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Influential mechanism of green consumption on the realization of ecological products value in China

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Introduction: Realizing the value of ecological products (EP) is of great significance to comprehensively promote the green transformation of China's economy. With the increasing demand of consumers for green, environmental protection and health, the great tendency of people's green consumption (GC) has been triggered. Based on the theory of sustainable development and the theory of ecosystem services, this paper constructs relevant econometric models and deeply discusses the influence mechanism of demand-side GC behavior on the E*p* value realization (EPVR).

Methods: This paper obtains the reliability data from the relevant statistical reports and statistical yearbooks, and innovatively constructs the index system of EPVR and GC whose comprehensive indexes are measured by entropy weight TOPSIS method. In the data analysis stage, STATA software was used for unit root test, cointegration test, multicollinearity test and descriptive statistics. On this basis, regression analysis was carried out by constructing a two-way fixed effect model, mediating effect and moderating effect model.

Results and discussion: (1) The level of EPVR is generally not high with a national average of 0.156 in the study area. The GC level of the study area is significantly different and the national GC level is 0.311; (2) From the regression results of the econometric model, GC has a significant positive effect on the EPVR, and has passed a series of robustness tests; (3) From the analysis of the influential mechanism, GC further affects the EPVR by affecting the supply willingness of EP, the advancement of industrial structure and the rationalization of industrial structure. Among them, the willingness to supply EP has a partial mediating effect, the advancement of industrial structure has a complete mediating effect, and the rationalization of industrial structure has a masking effect; (4) From the perspective of heterogeneity analysis, it is found that the influence of GC on the EPVR is enhanced in turn in eastern, central and western regions of China through grouping regression and adjustment effect test, and the promotion effect is more obvious in areas with lower economic development level. This paper provides an important literature reference for the impact of GC on the EPVR in China.

KEYWORDS

green consumption, value realization of ecological products, influence effect, mechanism analysis, heterogeneity discussion

1 Introduction

The key to realizing the value of ecological products (EP) is how to transform ecological benefits into economic benefits (Chen et al., 2024). On the one hand, through the market approach, that is, the beneficiaries of EP pay the suppliers of EP; on the other hand, through non-market approaches, that is, the government or public welfare organizations provide ecological compensation to the suppliers of EP, so that the ecological advantages can be transformed into economic benefits (Song and Du, 2024). In 2021, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council issued "Opinions on Establishing and Perfecting the Value Realization Mechanism of EP," and proposed the ways to accelerate the construction and improvement of the value of EP. In 2022, the 20th National Congress of the Communist Party of China once again pointed out that establishing a mechanism for realizing the value of EP, firmly establishing and practicing the concept that "lucid waters and lush mountains are invaluable assets" is an important task for the construction of ecological civilization. The good ecological environment provides a solid foundation for the comprehensive practice of the development concept of "two mountains." Through the realization of the value of EP, the green water and green mountains are transformed into "Jinshan" and "Yinshan," which can better promote the high-quality development of regional economy and society (Shen et al., 2022). In 2023, the Central Economic Work Conference once again attached great importance to the construction of ecological civilization and green low-carbon development, and committed to improving the realization mechanism of the value of EP. Under the current economic situation, the ecological products value realization (EPVR) is not only an important channel to promote the parallel practice of China's social and economic development and ecological environment protection, but also of great significance to comprehensively promote the green transformation of China's economy (Wang et al., 2023). The realization of the market value of EP depends on market regulation, guiding the matching of supply and demand to achieve ecological economic and social benefits (Li et al., 2021). In the face of people's increasing demand for a better ecological environment, it is worth exploring the impact mechanism of the EPVR from the demand consumption side.

The EPVR involves all aspects of social and economic development. At present, the research focuses on the supply of EP, influencing factors, realization paths and effects. Firstly, EP are the characteristic expression of China (Wang et al., 2023; Yang B. et al., 2023), and the closest study is about ecosystem services in the world (Bouwma et al., 2018; Costanza et al., 1997; Fisher et al., 2009; Mandle et al., 2021; Stevenson et al., 2021). The supply of EP mainly includes direct supply and indirect supply (Raviv et al., 2021; Xian-gang et al., 2014). The direct supply refers to global natural ecosystems directly providing human beings with necessary air, water, soil and other products (Li et al., 2021). Some scholars believe that the supply subject of EP comes from the ecosystem of natural world. Human beings do not participate in direct production, but complete the supply on the basis of environmental capacity (Rai et al., 2020), so the ecosystem is the direct supplier of EP (Costanza et al., 1997; Westman, 1977). The indirect supply of EP mainly refers to the indirect supply products led by the government or participated by multiple supply subjects. Most of them are about the construction of ecological compensation mechanism (Le and Leshan, 2020), ecological restoration (Suding et al., 2015) and improvement of optimized trading (carbon emission right, emission right, etc.) system (Zhou and Wang, 2022). Secondly, the research on the influencing factors of the EPVR mostly focuses on the influence of financial services and digital economy. Relevant financial services can guide the flow of funds and help to promote the value and capitalization of ecological resources (Wang et al., 2021; Yang and Masron, 2022), and the digital economy helps to break down the industry barriers and time and space constraints of EP in all aspects of the market (Liu et al., 2022), thus promoting the EPVR. Thirdly, the international community pays more attention to the payment for ecosystem services for the EPVR (Gaglio et al., 2023; Kaiser et al., 2023; Rakotomahazo et al., 2023). At the present stage, China pays more attention to the research of realization path and mode. Among them, Zhang et al. (2021) analyzes and summarizes relatively comprehensive results, including 8 practical paths refined to 22 specific practice modes. Most of the literature believe that the general path of the EPVR in China is government-led, market-led or "government + market" led paths. From the perspective of the consumption attribute of EP, the value of ecological pure public products is realized by the government, such as ecological compensation, tax adjustment, government financial transfer payment and so on (Fu et al., 2023; Yu et al., 2023); the value of ecological quasi-public goods is realized by "government + market" led path, such as resource quota trading (Zhang et al., 2020); private EP realize their value by market dominance, such as ecological industrialization, industrial ecology, etc. (Yang Y. et al., 2023). There are also a few literature suggesting that social welfare organizations are also one of the subjects of value realization (Wang et al., 2023). In addition, the research on the EPVR is rare. It is the degree to which the use value of EP is converted into exchange value (Perrings et al., 2010). Some scholars have studied different regions (e.g., Karst area and Yangtze River Basin) (Wu et al., 2021; Yang Y. et al., 2023) and the value realization benefits of forest EP (Rai et al., 2020; Yang B. et al., 2023; Zhao et al., 2023) were explored. Most of them were constructed from the aspects of ecological protection and policy guarantee, and the level of value realization was analyzed by measuring the comprehensive index.

In summary, the existing research focuses more on the path of EPVR. Although a few scholars pay attention to the EPVR, they mostly analyze the benefits themselves, and pay less attention to the impact mechanism of demand-side consumer behavior on the EPVR. In January 2022, the National Development and Reform Commission and seven other departments jointly issued the "Implementation Plan for Promoting Green Consumption," proposing that relevant enterprises, institutions and families and other groups implement GC behavior, which provides a new perspective for the improvement of the EPVR. Therefore, this paper explores the influential mechanism of GC on the EPVR from the perspective of GC. Firstly, it clarifies the theoretical mechanism of GC on the EPVR. On this basis, the research hypothesis is put forward. Secondly, the index system of EPVR benefit and GC is constructed and quantified, and the current discovery status is analyzed. Thirdly, by constructing a theoretical model, this paper empirically tests the influential mechanism of GC on the EPVR, analyzes the influence of mechanism variables, and further explores the heterogeneity of influence. Finally, according to the research conclusion, the countermeasures and suggestions are put forward to improve the EPVR.

The possible marginal contributions of this paper are as follows: Firstly, in terms of research perspective, this paper empirically explores the impact of GC based on the relationship between supply and demand of EP, which makes up for the shortcomings of previous studies that only focus on the supply of EP. Secondly, in terms of research content, based on the connotation of EP, the index system of EPVR is innovatively constructed from three dimensions: ecological regulation service benefits, ecological material and cultural product benefits and ecological social benefits. On this basis, based on the willingness of EP supply, industrial structure transformation and regional heterogeneity, the influence mechanism of GC on the EPVR is systematically explained. Thirdly, in terms of research methods, the role of masking effect is deeply explored in the path analysis of mechanism variables.

The organizational structure of the rest of this article is as follows. Section 2 is for the theoretical mechanism and research hypothesis, while Section 3 for the research design, including the introduction of research methods and variable descriptions, Section 4 for empirical analysis, including the current characteristics, empirical results, robustness and endogenous test, and Section 5 for a further discussion of the research content, exploring the impact mechanism and heterogeneity analysis of GC on the EPVR. Section 6 summarizes the research and puts forward countermeasures and suggestions. Finally, Section 7 discusses the research limitations and prospects.

2 Theoretical mechanism and research hypothesis

The theoretical basis of GC on the EPVR mainly includes ecosystem service theory, environmental economics theory, green economy theory and sustainable development theory. These theories provide important theoretical support and guiding significance for GC, and help to promote the EPVR and the protection of the ecological environment. Firstly, based on the theory of ecosystem services. The EP or ecosystem services are the benefits of various products and services obtained by human beings from ecosystems (Zhang et al., 2023). GC emphasizes the protection and sustainable use of ecosystems (Herreros-Cantis and McPhearson, 2021), and directly promotes the maintenance and enhancement of ecosystem services by selecting green products, saving resources and energy, and reducing pollution (Jiang and Gao, 2024). This kind of protection and utilization of ecosystem services provides an important theoretical basis for the EPVR. Secondly, on the basis of environmental economics theory. Environmental economics studies the relationship between economic development and environmental protection (Halkos and Managi, 2023). As a sustainable consumption model, GC emphasizes environmental protection, resource conservation and energy conservation in the process of consumption, and achieves a win-win situation between economic and environmental benefits (Peattie, 2010). This kind of consumption pattern conforms to the principle of environmental economics, that is, through reasonable economic means and policy measures, consumers and producers are guided to adopt behaviors conducive to environmental protection (Ali et al., 2022; Nascimento and Loureiro, 2024), so as to maximize the value of EP. Thirdly, on the basis of green economy theory. Green economy is a new economic form with the goal of sustainable development, based on ecological environment protection and resource conservation, supported by green technology and green industry (Chaaben et al., 2024; Wang et al., 2023c). GC is an important part of green economy. It promotes the formation and development of green economy by guiding consumers to choose green products and supporting the development of green industry (Hong et al., 2023). Under the framework of green economy, the EPVR has been better guaranteed and promoted. Fourthly, on the basis of the theory of sustainable development. Sustainable development refers to the development that meets the needs of contemporary people without harming the ability to meet the needs of future generations (Breuer et al., 2023). As a sustainable consumption mode, GC emphasizes on meeting the basic needs of human beings, paying attention to environmental protection and resource conservation, and realizing the harmonious coexistence between man and nature (Shiel et al., 2020). This consumption pattern conforms to the concept of sustainable development (Nygaard and Silkoset, 2023) and provides an important theoretical basis for realizing the sustainable value of EP. From the above analysis, it can be seen that GC is a kind of consumption behavior characterized by saving resources and protecting the environment. It means that consumers tend to choose the products or services that are environmentally friendly, resource-saving and low-carbon when purchasing and using them. GC helps to increase the market demand for EP (He and Sui, 2024; Xie and Madni, 2023; Yang M. et al., 2023). With the increasing attention of consumers to environmental protection and sustainability, GC has become a new consumption trend (Ali et al., 2022). This trend makes the market demand of EP gradually increase, thus promoting the development of EP industry. When the market demand for EP increases, the value of EP will be better realized. In addition, GC will promote the whole society to form a green, low-carbon and circular lifestyle, reduce environmental pollution and waste of resources, and drive the improvement and protection of ecological environment (Jiang and Gao, 2024). At the same time, GC will also drive the development of related industrial chains, create more employment opportunities and economic benefits, promote the sustainable development of society (Menebo et al., 2023), and further boost the EPVR. Therefore, the following research hypotheses are proposed.

> *Hypothesis 1*: GC can promote the EPVR.

GC not only reflects consumers' concern and responsibility for environmental protection, but also directly affects the market demand and sales of EP (Xu et al., 2022). When the consumers are more inclined to buy EP, the EPVR will increase accordingly. Because consumers' GC behavior provides a broad market space for EP, it promotes the production and sales of EP (Zhang and Wu, 2023; Zhou et al., 2022), forcing the production mode of EP to gradually change to be intensive, high value-added, high efficiency and low cost. At the same time, consumers' GC behavior also promotes the society's cognition and acceptance of EP, and further enhances the value of EP (Yi et al., 2021). Therefore, with the increasing demand of consumers for green, environmental protection and health, the potential of EP market is huge. GC will promote the increase of supply willingness or market expansion of EP (Herreros-Cantis and McPhearson, 2021), thus promoting the development of green industry and improving the EPVR. Moreover, with the growth of GC demand, the demand for green products and services in the market will continue to increase. This will promote

the adjustment and optimization of industrial structure, encourage enterprises to increase the R&D and production of green products, and improve the supply capacity of EP. At the same time, GC will also promote the development of related industrial chains (Sun and Chen, 2022), such as environmental protection equipment manufacturing, clean energy development, waste recycling and other industries, and then be further developed. Therefore, GC changes the industrial structure. That is to say, the proportion of EP industry and other industries has changed. The proportion of the former has been increasing, and the proportion of the latter two has been relatively reduced. The industrial structure tends to be advanced and rationalized. When the industrial structure is transformed to be of green, low-carbon and environmental protection (Wu C. et al., 2024), more products and services in line with the concept of GC will appear in the market, and promote the matching of supply and demand of EP, which is conducive to the improvement of the value realization efficiency of EP. Therefore, the following research hypotheses are proposed.

> *Hypothesis 2a*: GC improves the EPVR by increasing the supply willingness of EP.
>
> *Hypothesis 2b*: GC improves the EPVR by improving the advancement of industrial structure.
>
> *Hypothesis 2c*: GC improves the EPVR by improving the rationalization of industrial structure.

With the improvement of economic development, people's quality of life and consumption ability have gradually improved, and their demand for green, healthy and environmentally friendly consumption has also increased (Ali et al., 2022; Assan, 2023). This change in market demand will promote the development of GC and encourage enterprises to increase the supply of green products to meet the needs of consumers. At the same time, the improvement of the level of economic development is usually accompanied by the government's emphasis on environmental protection and sustainable development (Yang M. et al., 2023). The government can guide and support the development of GC by formulating relevant policies and measures, such as implementing green taxes, providing green credit, and promoting green certification. These policies will reduce the cost of GC and improve the competitiveness of green products, thus promoting the expansion of the green consumer market and improving the value realization efficiency of EP. In addition, the improvement of economic development level provides more resources and impetus for technological innovation and progress (Chen et al., 2023). With the continuous innovation and progress of technology, the production efficiency and quality of green products will be improved, and the production cost will be reduced. This will make green products more competitive in the market and promote the development of GC. However, the differences in consumption habits, environmental awareness, policies, market environment and public services among different regions with respective levels of economic development (Peattie, 2010) may lead to heterogeneity in the impact of GC on the EPVR. Therefore, the following research hypotheses are proposed.

> *Hypothesis 3*: The impact of GC on the EPVR is heterogeneous.

The theoretical mechanism of GC on the EPVR is shown in Figure 1.

3 Research design

3.1 Research methods and model construction

3.1.1 Entropy TOPSIS

This paper uses the entropy weight TOPSIS method which can fully consider the importance of each attribute, to evaluate the GC and the EPVR. In addition to avoiding the influence of subjectivity and uncertainty on the decision results, this method can also deal with situations where there is a correlation between the attributes, effectively exerting the advantages of the two and improving the accuracy and reliability of decision-making (Li G. et al., 2023; Li X. et al., 2023). Because the entropy weight TOPSIS method is relatively mature, the specific details refer to the research of Tan and Qi (2023).

3.1.2 Benchmark regression model

The benchmark regression model in this paper is set as Equation 1 (Imai and Kim, 2021).

$$\mathrm{EPVR}_{it} = \alpha + \beta\left(gc\right)_{it} + \theta Z_{it} + \mu_i + \nu_t + \varepsilon_{it} \tag{1}$$

Where: EPVR_{it} represents the EPVR in i region at t time, $\left(gc\right)_{it}$ represents the GC in i region at t time, and Z represents the control variable; μ_i and ν_t denote the individual and year fixed effects, respectively, and ε_{it} denotes the random perturbation term.

3.1.3 Mechanism effect model

In this paper, the mediating effect model and the interaction effect model are set as Equations 2–5 (Wu et al., 2023).

$$\mathrm{EPVR}_{it} = \alpha + \beta\left(gc\right)_{it} + \theta Z_{it} + \mu_i + \nu_t + \varepsilon_{it} \tag{2}$$

$$\mathrm{M}_{it} = \alpha_1 + \rho\left(gc\right)_{it} + \sigma Z_{it} + \mu_{1i} + \nu_{1t} + \varepsilon_{1it} \tag{3}$$

$$\mathrm{EPVR}_{it} = \alpha + \beta'\left(gc\right)_{it} + \gamma M_{it} + \varphi Z_{it} + \mu_{2i} + \nu_{2t} + \varepsilon_{2it} \tag{4}$$

$$\begin{aligned}\mathrm{EPVR}_{it} = \alpha + \alpha_1\left(gc\right)_{it} + \alpha_2 \mathrm{X}_{it} + \alpha_3\left(Xgc\right)_{it} + \\ \alpha_3 Z_{it} + \mu_{3i} + \nu_{3t} + \varepsilon_{3it}\end{aligned} \tag{5}$$

Where: (2–4) represent the mediating effect model, (2, 5) represent the moderating effect model. The coefficients before each variable are the corresponding regression coefficients; μ, ν and ε represent the individual, time fixed effect and random disturbance term, respectively. If both ρ and ā are significant, β' is not significant, the complete mediating effect is significant, and β' is significant, the mediating effect is significant. If at least one of ρ and ā is not significant, bootstrap test is needed to further determine whether the indirect effect is significant. Based on the sign of ργ and β', it is judged whether it is a partial intermediary or a masking effect. In addition, α_3 is the interaction effect coefficient, which indicates that with the

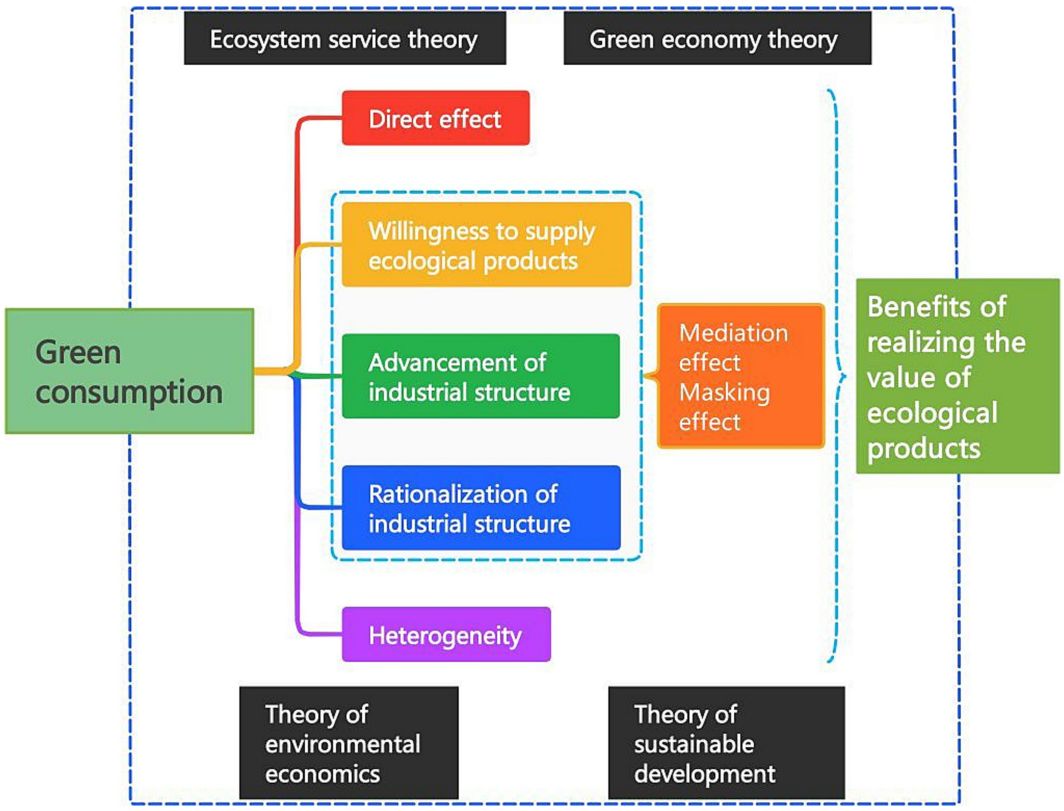

FIGURE 1
Theoretical mechanism diagram of GC on the EPVR.

change of adjustment variables, the influence of GC on the main effect of the EPVR is strengthened or weakened.

3.2 Data sources

China first proposed the concept of EP in 2010, so this paper selects data from 30 provinces (autonomous regions and municipalities also called provinces except Hong Kong, Macao, Taiwan and Tibet) from 2011 to 2022 as research samples. The original data is derived from the China Rural Statistical Yearbook, China Population and Employment Statistical Yearbook, China Tourism Statistical Yearbook, China Statistical Yearbook, China Energy Statistical Yearbook, Soil and Water Conservation Bulletin, Ecological Environment Bulletin, Natural Resources Bulletin, China Science and Technology Statistical Yearbook, Green Food Statistical Bulletin, the compilation of science and technology statistical data, the statistical yearbooks and statistical bulletins of the provinces over the years. Some missing data are estimated by the average growth rate of the past 5 years.

3.3 Variable declaration

3.3.1 Explained variable

EPVR is not only related to environmental protection and resource utilization, but also of great significance to promote high-quality economic development. It is a multi-dimensional and complex process, covering three aspects: ecological regulation service benefit, ecological material and cultural service benefit and ecological social benefit.

Firstly, one of the important goals of EPVR is to protect and improve the ecological environment (Zhang and Xu, 2024). The benefit of ecological regulation service is mainly reflected in the regulation function of ecosystem to environment. This includes water conservation, soil conservation, windbreak and sand fixation, air purification, water purification, carbon fixation and oxygen release services. These services not only help to maintain the stability and integrity of the ecosystem, but also provide a high-quality living environment for human beings. For example, as an important provider of ecological regulation services, forests effectively reduce surface runoff and soil erosion through their canopy and surface vegetation layers, and promote rainwater infiltration, thereby maintaining soil and water conservation. At the same time, forests can also absorb carbon dioxide through photosynthesis and release oxygen, which helps to alleviate global warming. And by protecting and restoring ecological resources, biodiversity and ecosystem integrity can be maintained, and the self-regulation and disaster resistance of ecosystems can be improved.

Secondly, the benefits of ecological material services are mainly reflected in the material products provided by the ecosystem for human beings, such as food, wood, medicinal materials, fiber, fresh water and so on. These material products are an important basis for human production and life (Khan et al., 2023). For example, animal and plant resources and agricultural and sideline products under

specific climatic and geographical conditions provide a rich source of food for human beings. The benefits of ecological and cultural services are reflected in the non-material benefits obtained by human beings from the ecosystem through spiritual enrichment, perceptual development, entertainment, and aesthetics. Such as scenic spots, forest parks, nature reserves, etc., for human beings to provide leisure, tourism and other diversified services.

Finally, EPVR not only directly improves the ecological benefits, but also helps to promote the transformation of ecological benefits to social benefits (Alshebami, 2023), thus contributing to the coordinated development of urban and rural areas. Specifically, The EPVR will help rural areas with rich ecological products give full play to the advantages of local ecological resources, attract migrant workers to return home for entrepreneurship and employment, and promote the flow of production factors such as labor, technology and capital between urban and rural areas. This flow of production factors has brought advanced production technology and management experience to rural areas. On this basis, rural areas are more able to provide high-quality ecological products and services for cities, and meet the needs of urban residents for green and healthy life. With the continuous expansion of the EP market, the income of rural residents will also be significantly improved, so as to promote the coordinated development between urban and rural areas, narrow their gap, and achieve comprehensive economic and social progress. Ecological regulation service benefits, ecological material and cultural service benefits, and ecological social benefits are interdependent and mutually reinforcing. For example, by protecting and rehabilitating ecosystems, the benefits of ecological regulation services can be enhanced, thereby providing more material and cultural services to humans; at the same time, a good ecological environment also helps to improve the quality of life and wellbeing of human beings and achieve ecological and social benefits.

In short, EPVR helps to promote the rise of green industries (Wang et al., 2023) and injects new impetus into economic growth. In the meantime, the driving force of the EPVR promotes the flow of urban and rural factors, further promotes the coordinated development of the region, and realizes the transformation of ecological benefits to social benefits. Therefore, this paper constructs the index system of EPVR from such three dimensions as environmental benefits, economic benefits and social benefits, respectively. In order to ensure the accuracy and objectivity of the evaluation results, we use the entropy weight TOPSIS method to calculate the comprehensive index represented by EPVR. The index system is shown in Table 1.

TABLE 1 Index system of EPVR.

First-level indicators	Second-level indicators	Unit	Attributes
Environmental benefits	Erosion area	Square kilometer	–
	Per capita water resources	Cubic meters/ person	+
	Wastewater discharge	Million tons	–
	Rate of excellent water quality	%	+
	PM 2.5 concentration	Micrograms/ cubic meter	–
	Inhalable particle concentration	Micrograms / cubic meter	–
	Exhaust gas amount	Million tons	–
	Air compliance rate	%	+
	Agricultural acreage	Million mu	+
	Garden area	Million mu	+
	Wooded area	Million mu	+
	Grassland area	Million mu	+
	Area of the wetlands	Million mu	+
	Percentage of forest cover	%	+
Economic benefits	Agricultural products output value	Billion yuan	+
	Forestry products output value	Billion yuan	+
	Animal husbandry products output value	Billion yuan	+
	Fishery products output value	Billion yuan	+
	Freshwater product output	Million tons	+
	Hydropower generating capacity	Billion kilowatt hours	+
	Tourism income	Billion yuan	+
Social benefits	Proportion of rural individual employment	%	+
	Rural per capita disposable income	yuan	+
	Urban and rural per capita income differences	%	–

3.3.2 Core explanatory variables

In the context of exploring the level of GC, based on the latest research in related fields (Yang M. et al., 2023), this paper focuses on the direct impact of consumer behavior on energy consumption and resource environment, and selects such four key dimensions as carbon dioxide emissions per unit of consumption, energy consumption per unit of consumption, water consumption per unit of consumption, and garbage removal per unit of consumption. Carbon dioxide emissions per unit of consumption measure the intensity of carbon emissions generated during consumption. Low carbon emission is one of the important characteristics of GC. By reducing the carbon dioxide emissions per unit of consumption, it can reflect the impact of consumers on the environment in the process of consumption, and then evaluate the level of GC. The lower the energy consumption per unit consumption is, the less energy consumers consume when meeting the same consumption demand, which reflects the higher resource utilization efficiency. Water resources are precious natural resources, and water saving is an important part of GC. By measuring the water consumption per unit of consumption, we can evaluate the degree of water conservation in the process of consumption, and then guide consumers to form water-saving awareness and promote the sustainable use of water resources. The lower the unit consumption is, the less garbage is produced when consumers meet the same consumer

demand, which reflects the efficiency and environmental awareness of consumers in dealing with garbage. At the same time, the lower amount of garbage removal also helps to reduce energy consumption and environmental pollution in the process of garbage disposal. Among them, carbon dioxide emissions refer to the specific data and methods in the IPCC "National Greenhouse Gas Emission Inventory Guidelines" to calculate the required carbon dioxide emissions. This paper also uses the entropy weight TOPSIS method to calculate the GC comprehensive index, and the index system is shown in Table 2.

3.3.3 Mechanism variables

Combined with theoretical analysis, this paper takes the advanced industrial structure ("isu"), the rationalization of industrial structure ("isr") and the willingness to supply EP ("lncep") as mediating variables, and the level of economic development ("ed") as a moderating variable. The industrial structure level, Theil index, green food supply multiplied by (100–100 * Engel coefficient) and per capita GDP are used as measurement indicators.

3.3.4 Control variables

The control variables mainly construct the analysis framework of the influencing factors of the EPVR from such aspects as education level, science and technology level, information level, economic development, urbanization level, population density and environmental regulation (Jiun et al., 2022; Sun and Wu, 2020). Education level (Edu) selects the proportion of regional colleges and universities in the national totality as the measurement index. Education can enhance the public's awareness of ecological value, which in turn affects people's demand for EP and consumption patterns. The level of science and technology (Tec) is gaged by the proportion of regional patent applications to the national total. Scientific and technological innovation has an important impact on the production, processing and circulation of EP, and can improve the quality and efficiency of EP. Information level (Inf) is captured by the proportion of regional post and telecommunications business to the national sum, reflecting the level of information development. The efficiency of information dissemination and acquisition affects the market supply and demand docking and EPVR. The urbanization rate (Urb) is determined by the proportion of the urban population to the national total. The process of urbanization has a profound impact on the demand and supply mode of EP. For example, urban expansion may occupy ecological land, but it may also increase the supply of EP through ecological restoration and compensation. Population density (Pop) is calculated as the number of people per square kilometer, and the intensity of environmental regulation (Env) is assessed using the ratio of industrial pollution control investment to industrial added value (Song et al., 2021). Pop reflects the intensity of human activities and has a direct impact on the ecological environment and the supply of EP and the government's environmental policies and regulations have a guiding and restraining effect on the production and consumption of EP. The control variable indexes all select the relative number to represent the development level, which can abstract the absolute difference of the phenomenon and make the comparison between the regions more meaningful. Table 3 is the descriptive statistics of relevant variables.

From Table 3, we can see that the maximum value of EPVR is 0.540, with the minimum value of 0.038, and the average value of 0.156, indicating that the EPVR between the regions is relatively large; the maximum value of GC (gc) is 0.907 whereas the minimum value being 0.119, indicating that the level of GC is different over the regions; the statistical results of other variables are also within the normal range.

4 Empirical test

4.1 Variation characteristics of the EPVR and GC

After the calculation, the comprehensive index of the value realization benefit and GC level of EP in 30 provinces of China from 2011 to 2022 is obtained. First of all, the average level of EPVR in various provinces is obviously different and the overall level is not high. The national average level is only 0.156. Among them, the average level of EPVR in Xinjiang, Heilongjiang, Inner Mongolia, Qinghai, Guangdong and Sichuan is higher. In particular, Xinjiang is much higher than the national average. The average level of EPVR in Ningxia, Tianjin and Shaanxi is relatively low, far below the national average. Secondly, the average level of GC in each province is significantly different, and the national average level of GC is 0.311. Among them, the levels of GC in Beijing, Liaoning, Jilin, Hainan, Chongqing and Xinjiang are higher than the national average, and the average levels of GC in Inner Mongolia, Guangxi, Guizhou, and Yunnan a lower than the national average. The related change trend is shown in Figure 2.

4.2 Analysis of model regression results

4.2.1 Parametric test

Panel unit root tests include the LLC test, IPS test and HT test (Wu Y. et al., 2024), in which the LLC test is suitable for the long panel while the IPS and HT tests for the short panel. Combined with the panel data in this paper, IPS and HT are selected to test the data stability. The test results show that all unit roots are stable and reject the null hypothesis. The results of the KAO co-integration test show that the *p*-value of ADF is significant at the level of 1%, rejecting the original hypothesis of all variables having a co-integration relationship,

TABLE 2 Index system of GC.

First-level indicators	Second-level indicators	Unit	Attributes
GC	Carbon dioxide emissions per unit of consumption	Ten thousand tons/billion yuan	–
	Energy consumption per unit of consumption	Thousand tons of coal standard/billion yuan	–
	Water consumption per unit of consumption	Cubic meters/yuan	–
	Unit consumption garbage removal volume	Ten thousand tons / billion yuan	+

TABLE 3 Descriptive statistics of related variables.

Variables symbol	Variable name	Obs	Mean	Std. Dev.	Min	Max
EPVR	Eco-product value realization	360	0.156	0.100	0.038	0.540
GC	Green consumption	360	0.311	0.120	0.119	0.907
edu	Education level	360	0.033	0.015	0.004	0.064
inf	Information level	360	0.033	0.030	0.001	0.189
tec	Science and technology level	360	0.033	0.045	0.000	0.232
urb	Urbanization rate	360	0.601	0.121	0.350	0.893
pop	Population density	360	0.047	0.070	0.001	0.393
env	Environmental regulation	360	0.003	0.003	0.000	0.031
ed	Economic development level	360	5.872	3.066	1.602	19.031
lncep	Willingness to supply eco-product	360	10.218	1.454	5.598	15.262
isr	Rationalization of industrial structure	360	0.147	0.111	0.007	0.451
isu	Advanced industrial structure	360	2.399	0.123	2.132	2.836

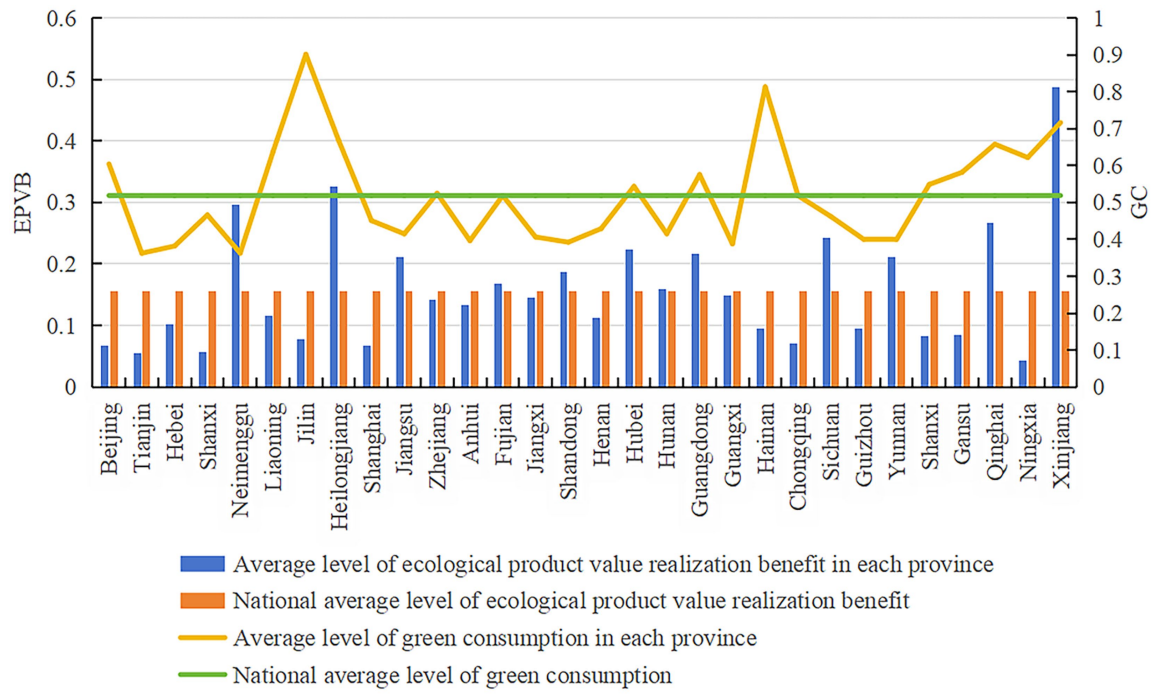

FIGURE 2
Average levels and rankings of EPVR and GC in 30 provinces in China.

and indicating a long-term stable relationship between variables, and a stable regression residual of the equation. Therefore, the original equation can be regressed directly on this basis, and the regression result is more accurate. The VIF test results show that the values are <5, indicating that there is no serious multicollinearity. Therefore, the original equation can be directly regressed on this basis to avoid a certain degree of pseudo-regression.

4.2.2 GC and EPVR

Based on the empirical model constructed above, this paper examines the relationship between GC and the level of EPVR, as shown in Table 4. On the basis of adding control variables, column (1) is the result of random effect regression. The results show that the regression coefficient of GC is significantly positive at the level of 10%. In column (2), only the individual fixed effect is added, and the regression coefficient of GC is still significantly positive. In Column (3), only the time fixed effect is added, and the results show that the regression coefficient of GC is significantly positive at the 5% level. The fourth column performs a two-way fixed effect regression, and the regression coefficient of GC is still significantly positive at the 5% level. Therefore, it is proved that GC will promote the improvement of EPVR, which verifies hypothesis 1. From the fitting degree of the model, this paper takes the regression results of the two-way fixed effect as the benchmark regression results.

TABLE 4 Relationship between GC and the EPVR tested.

Variables	EPVR			
	(1)	(2)	(3)	(4)
GC	0.029* (0.015) [−0.002, 0.060]	0.027* (0.015) [−0.004, 0.059]	0.043** (0.018) [0.007, 0.079]	0.037** (0.018) [0.001, 0.074]
edu	2.459*** (0.719)	3.177*** (0.847)	2.726*** (0.737)	3.484*** (0.886)
inf	−0.011 (0.140)	−0.023 (0.143)	−0.021 (0.141)	−0.028 (0.145)
tec	0.0421 (0.107)	0.050 (0.110)	−0.006 (0.112)	0.005 (0.117)
urb	0.161*** (0.042)	0.161*** (0.045)	0.029 (0.080)	0.042 (0.096)
pop	−0.702*** (0.266)	0.195 (0.795)	−0.511* (0.290)	0.061 (0.876)
env	0.479 (0.439)	0.423 (0.443)	0.470 (0.492)	0.458 (0.494)
ed	0.006*** (0.001)	0.005*** (0.001)	0.003 (0.002)	0.003 (0.002)
cons	−0.038 (0.036)	−0.101** (0.047)	0.020 (0.047)	−0.176 (0.144)
Fixed individual	No	Yes	No	Yes
Fixed time	No	No	Yes	Yes
Within R^2	0.388	0.392	0.398	0.401
N	360	360	360	360

Standard errors are in the parentheses, 95% confidence intervals are in the brackets: *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$ (the same in the following tables).

4.3 Robustness test

4.3.1 Stepwise regression

To verify the robustness of the results, this paper adds control variables in turn for stepwise two-way fixed effect regression. The regression results are shown in Table 5. After adding control variables one by one, the impact of GC on the EPVR is positive and significant, indicating that the benchmark regression results are relatively robust.

4.3.2 Substitution variable

The explained variables are, respectively, replaced by the comprehensive index calculated by the entropy weight method with the results from the entropy weight TOPSIS, and the regression is shown in Table 6 (1). The results show that the coefficient of GC is positive and significant. At the same time, the comprehensive index of ecological regulation services is further used to replace the explained variables. The regression results are shown in Table 6 (2), and the coefficient of GC is still positive and significant. The robustness of the original benchmark regression results is verified.

4.3.3 Excluding interference of outliers

In order to eliminate the interference of outliers on the benchmark regression results, the EPVR, GC and control variables can be tailed by 1%, and the model can be regressed again. The results are shown in Table 6 (3). After cleaning the data, it is found that the effect of all regression results is unchanged, indicating that the benchmark regression results are more robust.

4.3.4 Endogeneity test

In order to control the possible two-way causality, the explanatory variables are lagged one period in the model. Nevertheless, endogenous problems still need to be further considered. The theory of supply and demand in economics shows that consumption and supply are two indispensable components of the market economy. They are closely related and interact with each other (Liu et al., 2023). In view of this, this paper uses the number of green certified food as an instrumental variable for GC. In order to better ensure exogeneity and time series, this paper uses the earliest cross-sectional data of the number of green organic certified food published by the state in 2016 multiplied by the carbon emissions per unit of consumption in each year in the regression model (Rong, 2023). The regression results are as shown in Table 6 (4), assuming that the instrumental variables are insufficiently identified and tested. The test result LM statistic is 207.104, and its *p* value is significant at the 1% significance level, so the hypothesis of insufficient identification of instrumental variables is rejected. The weak identification of instrumental variables is tested. The results show that the Wald F statistic is 315.463, which is greater than the critical value of 19.93 at the 10% level. Therefore, it shows that the instrumental variable is reasonable. The over-identification test value is 0.300, and its $p > 0.1$, accepting that all instrumental variables is of an exogenous null hypothesis. The results of Table 6 (4) show that the regression results of GC are still positive and significant, which further verifies the robustness of the original benchmark regression results.

5 Influential mechanism

5.1 Mediation effect analysis

In order to investigate the mechanism of GC affecting the EPVR, this paper examines the three channels of EP supply willingness, industrial structure upgrading and industrial structure rationalization. According to the research of Rong (Rong, 2023), the willingness to supply EP is the sum of the supply of green food, organic food and the geographical indication certification quantity of agricultural products, multiplied by the value (100-Engel coefficient × 100). At the same time, with reference to the research of Yuan Hang (Hang and Chengliang, 2018), the upgrading of industrial structure is calculated according to Formula $Isu_{i,t} = \sum_{n=1}^{3} y_{i,n,t} \times n, n = 1,2,3$ to reflect the proportion evolution relationship of China's three industries, and the rationalization of industrial structure is based on Formula $Theil_{i,t} = \sum_{n=1}^{3} y_{i,n,t} \ln\left(\frac{y_{i,n,t}}{l_{i,n,t}}\right), n = 1,2,3$, to reflect the rationality of industrial structure. Among them, $y_{i,n,t}$ represents the proportion of the nth industry in the i region in the t period to the regional GDP, and $l_{i,n,t}$ represents the proportion of the nth industry in the

TABLE 5 Results of stepwise regression.

Variables	EPVR							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GC	0.049*** (0.017) [0.015, 0.084]	0.048*** (0.017) [0.015, 0.082]	0.048*** (0.017) [0.014, 0.083]	0.049*** (0.017) [0.015, 0.084]	0.049*** (0.017) [0.015, 0.084]	0.046** (0.018) [0.011, 0.082]	0.045** (0.018) [0.010, 0.081]	0.037** (0.018) [0.001, 0.074]
edu		3.069*** (0.755)	3.070*** (0.759)	3.128*** (0.770)	3.459*** (0.879)	3.392*** (0.886)	3.394*** (0.886)	3.484*** (0.886)
inf			−0.001 (0.140)	−0.012 (0.143)	−0.023 (0.143)	−0.036 (0.145)	−0.032 (0.145)	−0.028 (0.145)
tec				−0.050 (0.111)	−0.058 (0.111)	−0.054 (0.112)	−0.050 (0.112)	0.005 (0.117)
urb					−0.060 (0.077)	−0.036 (0.085)	−0.027 (0.086)	0.042 (0.096)
pop						0.536 (0.828)	0.529 (0.828)	0.0618 (0.876)
env							0.456 (0.495)	0.458 (0.494)
ed								0.003 (0.002)
cons	0.021* (0.011)	−0.084*** (0.028)	−0.084*** (0.028)	−0.084*** (0.028)	−0.0468 (0.055)	−0.131 (0.142)	−0.138 (0.142)	−0.176 (0.144)
Fixed individual	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Within R^2	0.3604	0.3921	0.3921	0.3925	0.3937	0.3945	0.3962	0.4011
N	360	360	360	360	360	360	360	360

i region to the total employment in the t period. To test whether it is a mediating effect or a masking effect, this paper refers to the research method of Wen Zhonglin (Ouyang et al., 2022) to examine the indirect effect of mediating variables on the EPVR. The regression results of the willingness to supply EP are shown in Table 7 (2, 3). The results show that ρ is not significant, but the bootstrap test method is used to test the significant coefficient of $\rho\gamma$, so there is an indirect effect on the willingness to supply EP. At the same time, β' is 0.0325, which is also significant at the 10% level, and $\rho\gamma$ and β' are the same. Therefore, lncep has a partial mediating effect, and the mediating effect value is 0.131 ($\rho\bar{a}/\beta$), which verifies Hypothesis 2a. The regression results of the upgrading of the industrial structure are shown in Table 7 (4, 5). The regression shows that both ρ and γ are significant, and β' is not significant, indicating that the upgrading of the industrial structure plays a full intermediary role in the impact of GC on the EPVR. There is no masking effect, which verifies hypothesis 2b. The regression results of industrial structure rationalization are shown in Table 7 (6, 7). The regression results show that both ρ and γ are not significant. Similarly, the bootstrap method is used for the next test. The results show that the indirect effect is significant, and the direct effect is 0.0375, which is also significant at the 5% significance level. However, $\rho\gamma$ and β' are different, so there is a masking effect, masking effect is 0.002 ($\rho\bar{a}/\beta'$), indicating that GC can further improve the EPVR by reducing the Theil index, that is, GC can further improve the EPVR by promoting the rationalization of industrial institutions, which verifies Hypothesis 2c.

5.2 Influential mechanism of different levels of mediating variables

On the basis of the previous research, this paper divides the three indicators of industrial structure upgrading, EP supply willingness and industrial structure rationalization into higher and lower groups according to the median, and conducts grouping test. The results of Table 8 (1, 3) show that the regression coefficient of GC is significantly positive in the group with higher industrial institutions and rationalization of industrial structure, but not significant in the lower group, indicating that the higher the industrial institutions and rationalization index, the greater the impact of GC on the EPVR, and the component coefficients show significant differences. The results of Table 8 (2) show that in the group with less willingness to supply EP, the regression coefficient of GC on the EPVR is positively significant, and the difference of component coefficient is not obvious. From the significance of the regression coefficient alone, it shows that in the group with less willingness to supply, GC has greater potential to promote the EPVR, and the effect is more obvious.

5.3 Further discussion

Based on the above analysis, GC has a significant positive impact on the EPVR. In order to test whether there is heterogeneity in the influence, this paper conducts econometric regression on the moderating effects of the higher and lower groups of economic development level, the eastern, central and western regions of China

TABLE 6 Regression results after replacement of explanatory variables, exclusion of outliers, and conducting an endogenous test.

Variables	EPVR1	C1	EPVR	EPVR
	(1)	(2)	(3)	(4)
GC	0.027* (0.014) [−0.001, 0.056]	0.046*** (0.011) [0.024, 0.069]	0.037** (0.018) [0.001, 0.074]	0.039* (0.023) [−0.006, 0.085]
LM statistic				207.104
LM statistic *P*-value				0.0000
Cragg-Donald Wald F statistic				315.463
Stock-Yogo weak ID test 10% critical value				19.93
Sargan statistic				0.300
Sargan statistic *P*-value				0.583
control variable	Yes	Yes	Yes	Yes
Fixed individual	Yes	Yes	Yes	Yes
Fixed time	Yes	Yes	Yes	Yes
N	360	360	360	330

TABLE 7 The intermediary influence mechanism of green consumption on the value realization of ecological products.

Variables	EPVR	lncep	EPVR	isu	EPVR	isr	EPVR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GC	0.037** (0.018) [0.001, 0.074]	0.210 (0.210) [−0.201,0.621]	0.032* (0.018) [−0.003,0.068]	0.090*** (0.019) [0.051, 0.129]	0.022 (0.019) [−0.015, 0.060]	0.015 (0.058) [−0.098,0.130]	0.037** (0.018) [0.001, 0.074]
lncep			0.023*** (0.004) [0.014, 0.033]				
isu					0.170*** (0.053) [0.066, 0.273]		
isr							−0.006 (0.018) [−0.043, 0.029]
Bootstrap*p*-value		0.045				0.082	
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed individual	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed time	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	360	360	360	360	360	360	360

and the level of economic development. The regression results are shown in Table 9. Table 9 (1–3) grouped and regressed China's eastern, central and western regions. The results show that the influence of GC on the EPVR is significant in turn. It shows that the more developed the economy is, the less obvious the promotion effect of GC on the EPVR is. The possible explanation is that the ecological environment in the eastern, central and western regions is different. Although the economy in the western region is relatively underdeveloped, it is vast and rich in resources, such as hydropower and wind energy (Niu et al., 2022). Its good ecological environment can better meet the needs of GC, so GC has a positive and significant effect on the EPVR in the western region. The economy in the eastern and central regions is relatively developed, but the ecological environment is relatively weak (Zhao et al., 2020), and the supply capacity of EP is relatively limited, which cannot better meet the demand for GC. In other words, there may be an imbalance between supply and demand.

Table 9 (4) to (5) grouped the economic development level according to the median for regression. The results show that in the group with lower economic development level, the effect of GC on the EPVR is positive and significant. The possible explanation is that, firstly, from the perspective of consumer demand and habits, the consumers in regions with high levels of economic development tend to pay more attention to quality and convenience, and are relatively less sensitive to price (Le et al., 2019). This may lead to their demand for EP is not strong enough, or even if they buy EP, they are more based on quality rather than environmental protection considerations. In contrast, in areas with relatively backward economies, the consumers are more sensitive to prices and may be more inclined to choose cost-effective eco-products.

TABLE 8 The influence mechanism of different levels of mediating variables.

Variables	EPVR					
	(1)		(2)		(3)	
	isu		lncep		isr	
	Higher group	Lower group	Larger group	Smaller group	Higher group	Lower group
GC	0.064*** (0.032) [0.002, 0.126]	−0.029 (0.016) [−0.060, 0.003]	−0.063 (0.036) [−0.135, 0.007]	0.055*** (0.021) [0.013, 0.096]	0.061** (0.024) [0.014, 0.107]	−0.037 (0.047) [−0.136, 0.013]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Fixed individual	Yes	Yes	Yes	Yes	Yes	Yes
Fixed time	Yes	Yes	Yes	Yes	Yes	Yes
chi^2 p-value	0.0264		0.5734		0.0003	
N	180	180	180	180	180	180

TABLE 9 Heterogeneity and interaction regression results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Eastern	Central	West	Low economic level	High economic level	Interaction effect
gc	−0.120** (0.050) [−0.217,0.023]	0.004 (0.015) [−0.025, 0.033]	0.084** (0.035) [0.015, 0.152]	0.056** (0.023) [0.012, 0.100]	−0.013 (0.032) [−0.142, −0.017]	0.135*** (0.035) [0.066, 0.205]
gced						−0.028*** (0.009) [−0.046, 0.011]
ed						0.009*** (0.003) [0.003, 0.013]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Fixed individual	Yes	Yes	Yes	Yes	Yes	Yes
Fixed time	Yes	Yes	Yes	Yes	Yes	Yes
N	120	120	108	180	180	360

Secondly, from the perspective of environmental awareness and cognition, although the regions with high levels of economic development may have higher environmental awareness as a whole, this may also lead to a differentiation in consumers' cognition of environmentally friendly products (Ali et al., 2022). Some consumers may be very concerned about environmental issues, willing to pay a premium for environmentally friendly products. Other consumers may think that there is not much difference between environmental protection products and ordinary products, or they are skeptical about the actual effect of environmental protection products. This differentiation may lead to a smaller promotion effect of GC in the areas with high levels of economic development. Thirdly, from the perspective of policy and market environment, the regions with high levels of economic development tend to have more mature and complex market environments, and the governments also pay more attention to economic development and industrial upgrading (Yang M. et al., 2023). In this context, the government may pay more attention to promoting technological innovation and industrial upgrading, while the support for the environmental protection industry is relatively small. In addition, due to the fierce market competition, enterprises may pay more attention to short-term profits and ignore environmental responsibility. These factors may lead to a small promotion effect of GC in the areas with high levels of economic development. Fourthly, from the perspective of infrastructure and public services, the regions with high levels of economic development often have more complete infrastructure and public service systems (Yu and Zhou, 2023), which provides residents with a more convenient and comfortable lifestyle. However, this may also lead to a decrease in residents' demand for environmentally friendly products. For example, in the areas where public transport is developed, the residents may be more inclined to choose public transport rather than buying environmentally friendly cars. In the areas where the garbage classification system is perfect, residents may pay more attention to garbage classification rather than purchasing degradable plastic products.

Table 9 (6) is to form an interaction term between economic development level and GC, and use the adjustment effect model to regress. The results show that the coefficient of the interaction term is significantly negative, namely - 0.028, and the main effect is significantly positive, indicating that the level of economic development weakens the impact of GC on the EPVR, and has a negative adjustment effect. From the above analysis, it is found that the three types of analysis actually verify the same situation, that is, with different levels of economic development, the impact of GC on the EPVR also differs. Therefore, hypothesis 3 is verified.

6 Conclusions and policy implications

6.1 Conclusion

To explore the influence mechanism of GC on the EPVR, this paper constructs the index system of the EPVR and GC, and uses the entropy weight TOPSIS method to measure its comprehensive index. On this basis, with the help of two-way fixed effect model, this paper empirically analyzes the impact of GC on the EPVR in China from 2011 to 2022, and carries out robustness test, endogenous test, mechanism test and heterogeneity discussion. The research shows following four. (1) The level of EPVR in various provinces is generally not high, with a national average of 0.156. The GC level of each province is significantly different, and the national GC level is 0.311. (2) From the regression results of the econometric model, GC has a significant positive effect on the EPVR, and has passed a series of robustness tests. (3) From the analysis of the impact mechanism, GC further affects the EPVR by affecting the supply willingness of EP, the advancement of industrial structure and the rationalization of industrial structure. Among them, the willingness to supply EP has a partial mediating effect, the advancement of industrial structure has a complete mediating effect, and the rationalization of industrial structure has a masking effect. (4) From the perspective of heterogeneity analysis, it is found that the influence of GC on the EPVR is enhanced in turn in eastern, central and western regions of China through grouping regression and adjustment effect test, and the promotion effect is more obvious in areas with lower economic development level. This paper provides an important literature reference for the impact of GC on the improvement of the EPVR in China.

6.2 Policy implications

Drawing upon the research conclusions, the following policy implications are proposed from various perspectives.

1 GC. Firstly, the government should strengthen publicity and education to enhance the awareness of GC. The government should increase the publicity of the concept of GC, regularly carry out publicity activities on the theme of GC, and enhance the public's awareness of environmental protection and sense of responsibility. Secondly, they should formulate GC policies and provide incentive mechanisms, establish a special fund for GC, give certain subsidies or rewards to consumers who purchase EP, and reduce the purchase cost of green products. Enterprises that produce EP should be given tax incentives, loan support and other policy measures to encourage them to increase the R&D and production of green products. Thirdly, they should establish and improve the GC service system, build a GC information service platform to provide consumers with green product purchase guidelines, environmental protection knowledge consulting and other services, and encourage retail enterprises to set up green product sales areas to provide consumers with convenient green product purchase channels. At the same time, the supervision and law enforcement should be strengthened. They should strengthen the supervision of the green consumer market and crack down on the production and sales of fake and shoddy green products, punish the enterprises and individuals who violate environmental laws and regulations according to law, and maintain the fairness and order of the green consumer market.

2 Industrial structure. Firstly, they should promote the development of green industry, formulate the development plan of green industry, clarify the development goals, key areas and policy measures of green industry, and provide guidance for the development of green industry. The government should increase the support for green industry, and promote the rapid development of green industry through the support of capital, technology and talents. Secondly, they should promote the green transformation of industrial structure. Through policy guidance and market mechanism, they should encourage traditional industries to develop in the direction of green, low-carbon and recycling, improve the efficiency of resource utilization and environmental benefits of the industry, strengthen the research and development and promotion of green technology, promote the technological upgrading and transformation of traditional industries, reduce pollutant emissions, and enhance product quality and added value. Besides they should establish a green supply chain system, encourage enterprises to build a green supply chain, from raw material procurement, product design, manufacturing to product sales and other links to achieve green, strengthen the coordination and cooperation of all aspects of the supply chain, realize the sharing and optimal allocation of resources, reduce production costs, and improve the environmental performance and competitiveness of products. Thirdly, they should promote the positive interaction between GC and industrial structure upgrading. Through the market demand of GC, they should guide enterprises to increase investment in technological innovation and product research and development, and promote the green transformation and upgrading of industrial structure. At the same time, the green transformation and upgrading of the industrial structure can provide more high-quality and environmentally friendly EP for GC, meet the needs of consumers, and form a benign interaction situation.

3 Willingness to supply EP. Firstly, they should improve the environmental awareness of EP suppliers. Through publicity and education, training, etc., they should improve the environmental awareness of EP suppliers, encourage enterprises to participate in environmental public welfare activities, enhance their sense of social responsibility, and thus increase their willingness to supply EP. Secondly, they should establish a green product certification system to certify and reward products that meet environmental protection standards, and enhance the motivation of enterprises to supply EP. Thirdly, they should improve the EP market system, establish and improve the market system of EP, increase the efficiency of market circulation, reduce transaction costs, and create a better market environment for EP suppliers. Fourthly, they should encourage technological innovation and R&D, encourage enterprises to increase technological innovation and R&D investment in the field of EP, improve the environmental performance and added value of products, and meet the growing needs of consumers.

4 Considerations of heterogeneity. First of all, they should strengthen the supply capacity of EP in developed economic regions, such as improving the market system of EP, strengthening the brand building of EP, improving the popularity

and reputation of products, enhancing consumers' trust and recognition of EP, and promoting the matching of supply and demand. Secondly, differentiated policy incentives are needed. According to the different needs and characteristics of consumers, they formulate differentiated policy incentives. For example: for low-income groups, more financial subsidies and tax incentives can be provided; for high-income groups, more emphasis can be placed on the concept of environmental protection and social responsibility; for different industries and enterprises, according to their willingness and ability to supply EP, different support policies are formulated, such as technological innovation support, market expansion help, etc. Thirdly, they should strengthen the cooperation and coordination. Governments, enterprises, social organizations and other parties should strengthen their cooperation and coordination to jointly promote the development of GC and EP. The government should play a guiding role and provide policy support and financial support, while the enterprises should actively innovate and produce high-quality EP, and social organizations should play a role as a bridge and link to promote the cooperation and exchanges among all parties.

However, it is worth noting that the implementation of GC policies may face multiple potential obstacles. From the perspective of consumers, the lack of awareness of GC, price sensitivity, purchasing power and consumption habits make it difficult for green products to be widely accepted. In terms of enterprises, insufficient investment in green technology R&D and innovation, high production costs, high market risks, and imperfect green supply chain management have all affected the production and promotion of green products. At the policy level, the lack of policy formulation and implementation, the lack of clarity of incentives and preferential policies, and the lack of supervision and law enforcement make it difficult to effectively implement GC policies. In addition, information asymmetry at the market level makes it difficult for consumers to accurately understand green products, and limited market acceptance also hinders the promotion of GC policies. These obstacles are intertwined and jointly affect the implementation effect of GC policy. In order to overcome these obstacles, the government needs to strengthen policy guidance and supervision, and provide more incentives and preferential policies. Enterprises need to increase investment in green technology R&D and innovation to improve the quality and performance of green products; consumers need to improve their awareness of environmental protection and enhance their awareness and acceptance of green products. At the same time, all sectors of society should also actively participate in promoting the development of GC and achieving a win-win situation between economy and environment.

7 Research limitations and prospects

7.1 Research limitations

Although this paper has achieved some results in exploring the impact of GC on the EPVR, there are still some obvious limitations. Firstly, it is insufficient in the consideration of spatial dimension. The research mainly adopts the two-way fixed effect model. Although this model can reveal the direct relationship between GC and the value of EP, it fails to fully explore the spatial spillover effect of GC among different regions. This means that we may ignore the spread and influence of GC among regions, thus failing to fully understand its complex role in the EPVR. Secondly, there are also some deficiencies in the construction of the index system. Although the research attempts to construct an indicator system from multiple perspectives, it may still fail to cover all key variables, or there are errors in the measurement methods of some variables. This may affect the accuracy of the research results and cannot fully reflect the real relationship between GC and the value of EP. In addition, the selection of indicators and measurement methods may also be affected by subjective factors, which further increases the uncertainty of research results.

7.2 Research prospects

In view of the above research limitations, future research can be expanded and deepened from the following aspects. Firstly, in the spatial dimension, the spatial spillover effect of GC should be fully considered. This requires us to incorporate spatial factors into the research design and adopt advanced analysis methods such as spatial econometrics to more accurately capture the interaction of GC among different regions. Through this method, we can have a deeper understanding of the transmission mechanism of GC among regions and its complex impact on the EPVR. Secondly, in the construction of index system, it should be further improved and optimized. This includes a more comprehensive consideration of the factors that may affect the realization of GC and the value of EP, as well as the adoption of more accurate and reliable measurement methods. By introducing new variables and indicators, we can more fully reflect the complex relationship between GC and the value of EP in China, and improve the accuracy and reliability of the research results.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JS: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft. CC: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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