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Original Research

Exploring the Role of Government Assessment Policy and Financial Development in Energy Conservation and Carbon Emissions Reduction in China

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Abstract

Achieving energy conservation (EC) and carbon emissions (CE) reduction through effective policies and economic instruments has become an important issue in China. Using China's provincial panel data, this paper quantitatively analyzes the impact of the Chinese government's EC assessment policy and financial development on EC and CE reduction. The results show that the government EC assessment policy can effectively promote EC, but have no significant impact on CE. Financial development has a significant positive effect on CE; however, it does not promote EC due to its significant positive effect on EC intensity. We found that the increasing proportion of tertiary industry does not effectively reduce total CE and CE intensity. Based on the results, to achieve the CE peak goal in 2030, we suggest: (1) To promote the development of green finance and provide financing support for green projects with CE reduction benefits; (2) To innovate and improve the energy pricing system, the green development and the energy consumption structure should be enhanced and restructured through the energy price mechanism; (3) Strict CE reduction system, energy consumption control, and other measures to strengthen the control of CE growth; (4) With higher market access standards and low-carbon product certification, it is mandatory for enterprises to save energy and reduce CE in the production process. The implementation of these policies will accelerate the process of transforming the economy into a low-carbon development model and achieve the goals of EC and CE reduction.

Keywords: government energy conservation assessment policy, financial development, carbon emissions reduction, energy conservation

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Introduction

In the past 20 years, global energy consumption and CE have maintained growth, which has adversely affected the environment [1, 2]. During this period, China's economy maintained long-term growth, but the extensive economic growth model for a long time led to continuous increases in energy consumption and CE. The China Energy Statistics Yearbook and the United Nations Environment Programme (UNEP) Emissions Gap Report show that China is already the largest end-use energy consumer and carbon emitter. Due to the unsustainable nature of the high-consumption, high-emissions economic growth model and consequences such as ecological degradation, China is striving to implement a transition to a low-carbon, sustainable economic growth model. CE reduction has become a long-term task for China since the Chinese government announced its commitment to reduce emissions at the Paris Climate Conference. At the 75th session of the UN General Assembly, China announced its aim to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060. Thus, from theoretical and practical aspects, the issue of EC and CE reduction has become important and urgent in China.

The Chinese government has taken a series of policies and methods to transform economic growth and implement EC and CE reduction targets. While promoting financial development to promote EC and CE reduction and industrial upgrading, the Chinese government also formulated and implemented an evaluation and assessment policy on the responsibility of EC targets in 2007. This policy takes the completion of EC goals as the evaluation content of local governments. At the same time, to ensure the implementation of EC and CE reduction across China, related accountability mechanisms and a "one vote veto" system are established for local governments. With the implementation of relevant policies, although China's finance and economy have grown rapidly since 2007, the growth rate of energy consumption and CE has slowed down considerably. The data shows that, from 2007 to 2022, China's GDP at comparable prices grew by 469.35% and the ratio of social financing to GDP rose by 118.97% to 287.50%, according to the World Bank, the National Bureau of Statistics of China, and the People's Bank of China. Over the same period, the total CE in China increased by 68.03%, while energy consumption and CE per unit of GDP decreased by 62.99% and 64.20%, respectively.

Some studies have argued that financial development in China promotes economic growth [3] and can contribute to total factor productivity [4] and green total factor productivity growth [5-7] and has inhibitory effects on CE. However, as an important driving force of economic growth, the impact of financial development on energy consumption CE is theoretically uncertain. On the one hand, financial development is conducive to easing financing constraints and promoting the growth of economic inputs, leading to higher energy consumption demand and driving CE growth. On the other hand, financial development, especially green financial development, can provide financial support for the R&D and diffusion of EC and CE reduction technologies. Therefore, from the perspective of technological innovation and application, financial development may promote EC and CE reduction. There is also a lack of research to support the policy effectiveness and policy effects of the energy consumption assessment policy, which is one of the key energy consumption policies of the Chinese government.

Do the Chinese government's EC assessment policy and financial development have a positive impact on EC and CE reduction? Does it provide path support for the Chinese government to implement EC and CE reduction regulations? By applying the extended STIRPAT model and using China's provincial panel data, this paper explores the impact of government EC assessment policy and financial development on China's provincial EC and CE reduction.

Literature Review

Many scholars have been conducting in-depth studies on the relationship between economic growth, urbanization, energy consumption and structure, trade opening, industrial structure, and other factors and CE [8-15]. In terms of the impact of Chinese government policies on EC and CE reduction, the current empirical studies are more focused on carbon tax policies [16, 17] and environmental regulations [18-20], while no empirical studies on the impact of government EC assessment policy have been reported.

Empirical studies on the impact of financial development on CE have not reached consistent conclusions. The results of empirical studies in different research contexts and designs show that the impact of financial development on CE has two sides. Some studies support the view that financial development has a positive impact on CE reduction. The study of the relationship between finance and CE was carried out by Shahbaz et al. [21] for Malaysian, Salahuddin et al. [22] for Gulf Cooperation Council (GCC) countries, Zaidi et al. [23] for Asia Pacific Economic Cooperation (APEC) countries, and Vo and Zaman [24] based on 101 countries conclude that financial development is conducive to reducing CE. In terms of research on the relationship between financial development and CE in China, Gu and He [25] used a panel vector autoregressive model to study the impact of financial development on CE in China's provinces from 1979 to 2008 and pointed out that the deepening of regional financial development had a significant inhibitory effect on per capita CE. Xing et al. Xing et al. [7] found that financial development in China can improve CE and that this impact is characterized not only by regional differences, but also by stage differences. Zhang [26] found that, in China, financial development is a key driver of the increase in carbon emissions. In a study on the relationship between financial inclusive development, economic growth, and CE in China, Zhu et al. [27] found that financial development in China is conducive to reducing CE and promoting low-carbon economic development. Guo and Hu [6] found that financial development inhibits CE both in the short run and in the long run in the study of the relationship between financial development and CE in China from 1997-2016. Cong et al. [28] found that financial development contributes to reducing CO_2 concentrations in China.

Other studies argue that financial development drives CE growth. Tamazian et al. [29] for BRICS 1992-2004, Maji et al. [30] for Malaysia, and Pata [31] for Turkish 1974-2014, found that financial development increases CO_2 emissions and reduces environmental quality. In a study of the relationship between financial development and CE in China between 1980 and 2014, Ahmad et al. [32] suggested that financial development has a large positive impact on CE. Shen et al. [17] studied the relationship between financial development and CE in China using panel data from 30 Chinese provinces from 1995 to 2017 and concluded that energy consumption and financial development have a positive impact on CE. Ofori et al. [33] found that the financial development index reduces CE in a study of BRICS, MINT, and G7 countries.

In summary, scholars' research on the impact of EC and CE reduction can be summarized as follows: (1) No attention has been paid to the impact of the implementation of government EC assessment policy on the intensity of regional energy consumption and CE intensity. (2) The findings in terms of empirical tests of the impact of financial development on CE are not uniform. Therefore, this paper is constructed to empirically test the impact of government EC assessment policy implementation and regional financial development on provincial EC and CE reduction using China's provincial panel data.

Modeling Framework and Variables

Theoretical Framework and Model Construction

The impact of financial development on EC and CE is multifaceted. Financial development can make corporate financing more convenient, reduce financing costs, stimulate enterprises to expand their scale, and increase energy demand while promoting economic growth, thus increasing regional EC and CE. At the same time, financial development promotes the process of urbanization. With the improvement of urbanization, per capita energy consumption increases [34]. Financial development, especially the rapid growth of green finance, will guide funds to flow to green and low-carbon industries to optimize the industrial structure, reduce energy consumption intensity, and curb carbon emissions growth. Financial development can promote the emergence of advanced production technologies, stimulate the promotion and application of low-energy high-tech, transform energy consumption structure, and improve energy efficiency, thereby inhibiting energy consumption intensity growth and carbon emissions.

In 2007, the Chinese government formulated and implemented a carbon emission target responsibility assessment policy to complete the EC target as the content of local government assessments. At the same time, relevant accountability mechanisms and a "one-vote veto" system for local governments should be established to ensure the implementation of EC and CE emission reductions throughout the country. In order to effectively achieve the goal of double control, governments at all levels improve energy efficiency by accelerating the transformation of industrial structure and energy consumption structure so as to implement the goal of "double control" of total energy consumption and intensity. The carbon emission target responsibility assessment policy is an important regulatory policy for regional energy consumption and carbon emissions, and it may have an important impact.

Based on the above analysis and the research of Acheampong [35] and Ofori et al. [33], the research framework of this paper is shown in Fig. 1.

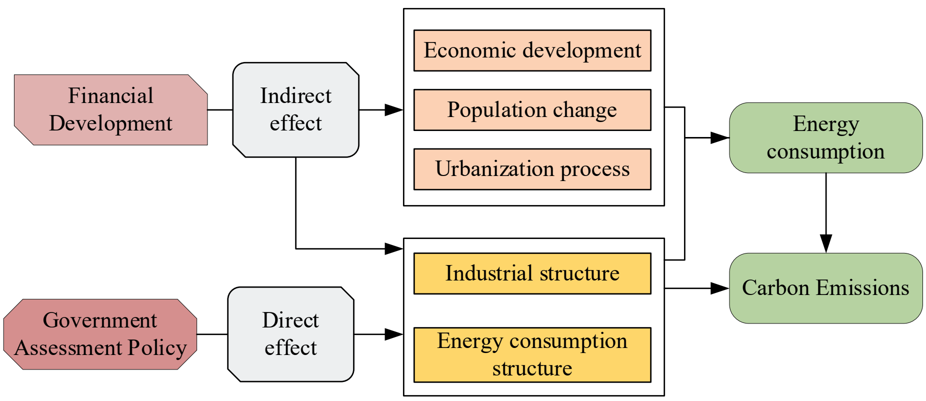

Fig. 1. Research framework.

As shown in Fig. 1, financial development has an indirect impact on economic growth, industrial restructuring, urbanization processes, and resident population movement through financial capital allocation. While financial development has an indirect influence on the energy consumption structure, it also directly supports energy consumption restructuring through green finance. The government EC assessment policy is to assess the incremental energy consumption and output energy intensity of each province. This policy directly motivates each local government to adjust the energy consumption structure and industrial structure, thus affecting energy consumption and CE.

The IPAT model, proposed by Ehrlich and Holdren in 1971 [36], has been widely used as a modeling framework for studying the drivers of environmental change due to its simplicity. The IPAT model has some shortcomings and limitations in the application process. In order to compensate for the shortcomings of the IPAT model, Dietz and Rosa [37, 38] developed the IPAT Equation and proposed a stochastic representation of the STIRPAT model.

The STIRPAT model can be expressed as follows:

$$I = aP^{b}A^{c}T^{d} \quad (1)$$

Equation (1) can be converted to logarithmic form.

$$lnI = a + blnP + clnA + dlnT \quad (2)$$

Where I is the environmental impact (which can be set to CE, emissions intensity, pollution or waste emissions, etc., depending on the study), P is the population size, A is the affluence level, and T is the technology level; b, c, and d are the coefficients of lnP, lnA, and lnT, respectively; a is the constant term.

The STIRPAT model allows for both the estimation of the regression coefficients as parameters and the appropriate decomposition of the influencing factors. Many scholars have expanded the STIRPAT model and carried out various empirical studies according to the characteristics of their research questions and objects. Following Wang and Dong [39], Usman and Hammar [40], Huang and Zhao [41], this paper employs the STIRPAT model as an analytical framework. The specification of the expanded STIRPAT, which is responsive to the research questions of this paper, is shown in Fig. 2.

As the conceptual model shows in Fig. 2, the population factor is divided into the resident population size factor and the urbanization level factor. Following Usman and Hammar [40], Khan et al. [42] use financial development (FD) and GDP per capita ($PGDP$) to capture affluence (A). Industrial structure (IS) and energy consumption structure (ES) are used to capture technology level (T). The α factor is decomposed into government assessment (GA) and α*.

Thus, the expanded conceptual model is as follows:

$$I = f\,(P, UR, PGDP, FD, IS, ES, GA) \quad (3)$$

Taking the natural logarithm of both sides of Equation (3), the logarithmic form of Equation (3) can be defined as follows:

$$lnI = a^{*} + blnP + clnUR + dlnPGDP + elnFD + flnIS + glnES + hGA \quad (4)$$

Where I is the environmental impact and is the explanatory variable, which consists of energy consumption and CE; the explanatory variables include P representing the total population, A representing the wealth level per capita, UR representing the urbanization rate, IS representing the industrial structure, ES representing the energy consumption structure, FD representing the level of financial development,

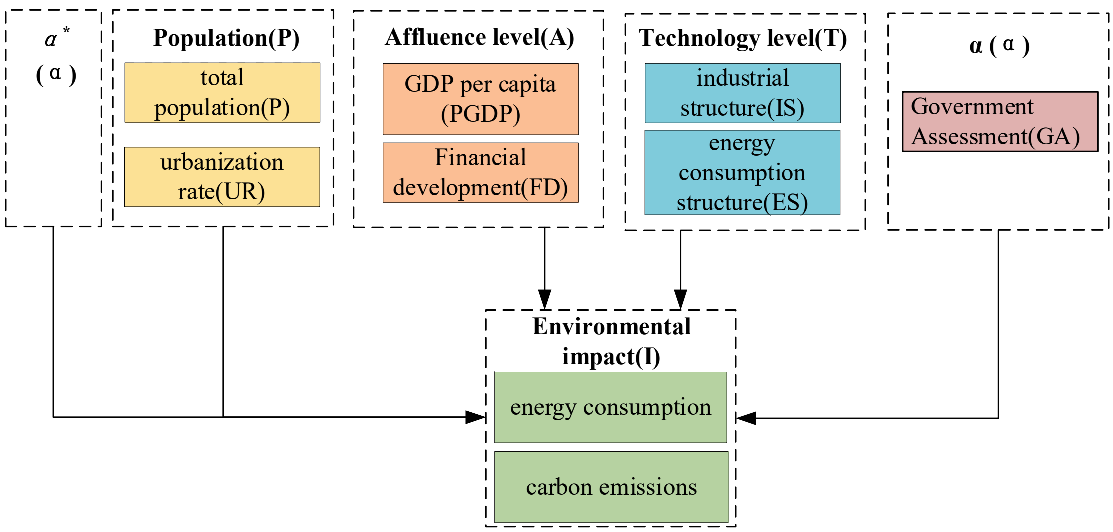

Fig. 2. Conceptual model.

and *GA* representing the government EC assessment policy.

Dependent Variables

Total carbon emissions (*TC*): *TC* is calculated based on the consumption of fossil fuels by using the method proposed in the Intergovernmental Panel on Climate Change guidelines (IPCC, 2006) [43].

Carbon emissions intensity per unit of GDP (*CI*): *CI* is the main reference indicator for CE research. With economic and social development, only if the *CI* decreases faster than the average annual growth rate of GDP can carbon dioxide emissions stop growing, thus achieving "carbon peaking" and laying the foundation for achieving "carbon neutrality".

Carbon emissions intensity per capita (*CP*): *CP* is calculated using the same method as *CI*. The population size criterion is the permanent resident population. Considering the uneven interprovincial distribution of population size in China, *CP* is chosen as the explanatory variable in this paper.

Energy consumption intensity per unit of GDP (*EI*): *EI* is an important assessment indicator for China's policy and reflects the intensity of energy consumption in the process of economic development.

Energy consumption intensity per capita (*EP*): Considering the uneven interprovincial distribution of population size in China and the influence of population size factors on total energy consumption, this paper chooses *EP* as the explanatory variable.

Energy consumption is converted from various energy sources to standard coal in accordance with the China Energy Statistics Yearbook conversion standards. GDP is calculated at comparable prices.

Independent Variables

Population size (*P*): The population size criterion is the annual resident population.

Per capita GDP (*PGDP*): The population size criterion is the annual resident population. GDP is calculated at comparable prices.

Urbanization rate (*UR*): Considering that many studies have found that the level of urbanization has a significant effect on CO_2 emissions [44-47], this factor was included in the empirical model. The urbanization rate is the proportion of the urban population in the resident population.

Industrial structure index (*IS*): Considering that the proportion of primary industry in most provinces is relatively low and the changes are small, the adjustment of industrial structure is mainly carried out between the secondary industry and the tertiary industry. The tertiary sector has the lowest energy consumption intensity per unit of output value among the three industries in China. In related studies, there are also two divergent views on the impact of tertiary industry development on CO_2: tertiary industry development has a CE reduction effect [48, 49], and tertiary industry development has a positive effect on the increase of CO_2 emissions [50-54]. In the economic restructuring and promotion of regional economic development, some local governments have made the development of the tertiary sector a key direction for economic construction and development. Therefore, in the construction of the industrial structure index, the proportion of the output value of the tertiary industry to GDP is chosen as the industrial structure variable in this paper to analyze the impact of industrial structure changes on energy consumption and CE.

Energy consumption structure index (*ES*): As the carbon dioxide emissions produced by the consumption of different energy sources are also different, coal combustion emits the most carbon dioxide per unit of heat. Therefore, the greater the proportion of coal, the higher the level of carbon dioxide emissions. The proportion of coal in China's primary energy consumption is much higher than the world average, and it is one of the few countries in the world that mainly consumes coal energy. This also causes the relatively high carbon dioxide emission intensity of China's energy consumption [53]. Therefore, this paper selects the proportion of coal consumption in total primary energy consumption to represent the energy consumption structure. All types of energy consumption are converted into standard coal according to the method provided by the China Energy Statistics Yearbook.

Government assessment (*GA*): In order to effectively reflect the implementation of the Chinese government's EC assessment policy and analyze the effects of the policy, this paper selects the completion of annual energy efficiency targets by province published by China's National Development and Reform Commission as a proxy variable for the EC assessment policy.

Financial development index (*FD*): In order to reflect the current bank-dominated financial model and financial structure in China, the loan balances of all financial institutions are selected as financial scale indicators, and the ratio of financial scale to GDP is used as the financial development index.

Experimental

Data

For some provinces with missing data for individual years, this paper uses the interpolation method to fill in the gaps. In view of the large number of missing data for Tibet, Hong Kong, Macao, and Taiwan, the sample of this paper is the data of the other 30 provinces in China. In specific, the financial development data is derived from the Almanac of China's Finance and Banking. All energy data are from the China Energy Statistics Yearbook. Population, GDP, and industrial added value are taken from the China Statistical Yearbook. The standard coal conversion coefficient is derived from the General Rules for Calculation of the Comprehensive

Energy Consumption (GB/T 2589-2008). The emission factor is taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). The annual government EC assessment results for each province are taken from the government announcement published by the National Development and Reform Commission of China. Then we got the provincial balanced panel data for econometric analysis.

Empirical Model and Econometric Methodology

Empirical Model

Based on the extended STIRPAT model shown in Equation (4), the empirical model is set to the following form according to the design of the research question, variables, and sample data.

Empirical model 1:

$$lnTC_{it} = \alpha_i^* + b_i lnP_{it} + c_i lnUR_{it} + d_i lnPGDP_{it} + e_i lnFD_{it} + f_i lnIS_{it} + g_i lnES_{it} + \varepsilon_{it} \quad (5)$$

Empirical model 1 is an empirical model of CE that is used to analyze the impact of financial development, government EC assessment policy, and other factors on CE. ε_{it} is the error term in period *t* and province *i*.

Empirical model 2:

$$lnCI_{it} = \alpha_i^* + b_i lnP_{it} + c_i lnUR_{it} + d_i lnPGDP_{it} + e_i lnFD_{it} + f_i lnIS_{it} + g_i lnES_{it} + h_i GA_{it} + \varepsilon_{it} \quad (6)$$

Empirical model 3:

$$lnCP_{it} = \alpha_i^* + c_i lnUR_{it} + d_i lnPGDP_{it} + e_i lnFD_{it} + f_i lnIS_{it} + g_i lnES_{it} + \varepsilon_{it} \quad (7)$$

Empirical model 4:

$$lnEI_{it} = \alpha_i^* + b_i lnP_{it} + c_i lnUR_{it} + d_i lnPGDP_{it} + e_i lnFD_{it} + f_i lnIS_{it} + g_i lnES_{it} + h_i GA_{it} + \varepsilon_{it} \quad (8)$$

Empirical model 5:

$$lnEP_{it} = \alpha_i^* + c_i lnUR_{it} + d_i lnPGDP_{it} + e_i lnFD_{it} + f_i lnIS_{it} + g_i lnES_{it} + \varepsilon_{it} \quad (9)$$

Empirical models 2, 3, 4, and 5 are used to analyze the impact of factors such as *FD* and *GA* on *CP*, *EI,* and *EP,* respectively.

Econometric Methodology

This paper uses provincial panel data from 30 provinces in China, which is suitable for panel data regression model methods. The panel data regression analysis process is mainly composed of three steps. The first step is to test the panel stationarity of the sample data (panel unit root test); the second step is to perform a cointegration test on the panel data; the third step is to select the panel data regression model and perform regression analysis.

The first step: Panel unit root. In order to avoid "false regression", it is necessary to perform a panel unit root test on the data. The LLC test method (Levin, Lin, and Chu) [55] is suitable for the same root case. The IPS-W-statistic test method (Im, Pesaran, and Shin) [56] is suitable for different root cases. In this paper, the LLC test and the IPS-W-statistic tests are used to check the stationary of the variables.

The second step: Panel cointegration tests. Panel data cointegration testing mainly has two types of methods. One is the cointegration test based on regression residuals; the other is the cointegration test based on regression coefficients. Because the time interval of the samples in this paper is short, the test methods proposed by Pedroni [57, 58], Kao [59], and Westerlund [60] based on the regression residuals of the E-G two-step method are used to conduct the panel cointegration test.

The final step: Panel regression analysis. Based on the sample selection in this paper, the fixed effects model was used for the panel data regression analysis.

Results

Empirical Results

To obtain evidence of the stationarity of the variables, this paper uses the LLC and IPS tests to conduct panel unit root tests on the panel data for each variable. The test results, as shown in Table 1, indicate that all variables pass the unit root test and the variables are stationarity.

The results of the panel cointegration test are shown in Table 2. The result shows that statistics are mainly static and that the panel data has a cointegration relationship. Then the panel data could be analyzed with the panel data regression model.

The Effects of Government Assessment Policy and Financial Development on CE

Table 3 shows that in Model 1, the elasticity coefficient of *FD* is -0.118 and passes the significance test, indicating that China's financial development has an abatement effect on total CE from energy consumption. This result is broadly consistent with Gu and He [25] and Guo and Hu [6]. In terms of the size of the abatement effect, a 1% increase in *FD* is associated with a 0.118% reduction in *TC*. The smallest elasticity coefficient of all variables passed the significance test. The elasticity coefficient of *IS* failed the significance test. This indicates that an increase in the share of the

Table 1. Panel unit root tests.

Variable	LLC-t*	IPS*
LnC	-6.199(0.000) ***	-4.108(0.000) ***
lnCI	-7.910(0.000) ***	-1.738(0.041) **
lnCP	-6.635(0.000) ***	-3.645(0.000) ***
lnEI	-6.982(0.000) ***	-2.533(0.006) ***
lnEP	-3.120(0.001) ***	-3.436(0.000) ***
lnP	-4.314(0.000) ***	-2.652(0.000) ***
lnUR	-4.973(0.000) ***	-2.308(0.000) ***
lnPGDP	-14.793(0.000) ***	-2.547(0.005) ***
lnFD	-32.599(0.000) ***	-9.149(0.000) ***
lnISt	-5.069(0.000) ***	-0.502(0.308)
lnES	-8.253(0.000) ***	-2.514(0.006) ***
GA	-10.982(0.000) ***	-2.098(0.001) ***

Note: *, **, *** indicate significant at 10%, 5%, and 1%, respectively.

tertiary sector is not effective in reducing the scale of CE from energy consumption, i.e., it cannot be relied upon to reduce total CE by increasing the share of the tertiary sector alone. The elasticity coefficients for *P*, *PGDP*, *UR,* and *ES* are all greater than zero and pass the significance test.

In Model 2, the elasticity coefficients of *GA*, *P,* and *IS* are insignificant, implying that these variables have no significant effect on *CI*. The elasticity coefficients of the *FD* and *PGDP* on *CI* are both negative and pass the significance test. It means that the increase in China's economic development level and the increase in China's financial development level have a positive impact on the decrease in *CI*. The elasticity coefficients of *UR* and *ES* are both positive and pass the significance test. This indicates that urbanization and an increase in the coal-based energy consumption structure remain the main drivers of growth in CE per unit GDP of energy consumption.

The elasticity coefficient for *PGDP* is -0.483, indicating that the rate of CE per unit of output is decreasing along with the rising level of China's economic development.

The coefficient of elasticity of *UR* is 0.710, indicating that urbanization can contribute to an increase in *CI* in China, i.e., a 1% increase in urbanization is associated with 0.710% *CI*. The coefficient for *UR* is significantly positive, suggesting that urbanization can have a significant positive impact on CE. The process of urbanization is usually accompanied by an increase in population and industrialization, and therefore an increase in energy consumption and CE. The elasticity coefficient of *ES* is 0.407, indicating that the share of coal in China's energy consumption structure has

Table 2. Panel cointegration tests.

Methods	Statistics	Model 1	Model 2	Model 3	Model 4	Model 5
Pedroni	Modified Phillips-Perron	8.953*** (0.000)	10.277*** (0.000)	8.993*** (0.000)	10.795*** (0.000)	9.681*** (0.000)
	Phillips-Perron	-11.614*** (0.000)	-18.501*** (0.000)	-11.760*** (0.000)	-27.340*** (0.000)	-18.443*** (0.000)
	Augmented Dickey-Fuller	-15.976*** (0.000)	-19.148*** (0.000)	-16.225*** (0.000)	-20.700*** (0.000)	-15.371*** (0.000)
Kao	Modified Dickey-Fuller	1.360* (0.087)	1.314* (0.095)	1.336* (0.091)	2.487*** (0.006)	2.992*** (0.001)
	Unadjusted Dickey-Fuller	-2.345*** (0.009)	-2.312** (0.010)	-2.411*** (0.008)	0.725 (0.234)	1.096 (0.137)
Westerlund	Variance ratio	6.416*** (0.000)	6.915*** (0.000)	5.930*** (0.000)	5.385*** (0.000)	6.310*** (0.000)

Note: ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance levels, respectively.

Table 3. Results of panel regression models.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
lnP	0.677** (2.29)	-0.324 (-1.09)	–	0.348** (1.97)	–
lnUR	0.709** (2.36)	0.710** (2.35)	0.655** (2.20)	0.305* (1.76)	0.363** (2.11)
lnPGDP	0.518*** (4.80)	-0.483*** (-4.46)	0.519*** (4.79)	-0.674*** (-9.78)	0.317*** (4.58)
lnFD	-0.118* (-1.85)	-0.117* (-1.82)	-0.105* (-1.66)	0.077* (1.67)	0.079* (1.70)
lnIS	0.122 (0.77)	0.120 (0.75)	0.104 (0.65)	-0.164* (-1.79)	-0.181* (-1.94)
lnES	0.408*** (5.45)	0.407*** (5.41)	0.441*** (6.44)	0.165*** (3.70)	0.122*** (2.86)
GA	–	0.002 (0.18)	–	-0.015*** (-2.08)	–
cons	0.540 (0.22)	5.949** (2.34)	2.476*** (8.46)	-1.750 (-1.20)	1.093*** (6.37)

Note: ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance levels, respectively.

a significant impact on *CI*, which can contribute to the increase of China's *CI*. The regression coefficient of *P* is not significant, implying that China's population size is not the main cause of *CI*. From the perspective of energy consumption, the larger the population size, the greater the energy demand and consumption due to lighting, heating, etc., and the greater the CE, which may lead to an increase in CE intensity. However, the overall coefficient corresponding to population size is insignificant. The possible reason is that the consumption of energy in China is mainly carried out on a household basis, so an increase in the total population does not necessarily contribute to a larger increase in CE. In contrast, an expansion in population size implies an increase in the size of the labor force, which facilitates the expansion of social reproduction and contributes to the growth of economic aggregates. On the one hand, an increase in population size may lead to an increase in CE; on the other hand, an expansion in population size may promote economic growth, thus reducing the intensity of CE per unit of GDP.

The *IS* elasticity coefficient is insignificant and positive, implying that the increase in the share of tertiary industry in China does not directly contribute to the decrease of *CI*.

In model 3, the elasticity coefficient of *FD* is negative and passes the significance test. The elasticity coefficients of *PGDP*, *UR,* and *ES* are positive and pass the significance test. The elasticity coefficient of *IS* is insignificant, indicating that an increase in the share of the tertiary sector does not directly cause a reduction in *CP* and does not have a significant CE reduction effect.

The elasticity coefficient of the *FD* is -0.105, indicating that financial development can contribute to the reduction of *CP* in China, i.e., a 1% increase in the *FD* is associated with a 0.105% reduction in *CP*. This suggests that the combined effect of financial development on *CP* in China is reversed and can contribute to a reduction in *CP*, but the effect is relatively small.

The elasticity coefficient of *PGDP* is 0.519, indicating that the increase in *CP* is accompanied by an increase in the level of China's economic development. With the improvement of China's economic development level, resident consumption has gradually upgraded. Private car ownership increased by 507% from 0.02 per capita to 0.13. At the same time, the scale of residential electricity consumption is also growing rapidly. While thermal power accounts for a relatively high proportion of China's electricity generation, the increase in electricity consumption is also bound to push up coal consumption, making CE grow.

The elasticity coefficient of *UR* is 0.655, indicating that urbanization can contribute to an increase in *CI* in China. *UR* can have a significant positive impact on *CP*. The process of urbanization is usually accompanied by population buildup, increased infrastructure construction, and higher levels of industrialization, which leads to an increase in direct and indirect energy consumption by the population. Moreover, it also leads to an increase in total social energy consumption and a consequent increase in CE. The elasticity coefficient of *IS* is insignificant and positive, implying that the increase in the share of the tertiary sector in China does not directly contribute to the decrease in *CP*.

The Effects of Government Assessment Policy and Financial Development on Energy Consumption

In Model 4, the regression coefficient for the *GA* is negative and passes the significance test. This indicates that the current government assessment has a positive driving effect on the reduction of energy consumption intensity in the provinces, indicating that a direct conservation effect exists. The implementation of conservation assessment and evaluation in China is based on setting the annual energy consumption reduction target per unit of regional GDP for each province and assessing the completion of the annual conservation target for each province. This assessment policy will urge provinces and municipalities to promote regional conservation in accordance with the overall conservation target, thus promoting local conservation efforts and reducing regional energy consumption intensity. However, the assessment targets set based on various factors, such as regional development level, vary greatly between provinces. It leads to the difference in actual conservation effect between provinces with the same rating, resulting in a relatively small effect on the semi-elasticity coefficient of the overall *EI*.

In both Model 4 and Model 5, the regression coefficients of *FD* are positive and pass the significance test, indicating that financial development has a catalytic effect on the rise in energy consumption intensity. Along with the financial development, it can provide financial support for the reproduction expansion, regional energy consumption demand enlargement, and intensity improvement of energy consumption. At the same time, financial development facilitates early consumption by residents and promotes the large consumption of real estate and automobiles, while the demand for real estate consumption promotes the development of related industries and increases energy consumption. The increased demand for automobiles not only directly promotes the development of automobile-related industries, bringing more energy consumption, but also requires continuous energy consumption during the use of automobiles. It may cause an increase in final total energy consumption. The elasticity coefficients of IS are all negative and pass the significance test, indicating that an increase in the share of the tertiary sector has a catalytic effect on the reduction of energy consumption intensity. In terms of economic structure, an increase in the share of the tertiary sector leads to a decrease in the share of the secondary sector. The current energy consumption intensity of the tertiary sector in China is lower than that of the secondary sector, and this relative change in industrial structure leads to a relative decrease in total energy consumption and realizes the conservation effect.

The elasticity coefficients of *UR* and *ES* are positive and pass the significance test. This indicates that urbanization and energy consumption structure are important factors influencing regional energy consumption intensity. The coefficient of elasticity of *PGDP* to *EI* is -0.674 and passes the significance test, which indicates that the increase in the level of economic development and the gradual diffusion of new energy-saving technologies have effectively reduced the *EI*. The coefficient of elasticity of *PGDP* to *EP* is 0.317 and passes the significance test, indicating that the rising demand for energy from appliances, cars, and home heating and cooling has contributed to the increase in *EP* as a result of economic development and rising living standards.

Discussion

From the results of the empirical study, we found that the EC assessment policy has a significant conservation effect on the energy consumption intensity and no significant effect on CE intensity. Financial development has a driving effect on the reduction of CE intensity and total CE. However, there is no significant conservation effect of financial development. Instead, we found that the increase in financial development will drive up the energy consumption intensity. This is consistent with Pan et al. [50], Chen et al. [51], Zhang et al. [52], Liu et al. [53], and Bai et al. [54], that the increase in the share of the tertiary sector does not effectively reduce total CE and CE intensity. The increase in the share of the tertiary sector can reduce the energy consumption intensity and achieve conservation targets. The current urbanization rate, development, and energy structure are still the main factors driving regional CE and energy consumption. The level of economic development has contributed significantly to the reduction of *EI* and *CI*. However, the increase in the level of economic development is still the main driver of the increase in total CE and *CP*, as well as *EP*.

Due to the starting point and assessment mode of policy formulation, government conservation assessment policy is found to have a significant conservation effect on energy consumption intensity, but no significant effect on CE intensity. By implementing the government's EC assessment policy, the central government sets annual targets to assess the status of energy consumption reduction (energy consumption per unit of regional GDP) and control the increase in energy consumption (million tons of standard coal) of provinces, according to the situation of each province, respectively. This has resulted in a game between the central government and local governments in setting energy efficiency targets [61]. In the practice of the policy, the actual EC in provinces and municipalities with the same assessment rating still varies. It reveals the fact that there are regional differences in this policy's constraints on local EC, which affects the actual effectiveness of the assessment policy. The essence of the assessment policy is to constrain local energy consumption intensity and total energy consumption growth targets. The policy has achieved direct regulation of local unit energy consumption intensity and growth, which is conducive to promoting a reduction in local energy consumption intensity and meeting conservation targets. The government's EC assessment policy does not regulate the type of local energy consumption and CE and therefore has no significant impact on total local CE and CE intensity. To address this issue, in addition to current EC policies, it is necessary for policymakers to add policies relating to the structure of energy consumption and CE per unit of energy consumption, making assessment policies effective for adjusting local CE. These approaches could accelerate the process of the EC and CE reduction targets across China.

The role of financial development in driving the intensity of energy consumption stems primarily from the role of financial expansion in driving economic development. Over the past 20 years, China's economic development has been dominated by the capital input mechanism of economic dynamics [62, 63]. Finance plays a very important role in the process of economic development driven by capital investment. While supporting economic development, finance also brings about economic expansion, which promotes the demand for energy consumption, thus contributing to the rise in energy consumption intensity. Financial development also provides support for the innovation and promotion of conservation and CE reduction technologies. As one of the main driving forces of China's economic development, financial development has a much greater impact on economic development and the resulting increase in energy consumption than on the promotion of energy-saving technologies during the same period. Based on this fact, financial development enhances the rise in energy consumption intensity.

While financial development provides impetus for economic development and promotes the growth of economic scale, it also supports the development of the new energy sector through various financial instruments, especially green financial development. In the new energy sector, for example, the development of clean energy resources (such as wind power, photovoltaic power generation, and hydropower) and new energy vehicles can't be separated from the supporting financial development. Thus, from this perspective, by boosting the growth of the new energy sector, financial development effectively curbs the rapid growth of CE brought about by the expansion of the energy consumption scale and contributes to the reduction of total CE and emission intensity [61].

Green finance in China is dominated by green credit and green bonds. China officially launched green credit in July 2007. The scale of green credit in China has grown from 256.17 billion Chinese Yuan (CNY) in 2008 to 11,950 billion (CNY) in 2020, and the share of green credit in the loan balance of financial institutions has grown from less than 1% in 2008 to 6.92% in 2020. The significant development of green finance has a dampening effect on China's CE from energy consumption [64-66]. The report from the People's Bank of China's financial institution loan investment statistics shows that, from the perspective of usage, more than 70% of green loans are used for infrastructure green upgrades and clean energy. From the industry perspective, about 60% is invested in the transportation industry and the production and supply of electricity.

China's green bonds started in 2015 and have grown rapidly in recent years. Fig. 3 shows that the annual issuance scale of green bonds in China has grown rapidly from 13.77B in 2015 to 386.37B in 2021, an increase of 2705.87%. In response to the demand for CE reduction and carbon neutral financing, carbon neutral green bonds were launched in 2021 to accurately support the fund-raising of green projects with CE reduction benefits. In 2021, the issuance scale of carbon neutral bonds was 228.08B, accounting for 37.09% of the green bond issuance scale in that year. With the rapid growth of scale, China's green finance has played a positive role in reducing CE and improving environmental quality [66-69]. Accelerating the development of green finance, represented by green credit and green bonds, can promote energy structure adjustment and EC and CE reduction.

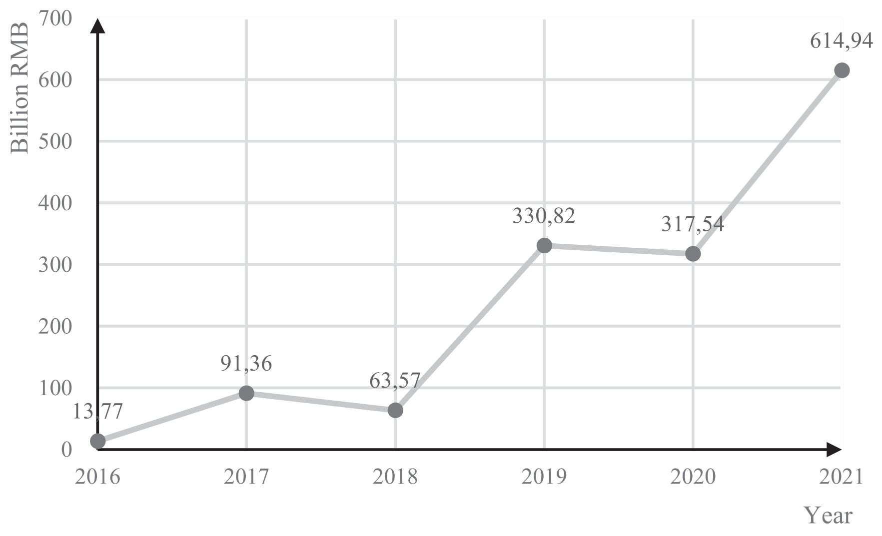

Fig. 3. Scale of green bonds in China.
Note: Data collated from the iFinD database.

The main reason why the increased share of the tertiary sector can reduce the energy consumption intensity and achieve conservation targets is that the tertiary sector has a lower *EI* and *EP* compared to the secondary sector. Therefore, an increase in the share of the tertiary sector will lead to a reduction in energy consumption intensity. Among the tertiary sector, the transport industry accounts for a relatively high proportion of energy consumption, over 50%, and is dominated by fossil energy, resulting in the tertiary sector not having an advantage in terms of actual CE intensity. Therefore, indiscriminate and accelerated development of the tertiary sector does not directly reduce energy CE. Priority should be given to the development of modern service industries while transforming the energy consumption structure of the transport industry and increasing the proportion of energy-saving, new energy-driven, and environmentally friendly equipment. These efforts can effectively reduce the energy consumption of the tertiary sector in end consumption, the intensity of CE from energy consumption, and control the growth of the total CE from the tertiary sector, thereby realizing the CE reduction effect of the development of the tertiary sector.

Conclusions

The aim of this paper is to analyze whether financial development and government EC assessment policy contribute to EC and CE reduction. To this end, we use a panel data model based on the extended STIRPAT model to explore how financial development and government EC assessment policy affect CE and EC in 30 Chinese provinces. The analysis leads to the following conclusions:

Firstly, the financial development of China's provinces has a catalytic effect on reducing CE. The current Chinese financial system is still dominated by banks, with loans still accounting for over 60% of the total social financing stock. Under this commercial bank-dominated financial system, China's central bank or government regulator could take the lead in integrating financial resources, incorporating CE reduction constraints into the financing system, and establishing a green credit incentive mechanism. In this way, the accelerating development of green finance will be guided so that it can promote CE reduction while serving economic development.

Secondly, the current government conservation assessment policy has significant EC benefits, but no significant impact on CE reduction. For the Chinese government, a possible solution is to form energy structure adjustment policies and energy usage optimization policies, in addition to the EC assessment policy. The government could support clean energy development through policies such as energy industry policies, annual power generation plan development, and green energy development planning. Promoting the growth of clean energy supplements provides a supply base for the development of a low-carbon energy consumption structure. The energy pricing system aimed at promoting green development needs to be innovated and improved. The energy consumption structure should be enhanced and restructured through the energy price mechanism. Strict emission reduction systems and energy intensity and energy consumption control systems are needed to control the growth of CE. Through higher market access standards and low-carbon product certification, the government is able to push companies' energy savings and emissions reduction at the production stage. Through these initiatives, on the one hand, low-carbon and clean energy development can be promoted and the share of fossil energy can be reduced; on the other hand, energy optimization technologies will be promoted and energy-usage efficiency will be improved. By these efforts, it can facilitate the achievement of CE reduction targets and the promotion of low-carbon development.

Thirdly, under the existing tertiary industry structure, increasing the proportion of the tertiary industry is conducive to achieving EC targets, but not effective in achieving CE reduction targets. Along with the implementation of EC and CE reduction policies for many years, the average unit energy consumption of the secondary industry has been significantly reduced. However, the energy consumption per unit of the transportation industry in the tertiary sector has exceeded the average level of the secondary sector, and it is particularly alarming that fossil energy accounts for a relatively high proportion of the energy consumption structure in the transportation industry. This leads to the fact that, at present, the energy consumption intensity of the tertiary sector is low but CE intensity is relatively high. To address this issue, it is necessary to pay attention to the implementation of green financial policies and EC and CE reduction policies. Through a series of policies, the transport industry can be guided to reduce the proportion of fossil energy consumption and optimize the efficiency of energy utilization, which facilitates the EC and CE reduction of the tertiary sector.

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Conflict of Interest

The authors declare no conflict of interest.

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