150	–2.57e-06	2.86e-06
Dummy2	0.0291***	0.0000	0.0132	0.0449
Cat_1	0.0188***	0.0000	0.0096	0.0279
Cat_2	0.0115	0.1090	–0.0025	0.0255
Cat_3	0.0139	0.0600	–0.0005	0.0283
constant	3.8970***	0.0000	3.6400	4.1540
Sigma_u	0.8038			
Sigma_e	0.0571			
Rho	0.9949			
R2	0.9883			

Table 4
Regression results of the nonlinear panel model

	Dependent variable ln wtotal					
	(1)		(2)		(3)	
	Coef.	P	Coef.	P	Coef.	P
LNF	–2.4039	0.0000	–3.0757	0.0000	0.3755	0.0030
	(–2.6456, –2.1622)		(–3.9831, –2.1684)		(0.1295, 0.6215)	
Lnflnf			0.3184	0.1320	–0.2994	0.0000
			(–0.0961, 0.7331)		(–0.4578, –0.1410)	
L					0.0164	0.2180
					(–0.0097, 0.0425)	
K					–3.19E-07	0.3250
					(–9.57e-07, 3.18e-07)	
LNG					–0.9462	0
					(–0.9769, –0.9154)	
Struff					0.0030	0.0150
					(0.0005, 0.0055)	
WCPA					6.03E-07	0.6680
					(–2.16e-06, 3.36e-06)	
Dummy2					0.0295	0.0000
					(0.0133, 0.0456)	
constant	–1.8566	0.0000	–1.5362	0.0000	4.1622	0.0000
	(–2.091208, –1.62203)		(–2.014621, –1.057787)		(3.9463, 4.3782)	
Observation sample	360	360	360	360	360	360
	$F(30, 371) = 61.58$		$F(30, 370) = 60.16$		$F(30, 364) = 1,077.30$	
	Prob. > F = 0.0000		Prob. > F = 0.0000		Prob. > F = 0.0000	

*The interval has been noted at the below line of each variables.

a certain stage, the fewer water resources per unit of GDP is used, and the higher the efficiency is. The Lnflnf coefficient of financial development is positive, which indicates that the higher the level of financial development is in the next stage, the more water resources are used per unit GDP, and the lower the efficiency is. The variable coefficient of the basic level of economy (LNG) is negative, which indicates that the faster the economic development is at present, the higher the efficiency of water resources utilization is. It indicates that economic development is accelerated, more attention is paid to the utilization of water resources, and the corresponding improvement of water treatment technology accelerates the utilization efficiency of water resources. The positive value of the cross term (Struff) coefficient between industrial structure and the first-order financial development indicates that the impact of industrial structure on the utilization of water resources is negative under the role of financial development at this stage, that is to say, the current financial development has not significantly improved the industrial structure, thus changing the consumption of water resources utilization, but reducing the efficiency of water resources utilization. The coefficient of dummy variable (Dummy2) is positive. Compared with the inland area, the coastal water-rich area has lower efficiency of water resource utilization. This is also similar to the results of other literature, for example, in many resources curse literature, Xinjiang, as an inland region, has relatively high water use efficiency in the national ranking.

Due to the relative abundance of water resources, the utilization efficiency is not high. Other control variables, water resources per capita (WCPA), human capital (L), and physical capital investment (k), have not passed the significance level test in this paper.

6.4. Comparison with OECD countries and the United States

By using the same index as China, the ratio of water utilization to GDP, this paper finds that the efficiency of water utilization in OECD countries is V-shaped from 1970 to 2017, decreased from 1970 to 2012, and gradually increased from 2012 to 2017. Fig. 4 shows the utilization of water resources in OECD countries, with data from the OECD database.

From the data of the United States, the left figure shows the efficiency of water use in the United States, and the right figure shows the level of financial development in the United States. From the perspective of American data as a whole, there are also two stages of change between the two, which are divided into two stages since 2007. In the first stage of 1999–2007, the two trends are in the opposite direction, and in the second stage of 2007–2017, the two trends tend to be the same. The data of OECD countries and the United States also confirm the conclusion of the above data on China in Fig. 5.

7. Conclusions and suggestions

The main focus of this paper is to examine the nonlinear mechanism of financial development on water resource utilization under different economic, financial, and structural factors in the context of China.

The study has an obvious difference in the water resource modeling where previous researches more emphasized either on the single linear of financial development and water resources utilization or of financial development and other natural resources. Furthermore, there are few types of research that have testified nonlinear relationships of these two in the macroeconomic framework. The general equilibrium model, threshold panel model, and panel fixed effect model are being used to assess the country's water resource profile that is influenced by the country's financial development. The study further substantiated the "threshold effect" of financial development on water resource utilization in a country. The main conclusions are as the following:

- Financial development has a threshold effect on water resources utilization, that is, the development of the financial industry has significantly different impacts on water resources before and after the threshold value. The relationship between financial development and water

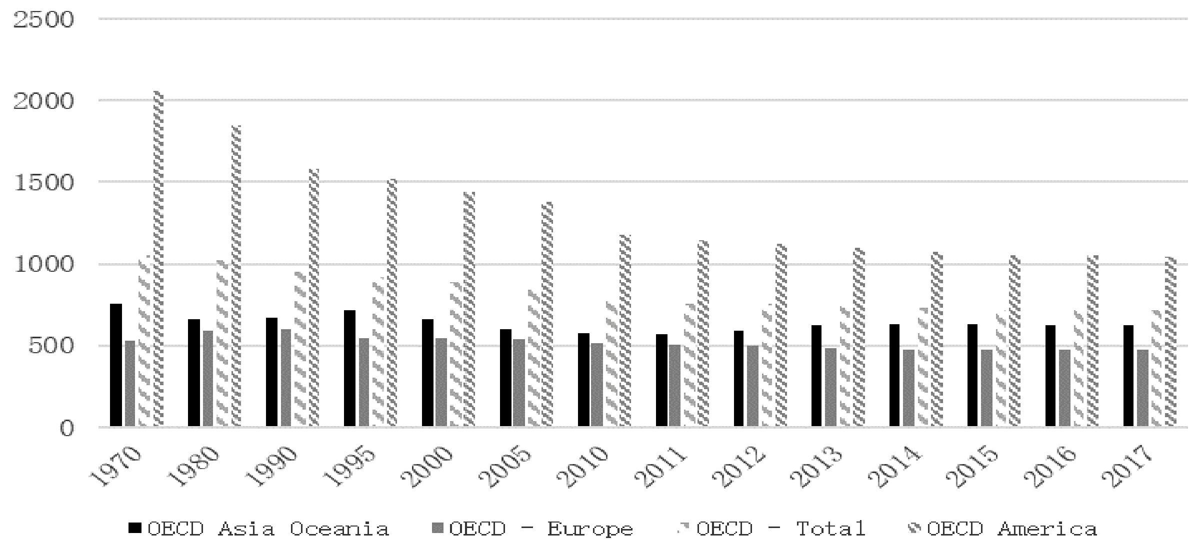

Fig. 4. Comparison with OECD countries.

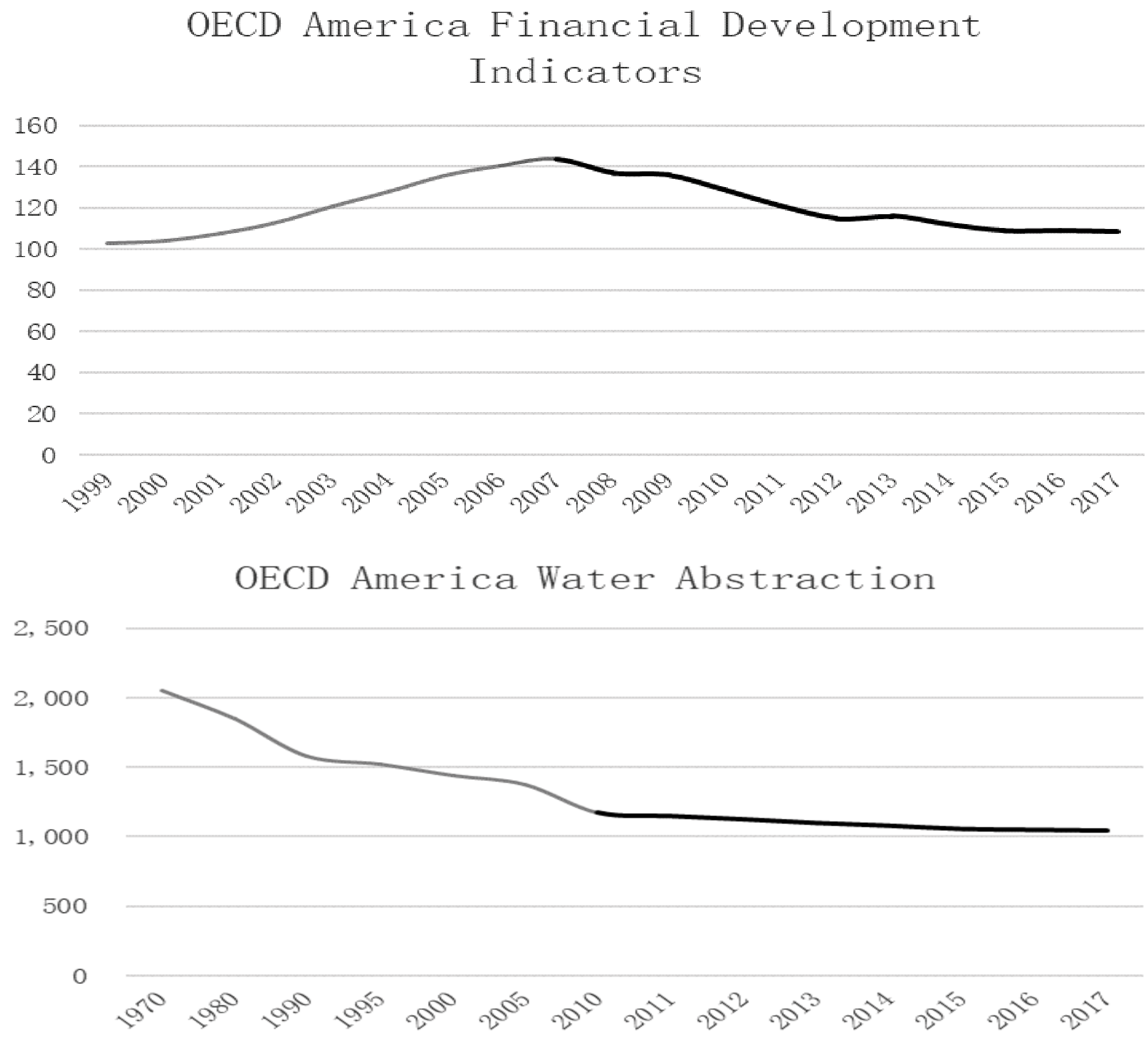

Fig. 5. Comparison with the United States.

resource utilization shows an inverted U-shaped trend. When financial development is improved, the financial industry can effectively promote the water resources utilization and make water resources utilization enter a virtuous circle through technological progress and industrial structure adjustment. When the level of financial development crosses the threshold, the role of financial development in promoting water resources utilization will be weakened. After the efficiency improvement of water resources utilization, firms are driven by financial development to increase investment and expand production scale, which leads to excessive consumption of water resources, and the effect of financial development on the efficiency improvement of water resources utilization is reduced. However, it can be predicted that after financial development is improved, its promoting effect on water resource utilization efficiency is strengthened again. Therefore, financial development should be regarded as an effective way to solve the problem of water resource utilization.

- Water resource utilization in the coastal area is lower than that in the inland area, which indicates that the resource curse also exists in water resource and finance development. In this paper, we should pay more attention to the efficiency of water resource utilization, especially water resource consumption in the areas with a high level of financial development. On the other hand, this paper also notes that the water resources in the central and western regions of China are relatively less than those in the coastal areas with abundant water resources. Therefore, financial development in these areas can promote economic growth, which is of great practical significance.
- Compared with inland areas, financial development in the coastal areas with abundant water resources is relatively higher. It is because of the influence of financial development on water resources the utilization is not a simple linear relationship, but a certain threshold effect, which indicates that the current level of financial development does not cross the threshold value. Along with

the adjustment of industrial structure and the identification of advanced technologies by financial development, water treatment enterprises will be less dependent on water resources in the production process when their technologies are improved, due to such measures as the progress of water-saving technology and the construction of water-saving facilities.

The policy implications deduced that sustainable development in the country includes not only environmental sustainability but also the rational distribution of financial resources. The following policy implications are proposed from the perspective of Water Resource and Financial Development in line with this paper's objectives.

- *Management of Water Resource*: The optimum assortment of water resources should include life water, industrial water, and ecological water that is imperative for the country's sustainable water management.
- *Financial Development*: The country needs more financing to develop water treatment infrastructure. To enhance the efficiency of water resource utilization by the promotion of financial development and technological innovations, financial resources should be allocated to create an environment where water resources can be exploited in a more frugal way.

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