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Research article

Does financial agglomeration enhance regional green economy development? Evidence from China

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Abstract: In the existing literatures concerning on relationship between financial agglomeration and regional economic growth, the contradiction between economic growth and environmental protection is often neglected. This paper employs the non-radial direction distance function, under the framework of super-efficiency DEA, to take the undesired output like waste water and exhaust gas in the process of regional economic growth into the measurement indicators of regional economic development. This paper further focuses on the relationship between financial agglomeration and regional green economic growth. Three main conclusions are drawn. First, there are inverted U-shaped relationships between financial agglomeration and regional green economy development. Compared with the undesirable output, the impact interval of financial agglomeration on economic growth has changed. Second, the heterogeneous impact of financial agglomeration on the regional green economy development is not only reflected in the significance of the impact, but also in the direction of the impact. Third, the impact of financial agglomeration on regional green economy has a non-linear threshold characteristic.

Keywords: financial agglomeration; regional green economy development; panel tobit model; panel threshold model

JEL Codes: R11, 44, C33

1. Introduction

Since the 1980s, with the global economic integration and the rapid development of the financial industry, the flow of international financial resources between regions has accelerated, and the financial industry has shown a trend of financial enterprise restructuring, which causing a phenomenon of high concentration of financial activities and financial institutions in a central city. More and more financial institutions have begun to coordinate transactions between enterprises to organize transactions and production. Financial agglomeration has gradually become the basic form of modern financial industry organization.

The financial agglomeration in China is also surging, the financial agglomeration areas such as Beijing Financial Street and Shanghai Pudong Financial District. Since the 14th National Congress of the Communist Party of China officially established the construction of Shanghai International Financial Center as a national-level strategy in 1992, China has opened the prelude to the construction of a financial center. After China's accession to the World Trade Organization, Beijing, Shanghai, Shenzhen, Chengdu, Tianjin, Chongqing, Wuhan, Jinan, Guangzhou and other cities have successively proposed the idea of building a financial center, and have gradually become a prominent phenomenon in the domestic major economic cities in recent years. However, from the perspective of China's actual situation, there are imbalances in financial development in different regions, and the dynamic process of the formation of this distribution and the final static results are closely related to financial agglomeration. Therefore, it is of great practical significance to fully understand the impact of financial agglomeration on the regional green economy development.

Financial agglomeration refers to the changing process of the spatial and temporal dynamics of the coordination, allocation, and combination of financial resources and regional conditions, the growth and development of the financial industry, and the generation of financial regional dense systems in a certain geographical space. Financial agglomeration is a corollary of financial industry deep development, as well as the inevitable requirement for improving the cross-regional allocation efficiency of financial resources. Meanwhile, it also accelerates the economic development (Levine, 1999; Yi et al., 2010; Li et al., 2011; Hassana et al., 2011; Xie, 2017).

While focusing too much on the impact of financial agglomeration on economic growth, the contradiction between economic growth and environmental protection has not been effectively solved, so the growth of green economy begins to attract more attention. Is the mechanism of financial agglomeration related to economic growth suitable for green economic growth? To answer this question, this paper takes China's regional development data as a sample to study the impact of financial agglomeration on the development of green economy by trying to solve the following key problems. And they are also the main contributions of this paper.

Firstly, does financial agglomeration affect regional green economy development? Previous literature analysis has fully demonstrated that financial agglomeration has a significant role in promoting regional economic growth, but whether the environment is protected has not been included in the research framework. On the one hand, this paper studies whether financial agglomeration has an impact on the development of regional green economy by using the non-radial directional distance function to construct the index, which can evaluate the green development of China's regional economy under the framework of super efficiency DEA. On the other hand, the moderation of financial agglomeration is studied in the case of influence existing, because moderate financial development is a necessary condition for optimal economic growth, and financial restraint or financial excess will damage economic growth.

Secondly, is there heterogeneous impact of financial agglomeration on regional green economy development? China is a large country with heterogeneous economy, and significant differences exist between the east and the west of China. According to the theory of competitive advantage, the essential characteristics of financial agglomeration are derived from resource endowment. In the process of financial agglomeration, the flow of information and the identification of dominant enterprises depend on the market. Financial development needs to adapt to the level of economic development, which has a certain impact on financial agglomeration. In particular, after the 2008 financial crisis, many changes take place in the mechanism of financial function. These differences may lead to the heterogeneous impact of financial agglomeration on the development of regional green economy.

Thirdly, how does financial agglomeration affect regional green economy development? From the above analysis, it can be seen that financial agglomeration affects the growth of green economy by playing a role in non-financial enterprises and industrial agglomeration. This mechanism should be non-linear. Based on this, this paper intends to investigate the non-linear mechanism.

This paper illustrated the following main conclusions. First, this paper adopts the panel Tobit model to test the inverted U-shaped relationship between financial agglomeration and regional green economy development. This study fully demonstrates that when studying the effect of financial agglomeration on economic growth, whether the economic growth measure variables consider environmental constraints, in other words, we take economy's undesirable output into account, does not change the significance, but the moderate range of the effect is changed. Second, the impact of financial agglomeration on the regional green economy development is heterogeneous, which may be reflected in both aspects of direction and significance. This study shows that the heterogeneity of financial agglomeration's effect on economic growth does not change in the direction of its effect, but only in the significance. However, the degree and direction of significance may change when environmental constraints are considered. Third, there are nonlinear threshold characteristics in the effect of the financial agglomeration on the regional green economy development. As an intermediary variable, under different thresholds of industrial structure, financial agglomeration significantly changes the regional green economy development.

The logical structure of this paper is shown in Figure 1. In the second part, we introduce the theoretical background. The third part uses the panel Tobit model to empirically analyze the impact of financial agglomeration on the development of regional green economy. The fourth part studies the heterogeneity of the impact of financial agglomeration on the development of regional green economy in different samples. The fifth part further studies the regulatory effect of financial agglomeration on regional green economic development. The sixth part is the conclusion.

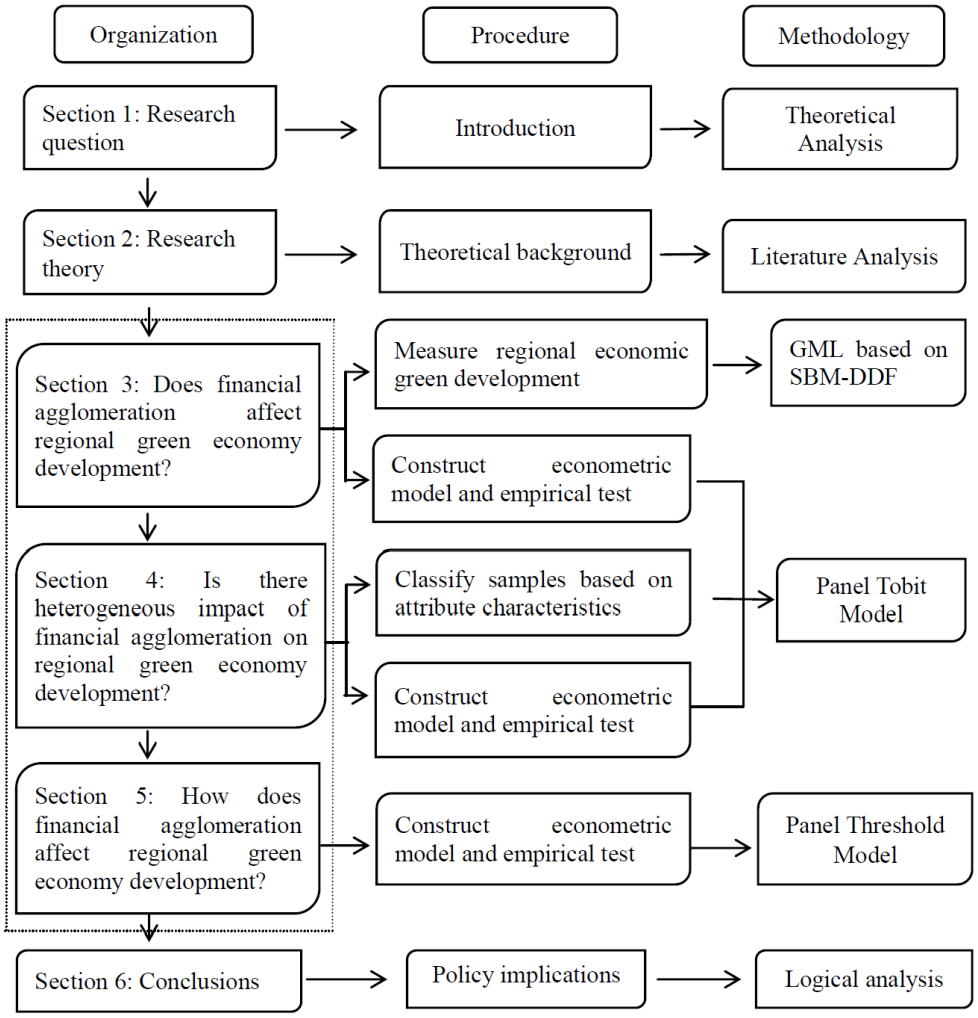

Figure 1. The logical organization of this paper.

2. Theoretical background

Relevant literature has focused more on promotion of financial agglomeration to economic growth (Li and Wang, 2014), but the sharp contradiction between economic growth and environmental protection has not been paid enough attention (Kwakwa et al., 2018).

The "information hinterland theory" developed by Porteous (1999) has greatly promoted the study of financial agglomeration. From the evolution process of world economic development, it is also found that with the continuous improvement of financial system, diverse financial services provided by various financial institutions play an important role in promoting the economic prosperity of countries or regions (Ye et al., 2018; Tripathy, 2019; Ntarmah et al., 2019). Financial agglomeration can promote economic growth in two ways: one is due to the role of information flow. The information externality, information asymmetry and path dependence have a strong promoting effect on the formation of information hinterland (Zhao et al., 2004; Corbridge, 1994; Zhao, 2003; Che et al., 2014). Information hinterland further promotes financial agglomeration. When financial resources are aggregated, information can flow more fully among financial institutions, which further

strengthens information agglomeration. Information aggregation can effectively identify related industries and new technologies, and make financial resources cluster to industries that are more conducive to economic development (Buera et al., 2011), so as to promote economic growth (Zhang, 2014). Of course, the development of information technology makes it possible to provide financial services over a longer distance, which is also the condition for the formation of financial agglomeration. The function mechanism of finance on innovation and economic growth is realized through financial markets. Through information gathering, financial markets can identify enterprises and entrepreneurs who have successfully developed new products and applied new technologies, and provide abundant credit and risk diversification services for innovation activities. The other way is that by providing more support to enterprises, financial agglomeration plays a more important role in financial intermediation, thus promoting economic growth. The concentration of financial institutions in an area and the services provided by financial intermediaries, such as concentrated savings, scheme and operational risk assessment, motivating managers and transactions promotion, promote entrepreneurial innovation and hence foster economic growth. In a sense, it can be considered that the more complete the financial system composed of commercial banks, securities companies, insurance companies and other financial organizations (Li and Liao, 2020), the greater the possibility of the success of economic innovation activities, and the greater the function on total factor productivity improvement and economic growth.

The effect of financial agglomeration on economic growth has been explained by spatial interrelationship. The emergence of financial agglomeration stems from the geographical aggregation or concentration of financial institutions, which can obtain economies of scale in business cooperation, information dissemination and flow, labor specialization and infrastructure sharing (Kukalis, 2010). This economic benefit is embodied in the following aspects: firstly, it saves working capital balance and provides financing and investment convenience. Secondly, it improves market liquidity and reduces market financing cost and investment risk (Kindleberger, 2015; Arbpleda, 2015; Wen et al., 2018). Thirdly, it facilitates cooperation between financial institutions and shares auxiliary industries (Huang et al., 2019; Li et al., 2018). Once scale economy comes into being, it will continue to be strengthened. More and more financial institutions and their auxiliary institutions will be attracted to the specific geographical space, and financial participants, such as individuals and enterprises, will continue to move to this gathering area. The concentration of a large number of non-financial enterprises in the financial agglomeration area, not only promotes competition among enterprises, but also improves the speed of information dissemination (Szirmai, 2012). Under the influence of intensified competition and convenient information exchange between the supplier and the demander, the innovation motivation of enterprises will be strengthened, and the application of innovation achievements will be accelerated. In particular, the convenience of information collection in the financial agglomeration area makes the financial intermediary improve the level of innovation by identifying the entrepreneurs, who are most likely to succeed in new products and new processes. It can also effectively reduce the risk of entrepreneurship, improve the economic return brought by innovation, make the innovation system more efficient, and then promote the improvement of regional economic growth potential.

3. Methodology and data

3.1. Panel tobit model

Financial agglomeration affects the green development of regional economy mainly from two aspects. On the one hand, financial agglomeration leads to industrial agglomeration, thus promoting the regional economy green development. Financial agglomeration provides rich financial resources, sound financial institutions and perfect financial markets, and forms a complex cluster network, which is conducive to the high-speed and effective flow of information. Information agglomeration can effectively identify related industries, make financial resources gather to the industry which is more favorable to economic development, and thus lead to industrial agglomeration. Industrial agglomeration, which has a perfect public infrastructure, can bring knowledge spillover and help to improve the efficiency of resource allocation and awareness of environmental protection, further promote environmental protection and green development of regional economy. On the other hand, financial agglomeration helps to identify innovation, thus promoting the green development of regional economy. Through knowledge spillover effect and regional innovation network effect, financial agglomeration introduces clean production technology, improves regional technological innovation ability and environmental quality, and improves marginal productivity of capital, so as to promote regional green economy development.

The data envelopment analysis (DEA) method is adopted to measure the development of regional green economy, and its value is always no less than 0. Moreover, the DEA score is a relative efficiency index rather than an absolute index (Selim and Bursalioglu, 2013), and the correlation between the efficiency scores makes OLS regression invalid, so it is not suitable to use the OLS for coefficient estimation (Cheng et al., 2019). Otherwise, the coefficient and the estimation deviation will not be consistent. The panel Tobit model estimated by the maximum likelihood (ML) method is an alternative to the OLS method (Greene, 2004). Tobit model is also called sample selection model or limited dependent variable model (Tobin, 1958). In Tobit model, the change of dependent variable is limited to some extent (Zhou and Li, 2012), and variables with limited values are defined as “deletion” or “truncation”. In this paper, the development of regional green economy is always limited to no less than 0. Therefore, we select the panel Tobit model to study the impact of financial agglomeration on the regional green economy development. The panel Tobit model is constructed as follows:

$$\begin{aligned} GTFP_{it} = {} & \mathrm{c} + \beta_1 * fin\_cluster_{it} + \beta_2 * fin\_cluster_{it}^{\ 2} + \beta_3 * market_{it} + \beta_4 * lnhc_{it} + \\ & \beta_5 * lninno_{it} + \beta_6 * lnperGDP_{it} + \beta_7 * indu_{it} + \varepsilon_{it} \end{aligned} \tag{1}$$

where *GTFP* represents the regional green economy development; *fin_cluster* represents financial agglomeration. Referring to relevant literature (Xie, 2017; Gennaioli and Porta, 2013), we select control variables as follows: *market* is the marketization index; *lnhc lninno* and *lnperGDP* represents the logarithm of human capital, innovation capacity and level of economic development respectively; *indu* represents the industrial structure; c is the constant term; β is the regression coefficient; ε is the random disturbance term.

3.2. Data and variable

3.2.1. Data and sample

This paper mainly studies the influence of China's financial agglomeration on the regioinal green economy development. Considering the completeness and availability of data, this paper selected 30 provinces (municipality) in China as samples, excluding Tibet, Hong Kong, Macao and Taiwan. The time dimension of the annual data is from 1998 to 2015. The main reasons are as follows: first, data released by the National Bureau of Statistics or related database are annual data; second, since Chongqing municipality is founded in 1997, and its data are published after 1997; third, industrial waste gas emissions data are stopped publishing after 2015.

3.2.2. Measurement of regional green economy development

The development of regional green economy is the explained variable, which is measured by green total factor productivity (GTFP), since it takes environment and energy into consideration, so it can better reflect the green development of regional economy (Li et al., 2019). Following Liu and Xin (2019), we measure the GTFP by employing Global Malmquist-Luenberger (GML) index based on slacks-based measure directional distance function with the maxDEA software.

Every province (municipality) in China is regarded as a decision-making unit (DMU). At first, according to the contribution of Oh (2010)，we generate a global production possibility set (PPS), which contains N inputs (labor input, capital input and energy input), $x=(x_1,\cdots,x_n)\in R_N^+$, M desirable outputs (real GDP)，$y=(y_1,\cdots,y_n)\in R_M^+$, and J unexpected outputs (discharge of waste water and exhaust gas), $b=(b_1,\cdots,b_n)\in R_J^+$. The PPS is defined as follows:

$$P^G(x)=\left\{(y^t,b^t):\sum_{t=1}^{T}\sum_{k=1}^{K}z_k^t y_{km}^t\geq y_{km}^t,\ \forall m;\ \sum_{t=1}^{T}\sum_{k=1}^{K}z_k^t b_{ki}^t\geq b_{ki}^t,\ \forall i;\ \sum_{t=1}^{T}\sum_{k=1}^{K}z_k^t x_{kn}^t\leq x_{kn}^t,\ \forall n;\ \sum_{k=1}^{K}z_k^t=1,\ z_k^t\geq 0,\ \forall k\right\} \tag{2}$$

where z_k^t represents the weight of each province. $z_k^t\geq 0$ means that the return on scale remains unchanged.

Based on the research of Fukuyama and Weber (2009) and Liu and Xin (2019),we then construct a global SBM directional distance function, which covers the unexpected output such as waste water and exhaust gas in the process of economic growth, as shown below:

$$\vec{S}^{G}(x^{t,k'}, y^{t,k'}, b^{t,k'}, g^{x}, g^{y}, g^{b})$$
$$= \max_{s^{x},s^{y},s^{b}} \frac{(1/N)\sum_{n=1}^{N}(s_n^x/g_n^x)+(1/(M+I))(\sum_{m=1}^{M}s(s_m^y/g_m^y)+\sum_{i=1}^{I}(s_i^b/g_i^b))}{2}$$
$$s.t.\begin{cases} \sum_{t=1}^{T}\sum_{k=1}^{K} z_k^t x_{kn}^t + s_n^x = x_{k'n}^t, & \forall n; \\ \sum_{t=1}^{T}\sum_{k=1}^{K} z_k^t y_{km}^t + s_m^y = y_{k'm}^t, & \forall m; \\ \sum_{t=1}^{T}\sum_{k=1}^{K} z_k^t b_{ki}^t + s_i^b = b_{k'i}^t, & \forall i; \\ z_k^t \geq 0, & \forall k; \\ s_m^y \geq 0, & \forall m; \\ s_i^b \geq 0, & \forall i; \end{cases} \tag{3}$$

where (g^x, g^y, g^b) respectively represent the direction vector of the decrease of labor, capital and energy input, the increase of real GDP and the increase of waste water and exhaust gas emissions; (s_n^x, s_m^y, s_i^b) represent the slack vectors of redundant labor, capital and energy inputs, inadequate real GDP and unexpected waste water and exhaust gas emissions. If the value is greater than 0, the real labor, capital and energy input and waste water and exhaust gas emissions are greater than the boundary labor, capital and energy input and waste water and exhaust gas emissions, while the real GDP is less than the boundary GDP.

Finally, we build the GML index as follows:

$$GML^{t,t+1}(x^t, y^t, b^t, x^{t+1}, y^{t+1}, b^{t+1}) = \frac{1+\vec{S}^{G}(x^t, y^t, b^t; g^x, g^y, g^b)}{1+\vec{S}^{G}(x^{t+1}, y^{t+1}, b^{t+1}; g^x, g^y, g^b)} \tag{4}$$

where $\vec{S}^{G}(x^t, y^t, b^t; g^x, g^y, g^b)$ represents the global SBM directional distance function based on non-radial and non-guided measurements. The GML index shows the change from time t to time $t+1$. If GML is greater than 1, an increase in GTFP is indicated. If GML is equal to 1, then GTFP is in a stable state. Otherwise, GTFP decreases.

Table 1. Measurement of GTFP.

	Variable	Measurement	Source
Inputs	Labor	Number of year-end employed people	EPS macro database
	Capital stock	Perpetual inventory method	National Bureau of Statistics
	Energy	Total energy consumption of every area	EPS macro database
Outputs	Desirable output	Real GDP	National Bureau of Statistics
	Undesirable output	Total industrial waste gas discharge	EPS macro database
		Total industrial waste water discharge	EPS macro database

Note: This table documents the measurement and source of a system of indicators for measuring green total factor productivity (GTFP), including three inputs (Labor, Capital stock, Energy), one desirable output (Real GDP) and two undesirable output (Total industrial waste gas discharge and Total industrial waste water discharge).

However, the GML index is not the GTFP, but the change rate of GTFP. Therefore, it is assumed that the GTFP of each province in 1997 is 1. The GTFP in 1998 is $GTFP_{1998} = GTFP_{1997} * GML_{1997-1998}$. The GTFP calculations for the rest of the years are the same.

When measuring GTFP, this paper selects three input variables: labor input, capital input and energy input. The real GDP is the desirable output variable, and industrial waste water and gas discharge are the two undesirable output variables (Zhong and Li, 2020; Song et al., 2018). The measurement methods and data sources of these input and output indicators are shown in Table 1.

3.2.3. Other variables and descriptive statistics

The explanatory variable of this research is financial agglomeration. In addition, in the process of modeling, there are many factors that affect the development of regional green economy. In order to more accurately explore the impact of financial agglomeration on the development of regional green economy, it is necessary to assume that other influencing factors are unchanged, that is, other major influencing factors need to be controlled and set as the control variables in the metrological test. Based on a systematic summary of relevant literature, this paper selects five control variables: marketization index, human capital, innovation capability, economic development level, and industrial structure.

Financial agglomeration: Referring to relevant literature (Xiao et al., 2018), combined with the availability of data, location entropy is selected as an indicator to measure financial agglomeration. $fin\_cluster_{it} = \left(fin_{it} / GDP_{it} \right) / \left(fin_t / GDP_t \right)$, where $fin\_cluster_{it}$ represents the degree of financial agglomeration of province i in year t, and if its value is greater than 1, the financial agglomeration trend of the province is relatively obvious; fin is the sum of deposits and loans of financial institutions; GDP refers to gross domestic product. Data on financial agglomeration can be obtained from the National Bureau of Statistics.

Marketization index: According to Fan (2011), the marketization index is mainly constructed from five aspects: the relationship between government and market, the development of non-state-owned economy, the development of product market, the development of factor market, the development of market intermediary organization and the legal system environment. The marketization index of each province in China can be extracted from the Report of Marketization Index of China's Provinces.

Human capital: Human capital is usually the sum of knowledge, technical skills, ability and quality that can create economic and social value, and it is an important factor that affects the development of regional green economy (Gennaioli and Porta, 2013). The higher the level of human capital, the more conducive it is to the production and the adoption of new technology, improves the efficiency of resource utilization, and thus promoting the development of regional green economy. This paper calculates human capital by multiplying the number of year-end employees by the average number of years of education. Human capital related data can be obtained from the EPS macro database.

Innovation Capability: The improvement of innovation capability is conducive to improving production technology, optimizing energy structure, thus improving environmental quality and promoting green development of regional economy (Kogan et al., 2017). The stronger the innovation capability, the more conducive it is to the development of regional green economy. In this paper, the natural logarithm of the number of patent applications is used to measure the innovation capability, and the relevant data come from EPS macro database.

The level of economic development: In this paper, per capita GDP is used to represent the level of economic development. The higher the per capita GDP is, the higher the level of economic development is. The data related to the level of economic development are from the National Bureau of Statistics.

Industrial structure: Upgrading of industrial structure refers to the continuous evolution of industrial structure from the low level to the high level. The upgrading of an area's industrial structure means that its resource utilization efficiency is constantly improving and the environmental cost of economic development is constantly decreasing. According to the principle of industrial evolution, we use the sum of the proportion of the added value of three industries to the added value of the first industry to calculate the industrial structure coefficient (Liu et al., 2016). The relevant data come from the EPS macro database.

Descriptive statistics of variables are shown in Table 2. Due to the constraints of the length of the paper, we only report the mean value of each variable in the whole sample and sub samples. On the whole, the mean value of GTFP is greater than 1, indicating that China's green total factor productivity is increasing. The average value of financial agglomeration is less than 1, indicating that the trend of financial agglomeration degree in China is not obvious enough. From the perspective of sub samples, each variable is different across sub samples. Firstly, the mean values of the GFTP are all greater than 1 in the four sub samples: the eastern region, the post financial crisis, the high degree of marketization and the high level of economic development, indicating that in these sub samples, green total factor productivity is improving. In the other four sub samples, the mean values of GFTP are less than 1, indicating that in these sub samples, the green total factor productivity is decreasing. Secondly, the mean values of financial agglomeration of the three sub samples, the eastern region, the high degree of marketization and the high level of economic development, are all greater than 1, indicating that the trend of financial agglomeration is more obvious in these sub samples. However, in the three sub-samples of non-eastern regions, low marketization degree and low economic development level, the mean values of financial agglomeration are all less than 1, indicating that the financial agglomeration trend is not obvious enough in these sub samples. However, in the time samples, there is no significant difference in the degree of financial agglomeration, indicating that the trend of financial agglomeration is not obvious before or after the financial crisis. In addition, there are significant differences in the industrial structure among the sub samples. The industrial structure level of the four sub samples of eastern region, post financial crisis, high degree of marketization and high level of economic development is significantly higher than that of the four sub samples of non-eastern region, post financial crisis, low degree of marketization and low level of economic development.

Table 2. Descriptive statistics (mean).

Variable	Full	Area		Time		Market		perGDP	
	sample	East	nonEast	before	after	Low	high	low	high
GTFP	1.012	1.159	0.927	0.977	1.068	0.952	1.072	0.940	1.084
fin_cluster	0.984	1.261	0.823	0.982	0.987	0.894	1.073	0.823	1.144
market	5.753	7.266	4.878	5.492	6.164	4.279	7.227	4.950	6.557
lnhc	8.486	8.891	8.252	8.234	8.883	8.009	8.964	8.101	8.872
lninno	8.981	9.919	8.437	8.288	10.069	7.857	10.105	7.924	10.038
lnperGDP	2.882	3.362	2.604	2.397	3.644	2.408	3.356	2.150	3.614
indu	15.917	30.811	7.295	12.472	21.330	7.757	24.078	6.550	25.285

3.3. Empirical results

In this section, we use the panel Tobit model to explore the impact of financial agglomeration on the development of regional green economy. Before estimating the model, we need to test the multicollinearity problem between variables. Table 3 shows the correlation coefficients between variables, and it can be seen that high collinearity exists only between individual control variables, such as *lnhc* and *inno*. It will not affect the consistency of *fin_cluster* parameter estimation, nor will it affect the validity for GTFP. In addition, different methods are used to test the robustness, such as fixed effect panel regression (Fe), random effect panel regression (Re). The development of green economy will promote the agglomeration effect of financial resources to some extent, and there is a certain endogenous problem between financial agglomeration variables and GTFP. To this end, the first-order hysteresis variable of GTFP is taken as the instrumental variable, and the two-stage least square regression (2SLS) and generalized moment estimation (GMM) are used to process the endogeneity problem among variables, and more robust conclusions are obtained. The estimated results of model parameters are shown in Table 3. Column 2–6 of Table 4 respectively reports the regression results of panel Tobit model, fixed effect panel regression, random effect panel regression, two-stage least square regression and generalized moment estimation.

Table 3. Correlation matrix.

	GTFP	fin_cluster	market	lnhc	lninno	lnperGDP	indu
GTFP	1.000						
fin_cluster	0.391	1.000					
market	0.231	0.262	1.000				
lnhc	0.124	0.053	0.681	1.000			
lninno	0.198	0.183	0.793	0.905	1.000		
lnperGDP	0.307	0.298	0.642	0.562	0.759	1.000	
indu	0.678	0.686	0.465	0.241	0.363	0.494	1.000

There is an inverted “U”-shaped relationship between financial agglomeration and regional green economy development. From the regression results in Table 4, it can be seen that no matter which estimation method is used, the regression coefficients of the quadratic term of financial agglomeration are negative and significant at the level of 1%. These results show that there is an inverted “U”-shaped relationship between financial agglomeration and the development of regional green economy. That is to say, when the level of financial agglomeration is low, an increase of financial agglomeration can promote the development of regional green economy; when the degree of financial agglomeration is greater than the critical value, the improvement of the degree of financial agglomeration will have a negative impact on the development of regional green economy. The inverted “U”-shaped relationship between financial agglomeration and regional green economy development is consistent with reality, but it is different from the results of Xie (2017), who found that financial agglomeration plays a positive impact on regional economic growth. When the degree of financial agglomeration is in a reasonable range, the positive externalities brought by agglomeration reduce the cost of information communication, increase the labor opportunities in the labor market, and improve the technology spillover effect among enterprises, so as to increase the overall energy and resource utilization efficiency. At the same time, the emissions of pollutants are

reduced, and thus promoting the development of regional green economy. When financial agglomeration is excessive, a large number of labor workers will pour into the region, resulting in inadequate local infrastructure, which will cause pressure and challenges to the bearing capacity of the local economy and natural resources, mainly manifested in traffic congestion, thus reducing the labor productivity and resource utilization efficiency of enterprises, increasing the emission of pollutants, which is not conducive to the development of regional green economy.

Table 4. Impact of financial agglomeration on regional green economy development.

	Tobit	Fe	Re	2SLS	GMM
GTFP					
fin_cluster	0.182***	0.193***	0.178***	0.254***	0.254***
	(0.063)	(0.065)	(0.064)	(0.095)	(0.064)
fin_cluster^2	−0.077***	−0.079***	−0.076***	−0.098***	−0.098***
	(0.019)	(0.021)	(0.020)	(0.034)	(0.020)
market	−0.012	−0.010	−0.013	−0.009	−0.009
	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)
lnhc	−0.035	−0.028	−0.036	−0.008	−0.008
	(0.043)	(0.047)	(0.043)	(0.057)	(0.048)
lninno	0.063**	0.068***	0.062**	0.067***	0.067***
	(0.025)	(0.025)	(0.025)	(0.024)	(0.025)
lnperGDP	−0.106***	−0.119***	−0.103***	−0.122***	−0.122***
	(0.029)	(0.032)	(0.029)	(0.032)	(0.032)
indu	0.014***	0.014***	0.014***	0.013***	0.013***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
_cons	0.825***	0.734**	0.844***		
	(0.271)	(0.302)	(0.266)		
sigma_u	0.287***				
	(0.038)				
sigma_e	0.157***				
	(0.005)				
N	540	540	540	510	510
R^2		0.575		0.595	0.595

Notes: Fe, Re, 2SLS and GMM are the parameter estimation results obtained by the panel regression model of fixed effect, random effect, two-stage least squares estimation and generalized moment estimation respectively. The standard errors of corresponding parameters are in brackets; *** p < 0.01, ** p < 0.05, * p < 0.1. Among them, GMM estimation results show that arellano-bond test for AR(1) in first differences: z = 3.62 (0.000); Arellano-bond test for AR(2) in first differences: z = 7.34 (0.000); Sargan test excluding group: chi2(130) = 992.31 (0.000).

4. Heterogeneous impact of financial agglomeration on regional green economy development

4.1. A theoretical analysis on the heterogeneity of the impact of financial agglomeration on regional green economic development

The effect of financial agglomeration on the development of regional green economy comes from the difference of regional resource endowment. There is significant difference in the spatial distribution of financial agglomeration in China. From the perspective of spatial characteristics, due to the significant advantages of talents and capital in eastern China, the degree of financial agglomeration in eastern China is significantly higher than that in other regions of China. At the same time, the eastern region has a high degree of industrial correlation with other regions, strong cross-border service and intensive talent and knowledge, so its financial agglomeration has obvious external effects on the development of green economy. With the advantage of resource endowment, financial agglomeration promotes regional economic growth through specialization, reduction of intermediate services and transaction costs, spatial spillover effect, and competition and learning effects. Besides, the government has a stronger awareness of environmental regulation, thus promoting the development of green economy. In addition, financial agglomeration is a high-end industry. From the perspective of the actual development process of global industrial agglomeration, high-end productive industries tend to gather in London, Paris and other global metropolises. The main reason is that in large cities, financial agglomeration can be close to higher-end talents and high-efficiency enterprises. Therefore, financial agglomeration is more obvious in eastern China, which has a more significant effect on the development of regional green economy.

The financial crisis in 2008 has a significant impact on the financial order and enterprise management, so the influence of financial agglomeration on the regional green economy development has also changed significantly. From the perspective of global economic order and governance, there are four internal dilemmas in the international financial field, namely, level conflicts, non-neutral rules, public choice and hegemonic dominance. The occurrence of the crisis makes many economic subjects achieve economic development through cross regional economic governance, regional economic governance, bilateral economic governance and internal economic governance. From the perspective of the impact of finance on the economy, after the crisis, the global economy began to transform from the virtual economy to the real economy. All levels emphasize that finance serves the real economy, so the original nature of finance is more fully exerted. From the perspective of enterprise management, the allocation of financial resources by high-end enterprises has changed, in particular, different business enterprises tend to diversify between financial behavior and corporate responsibility, which makes financial agglomeration appear heterogeneous in promoting green economic growth through innovation and other ways. Therefore, after the financial crisis, the effect of financial agglomeration on the development of regional green economy has changed accordingly.

The precondition of financial agglomeration and its effect on the development of regional green economy is to allocate corresponding resources through marketization. The remarkable effect of marketization on financial agglomeration is due to two reasons: on the one hand, from the macro perspective, the efficiency of the financial system can be improved through the market. Financial agglomeration, which gathers all kinds of factors into a certain degree, can improve the conversion efficiency of households' savings into investment. As an accelerator, it can also stimulate entrepreneurship and promote enterprise innovation. The enhancement of enterprises' innovation

ability, coupled with the fact that financial agglomeration belongs to high-end industrial agglomeration, will promote the development of regional green economy. On the other hand, from a micro perspective, the efficiency of the financial industry and other enterprises will be improved. No matter financial enterprises or other enterprises, in the face of external marketization, enterprises will face competition and serve customers. While customers pay corresponding consideration, enterprises will benefit themselves by gaining business income through altruism. There are many enterprises that can provide similar products or services in the market, and competition will be formed between enterprises. Customers will eventually choose the enterprises with high performance and good service. Based on this, when enterprises allocate resources, they can win the market by finding more cost-effective resources and efficient use of resources, creating more cost-effective products or services, and accordingly improve the efficiency of enterprises at the micro level and promote the green development of regional economy. At different levels of marketization, financial agglomeration has significant differences in the green development of regional economy.

The effect of financial agglomeration is closely related to the level of economic development. Economic development has the characteristics of evolution. In the process of evolution, economic growth is often achieved through the improvement and optimization of economic structure and economic quality. With the development of economy, the effect of financial agglomeration is also rising. The main reason is the comparative advantage in the process of industrial evolution, which can be explained from the perspective of "headquarters economy". "Headquarters economy" refers to an economic form in which a region attracts enterprises to cluster their headquarters in the region due to its unique resource advantages, and places production and manufacturing bases in other regions with comparative advantages, so as to realize optimal spatial coupling between enterprise value chain and regional resources, and thus have an important impact on the green development of the regional economy. According to the pattern of headquarters economy, enterprises arrange their headquarters in developed central cities and their production and processing bases in underdeveloped areas, so that enterprises can obtain strategic resources of central cities and conventional resources of underdeveloped areas at a lower cost, and realize the centralized allocation of advantageous resources of two different regions in the same enterprise. It can not only reduce the comprehensive cost of enterprise resource allocation, but also make the most efficient release of the intensive talents, information and technology resources in the central city where the headquarters are located, and maximize the intensive manufacturing resources in the underdeveloped area where the processing base is located.

4.2. An empirical analysis on the heterogeneity of financial agglomeration affecting regional green economy development

According to the theoretical analysis of 4.1, in order to better study the impact of financial agglomeration on the development of regional green economy, this paper classifies samples according to four attributes, i.e. region, time, degree of marketization and level of economic development, and then conducts sub-sample research on them. The region is divided into the eastern region and the non-eastern region, which is different from most literature that divide China into the East and the West. This different classification comes from the fact that the research objective of this paper is to study the influence of financial agglomeration on the development of regional green economy. Although the central and western regions of China have significant differences in factor endowment and other aspects, there is no significant difference between them in terms of their impact on the research objective. The period is divided into two with the 2008 financial crisis as the

critical point, i.e., the periods before and after the 2008 financial crisis, when the financial operation order has changed significantly. Meanwhile, according to the level of marketization, samples are divided into two groups of high and low marketization level, with the median of marketization level as the critical point. For the level of economic development, take the median of per capita GDP as the critical point, and divide each region into two samples of high and low level of economic development. By grouping the samples according to different markers, the sub-samples are obtained. The parameters in model (1) are estimated by using the sub-samples data. The parameter estimation results are shown in Table 5.

Table 5. Heterogeneous impact of financial agglomeration on regional green economy development.

	Area		Time		Market		perGDP	
	East	nonEast	before	after	low	high	low	high
GTFP								
fin_cluster	0.343***	−0.296**	−0.051	−0.595**	−0.146	0.134	−0.300**	0.183
	(0.115)	(0.119)	(0.072)	(0.241)	(0.089)	(0.111)	(0.124)	(0.134)
fin_cluster^2	−0.126***	0.156***	0.003	0.265***	0.085**	−0.087***	0.125**	−0.088***
	(0.027)	(0.057)	(0.023)	(0.090)	(0.034)	(0.029)	(0.062)	(0.030)
market	−0.034**	0.009	−0.009	0.037	0.017	−0.021	0.002	−0.019
	(0.013)	(0.013)	(0.012)	(0.025)	(0.017)	(0.013)	(0.014)	(0.014)
lnhc	−0.178**	0.023	−0.117*	0.206**	−0.156**	0.121	−0.109	0.101
	(0.074)	(0.055)	(0.061)	(0.092)	(0.062)	(0.075)	(0.071)	(0.075)
lninno	0.095**	0.047	0.048	−0.089**	0.037	0.022	0.018	−0.028
	(0.046)	(0.028)	(0.036)	(0.044)	(0.034)	(0.039)	(0.041)	(0.040)
lnperGDP	−0.026	−0.080*	−0.088**	0.027	0.006	−0.117*	0.001	0.056
	(0.055)	(0.041)	(0.040)	(0.092)	(0.042)	(0.061)	(0.048)	(0.072)
indu	0.013***	−0.008	0.012***	0.008***	−0.016***	0.014***	−0.012	0.012***
	(0.001)	(0.009)	(0.001)	(0.001)	(0.006)	(0.001)	(0.010)	(0.001)
_cons	1.576***	0.688*	1.693***	−0.110	2.022***	0.010	1.923***	0.024
	(0.425)	(0.360)	(0.395)	(0.522)	(0.424)	(0.448)	(0.463)	(0.417)
sigma_u	0.271***	0.292***	0.240***	0.360***	0.268***	0.359***	0.237***	0.334***
	(0.060)	(0.049)	(0.033)	(0.051)	(0.043)	(0.054)	(0.036)	(0.045)
sigma_e	0.153***	0.150***	0.142***	0.124***	0.140***	0.152***	0.133***	0.147***
	(0.008)	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)
N	198	342	330	210	270	270	270	270

Notes: Standard errors of corresponding parameters are in brackets; *** p < 0.01, ** p < 0.05, * p < 0.1.

It can be seen from Table 5 that there is heterogeneity of the impact of financial agglomeration on regional green economy development in different sub-samples. Based on the analysis of the regional sub-sample, the overall effect of financial agglomeration on the development of regional green economy is reflected in the inverted U-shaped relationship in the eastern region, but in the non-eastern region, it is reflected in the U-shaped trend. According to the U-shaped relationship of the two regions, we can further analyze the heterogeneity of eastern and non-eastern regions when financial agglomeration is in different intervals. The inflection point of the U-shaped relation in non-eastern region is 0.949 (−(−0.296/2*0.156) = 0.949), and the inflection point of the inverted

U-shaped relation in eastern region is 1.361 (−(−0.343/2*0.126 = 1.361)). Therefore, when the financial agglomeration level is less than 0.949, financial agglomeration promotes the development of regional green economy in the eastern region but inhibits the development of regional green economy in the non-eastern region. When the financial agglomeration level is between 0.949 and 1.361, financial agglomeration promotes the development of regional green economy in both regions. However, the positive effect of financial agglomeration on the regional green economy development in the eastern region is of a convex function rather than a concave function. When the financial agglomeration level is greater than 1.361, financial agglomeration restrains the development of regional green economy in the eastern region but promotes the development of regional green economy in the non-eastern region. This situation can be explained from two aspects. On the one hand, after the financial agglomeration in the eastern region reaches a certain degree, it may lead to excessive financialization, which will have a negative impact on the development of the regional green economy. Further development of financial agglomeration requires industry coordination and higher level of environmental protection. On the other hand, for non-eastern regions, their financial agglomeration has reached a certain threshold. The promotion of financial agglomeration can effectively reduce the cost of information communication, increase employment opportunities, enhance the awareness of environmental protection, and pay attention to improving environmental pollution, thus promoting the development of regional green economy.

In terms of time, the heterogeneity of sub-samples is reflected in two aspects. On the one hand, there are differences in the aspect of significance. Financial agglomeration has no significant impact on the development of regional green economy before the 2008 financial crisis, but it shows a significant impact after the financial crisis in 2008. This is closely related to the enlightenment to the global economy after the international financial crisis in 2008. Before 2008, the financial services to the real economy did not receive enough attention, and the financial agglomeration effect could not be fully manifested. After the financial crisis in 2008, finance returns to its original function. On the other hand, from the perspective of effects, financial agglomeration had no significant impact on the development of regional green economy before 2008, so its effect is very small. After the financial crisis in 2008, financial agglomeration promotes the regional green economy development and presents a U-shaped trend. The U-shaped trend analysis shows that the turning point of financial agglomeration's impact on the development of regional green economy appears at the financial agglomeration level of 1.123 (−0.595/2*0.265) = 1.123), that is, before the financial agglomeration level of 1.123, financial agglomeration has a restraining effect on the development of regional green economy. When the financial agglomeration level reaches 1.123, financial agglomeration promotes the development of regional green economy.

In terms of the level of marketization, the relationship between financial agglomeration and the development of regional green economy is U-shaped when the level of marketization is low, but inverted U-shaped when the level of marketization is high. According to the U-type relationship of different marketization levels, we can further analyze the heterogeneity between high and low marketization levels when financial agglomeration is in different intervals. The inflection point of the U-shape relationship at low marketization level is 0.859 (−0.146/2*0.085)), and the inflection point of the inverted U-type relationship at high marketization level is 0.77 (−0.134/2* − 0.087 = 0.77). Therefore, when the financial agglomeration level is less than 0.77, financial agglomeration inhibits the development of regional green economy at a low level of marketization; but at a high level of marketization, financial agglomeration promotes the regional green economy development. When the

level of financial agglomeration ranges from 0.77 to 0.859, financial agglomeration inhibits the development of regional green economy. However, at a high level of marketization, financial agglomeration exerts a convex function impact on the development of regional green economy, while at a low level of marketization, financial agglomeration exerts a concave function impact on the development of regional green economy. When the level of financial agglomeration is greater than 0.859, at a low level of marketization, financial agglomeration promotes the regional green economy development, but at a high level of marketization, the reverse is true. The main reasons for this phenomenon are that, on the one hand, at the low level of marketization, when financial agglomeration reaches a certain degree, it can effectively stimulate entrepreneurship, promote enterprise innovation, improve the efficiency of resource allocation, and thus promote the development of regional green economy; on the other hand, when the financial agglomeration reaches a certain threshold, the continuous expansion of financial agglomeration will squeeze the investment in the real economy, which is not conducive to the green development of regional economy.

In terms of different levels of economic development, financial agglomeration has a U-shaped relationship with the development of regional green economy at the low level of economic development, but an inverted U-shaped relationship is shown at the high level of economic development. According to the U-typed relationship of different economic development levels, we can further analyze the heterogeneity between high and low economic development levels when financial agglomeration is in different intervals. The inflection point of the U-shaped relationship is 1.2 (−0.3/2*0.125)) at the low level of economic development, and the inflection point of the inverted U-shaped relationship is 1.04 (−0.183/2* − 0.088 = 1.04) at the high level of economic development. It can be seen that when financial agglomeration is less than 1.04, at low economic development level, financial agglomeration restrains the development of regional green economy, but at high economic development level, it promotes the development of regional green economy; when financial agglomeration interval is between 1.04 and 1.2, financial agglomeration restrains the development of regional green economy. However, at a low level of economic development, the financial agglomeration has a concave function effect on the development of regional green economy, while at a high level of economic development, it has a convex function opposite effect. When financial agglomeration is greater than 1.2, it promotes the development of regional green economy at a low level of economic development, but it inhibits the development of regional green economy at a high level of economic development. The main reasons for the heterogeneity at different levels of economic development are as follows: on the one hand, at the low level of economic development, the improvement of financial agglomeration will help to improve and optimize the economic structure, improve the economic quality, realize the optimal allocation of regional resources, and thus promote the development of regional green economy; on the other hand, at high economic development level, after financial agglomeration reaches a certain degree, the improvement of financial agglomeration will cause a large number of labor force to flow into the area, which will cause pressure on the bearing capacity of local economy and natural resources, mainly manifested in traffic congestion, and thus aggravate the emission of pollutants, which is adverse to the green economy development of the region.

5. The moderating effect of industrial agglomeration

5.1. Panel threshold model

Industrial agglomeration can regulate the relationship between financial agglomeration and the development of regional green economy. Industrial agglomeration can reduce the in-transit loss and transportation cost of intermediate inputs, so as to reduce the price of intermediate inputs, which leads to the concentration of manufacturers in the same region to work and collaborate together. At the same time, the industrial cluster has a relatively complete public infrastructure, including roads, railways and aviation, which is conducive to the development and management of enterprises in the cluster. The knowledge spillover, market demand change, information exchange and resource circulation brought by industrial agglomeration are not only helpful to improve the technological innovation, reduce the regional transaction cost, promote the application of new technology, and accelerate the circulation of social resources, but also promote the optimal allocation of social resources such as labor force and capital. In geographical space, financial agglomeration follows industrial agglomeration. The formation and development of industrial agglomeration lays the foundation for financial agglomeration, and the infrastructure and high-quality resources it provides play an important role in the formation and expansion of financial agglomeration. Financial institutions promote the development of regional green economy by improving the level of technological innovation (Zhang and Li, 2017; Ren et al., 2010), stimulating the related benefits, scale benefits and agglomeration benefits of related industries. Therefore, industrial agglomeration can regulate the relationship between financial agglomeration and regional green economy development.

In order to better study the regulatory effect of industrial agglomeration on the relationship between financial agglomeration and regional green economy development, we build a model based on Hansen's (1999) and Wang's (2015) panel threshold regression model, and its basic equation is:

$$y_{it} = u_i + \beta_1 * x_{it} * I(q_{it} \le \gamma) + \beta_2 * x_{it} * I(q_{it} > \gamma) + e_{it} \tag{5}$$

where i represents region; t represents time; q_{it} is the threshold variable; γ is the unknown threshold; e_{it} is the random disturbance term; $I(\cdot)$ is an indicative function. Function（5） is equivalent to：

$$y_{it} = \begin{cases} u_i + \beta_1 * x_{it} + e_{it}, & q_{it} \le \gamma \\ u_i + \beta_2 * x_{it} + e_{it}, & q_{it} > \gamma \end{cases} \tag{6}$$

This model is actually equivalent to a piecewise function model, when $q_{it} \le \gamma$, the coefficient of x_{it} is β_1; when $q_{it} > \gamma$, the coefficient of x_{it} is β_2.

Referring to Hansen's threshold model, the panel threshold regression model in this paper is set as:

$$\begin{aligned} GTFP_{it} = {} & u_i + \beta_1 * fin\_cluster_{it} * I(Indus\_cluster_{it} \le \gamma) + \\ & \beta_2 * fin\_cluster * I(Indus\_cluster_{it} > \gamma) + \beta_3 * market_{it} + \beta_4 * lnhc_{it} \\ & + \beta_5 * lninno_{it} + \beta_6 * lnperGDP_{it} + \beta_7 * indu_{it} + \varepsilon_{it} \end{aligned} \tag{7}$$

where $GTFP$ represents the development of regional green economy; $fin\_cluster$ represents financial agglomeration; $Indus\_cluster$, as the threshold variable, represents industrial agglomeration; $market$ is the marketization index; $lnhc$ represents the logarithm of human capital; $lninno$ is the logarithm of innovation capability; $lnperGDP$ is the logarithm of the economic development level; $indu$ represents the industrial structure. i represents province, t represents year, β is the regression coefficient; γ is the threshold value; ε is the random disturbance term.

5.2. Empirical results

Before estimating the parameter of the panel threshold regression, the correlation test is carried out. First, to test whether there is threshold effect between financial agglomeration and the development of regional green economy. As the panel threshold regression model is driven by sample data, the number of thresholds is determined according to the significance level of each threshold. If the nth threshold of industrial agglomeration is not statistically significant, and its n-1 threshold is significant at 90% or higher confidence level, then industrial agglomeration has n-1 thresholds. Table 6 shows the results of the threshold effect test.

Table 6. Results of threshold effect tests.

Threshold	F-Value	p-value	Critical Value		
			10%	5%	1%
Single	73.530**	0.040	34.517	46.359	150.403
Double	15.850	0.353	31.894	43.949	56.228
Triple	6.470	0.893	36.031	47.920	116.581

Notes: *, ** and *** represents the significance level of 10%, 5% and 1%, respectively; both the p value and the critical value are obtained after 300 times of bootstrap simulation.

As shown in Table 6, there is a significant threshold effect in industrial agglomeration. According to the P value of industrial agglomeration, it can be seen that at the single threshold, the P value of industrial agglomeration is 0.04, that is, at the significance level of 5%, the single threshold effect of industrial agglomeration is significant. At the double threshold, the P value is 0.353, i.e., it is not significant at the significance level of 10%, and the null hypothesis that industrial agglomeration has a double threshold effect is rejected. It shows that industrial agglomeration has a single threshold effect.

Second, determine the threshold value. Table 5 shows that industrial agglomeration has a single threshold effect. Therefore, a single threshold panel regression model is constructed to determine the threshold value of industrial agglomeration. The results are shown in Table 7, which shows that the threshold value of industrial agglomeration is 0.4726.

Table 7. Threshold values and confidence intervals.

Threshold variable	Coefficient	95% Confidence Interval
Indus_ cluster	0.4726	[0.443, 0.480]

After confirming that industrial agglomeration has single threshold effect and the threshold value is 0.4726, the panel threshold regression model is estimated. The estimated results are shown in Table 8.

Table 8. Results of panel threshold model (Threshold variable: indus_cluster).

GTFP	Coef.	Std. Err.	t	P value
Indus__cluster < 0.4726	0.273***	0.047	5.79	0.000
Indus__cluster > 0.4726	0.028	0.032	0.87	0.383
market	−0.0004	0.009	−0.05	0.964
lnhc	−0.023	0.045	−0.50	0.615
lninno	0.066***	0.024	2.73	0.007
lnperGDP	−0.123***	0.031	−4.03	0.000
indu	0.013***	0.001	18.20	0.000
cons	0.728**	0.286	2.54	0.011
N	540			
R^2	0.617			

Note: *, ** and *** represents the significance level of 10%, 5%, and 1%, respectively.

It can be seen from Table 8 that industrial agglomeration has a single threshold effect on the relationship between financial agglomeration and regional green economy development. On the one hand, when the industrial agglomeration level is less than 0.4726, the impact coefficient of financial agglomeration on the development of regional green economy is 0.273, which is significant at the level of 1%. With other variables remaining unchanged, the regional economic development level increases by 0.273 on average for each additional unit of financial agglomeration. In other words, when industrial agglomeration level is less than 0.4726, financial agglomeration has a significant positive impact on the development of regional green economy. On the other hand, when the industrial agglomeration level is greater than 0.4726, the impact coefficient of financial agglomeration on the development of regional green economy is 0.028, but it is not significant at the significance level of 10%, that is, when the industrial agglomeration is less than 0.4726, the financial agglomeration has no significant impact on the development of regional green economy. The reason for this phenomenon may be that moderate industrial agglomeration is conducive to improving technological innovation ability, accelerating the circulation of social resources, realizing the optimal allocation of resources, accelerating the formation of financial agglomeration and improving its agglomeration benefits, thus promoting the development of regional green economy. However, the negative externalities brought by the excessive industrial agglomeration gradually appear. Excessive industrial agglomeration leads to relative scarcity of resources and rising labor costs, and enterprises' investment in environmental protection facilities, equipment and technology research and development is reduced as much as possible. The positive and negative externalities of industrial agglomeration will lead to the fact that financial agglomeration has no significant influence on the development of regional green economy.

6. Conclusions and policy implications

This paper uses the sample data of 30 provinces in China from 1997 to 2015 to study the impact of financial agglomeration on the development of regional green economy. First, the method of GML

based on SBM DDF is used to measure the development of regional green economy in 30 provinces of China. Then, the panel Tobit model is adopted to study the impact of financial agglomeration on the development of regional green economy. Finally, the panel threshold model is employed to study how financial agglomeration affects the development of regional green economy. Based on the above empirical analysis, this paper draws the following conclusions:

Firstly, there is an inverted U-shaped relationship between financial agglomeration and the development of regional green economy. This can be attributed to two reasons: on the one hand, when the degree of financial agglomeration is in a reasonable range, the positive externalities brought by agglomeration improve the resource utilization rate of the region, reduce the emissions of pollutants, and thus promote the development of regional green economy; on the other hand, when the degree financial agglomeration process is too high, a large number of labor force will flood into the region, which will reduce the labor productivity and resource utilization rate of enterprises and aggravate the emission of pollutants, which is not conducive to the regional green economy development.

Secondly, under different sub-samples, the impact of financial agglomeration on the development of regional green economy is heterogeneous. 1. In terms of regional sub-samples, there is an inverted U-shaped relationship between financial agglomeration and the development of regional green economy in the eastern region, but it is a U-shaped relationship in the non-eastern region. 2. In terms of time sub-samples, before the financial crisis in 2008, financial agglomeration had no significant impact on the development of regional green economy; however, after the financial crisis in 2008, financial agglomeration had a significant impact on the development of regional green economy. This is closely related to the revelation the global economy gets after the 2008 international financial crisis. 3. As far as the sub-samples of marketization level are concerned, there is a U-shaped relationship between financial agglomeration and the development of regional green economy at a low marketization level, but it is reflected in an inverted U-shaped relationship at a high marketization level. 4. From the perspective of different levels of economic development, the relationship between financial agglomeration and the development of regional green economy is U-shaped at the low level of economic development, but it shows an inverted U-shape at the high level of economic development.

Thirdly, industrial agglomeration has a single threshold effect on the relationship between financial agglomeration and the development of regional green economy. The reason for this single threshold effect may be that moderate industrial agglomeration is conducive to improving technological innovation ability, accelerating the circulation of social resources, realizing the optimal allocation of resources, accelerating the formation of financial agglomeration and improving its agglomeration benefits, thus promoting the development of regional green economy. However, the excessive industrial agglomeration makes negative externalities gradually appear. The positive and negative externalities of industrial agglomeration will lead to the phenomenon that financial agglomeration has no significant influence on the development of regional green economy.

Based on the above conclusions, this paper can draw the following policy implications: first, because of the inverted U-shaped relationship between financial agglomeration and the development of regional green economy, the government should effectively guide financial agglomeration, rather than blindly rely on financial agglomeration to improve the efficiency of green economy. When expanding the degree of financial agglomeration, each province should comprehensively consider the local economy, infrastructure and the bearing capacity of natural resources. Besides, a certain threshold should be set, and the financial agglomeration should be expanded reasonably to prevent the negative effect caused by the excessive agglomeration process. Second, for different regions,

governments should formulate structured and differentiated financial agglomeration policies according to the heterogeneity of regional resource endowment. For example, when expanding the degree of financial agglomeration in the eastern region, attention should be paid to avoid excessive financial agglomeration. In the non-eastern region, financial agglomeration should be encouraged so as to promote the development of regional green economy.

This paper exists several limitations and can be expanded by further research in the following aspects. Firstly, owing to the lack of data, this paper didn't include all the inputs and outputs when measure GTFP. Further research can expand the inputs and outputs with data availability. Secondly, empirical research in this paper is based on the analysis of macro data to analyze the impact of financial agglomeration on the development of regional green economy. Further research could expand on the micro perspectives, such as the impact of corporate financial behavior on the development of regional green economy.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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