Journal of Digital Intelligence and Economic Growth
Website: https://www.jdieg.com
Vol. 2 No. 1, March 2025, 1-19

ISSN (Print): 3058-3535
ISSN (Online): 3058-6518
DOI: https://doi.org/10.63768/jdieg.v2i1.001

Fiscal Decentralization, Fiscal Environmental Protect Expenditures and Social Welfare Unbalance Development: An Empirical Study in China

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Abstract: Based on the panel data of 30 provinces in China from 2007 to 2017 and the theory of feasible ability, this paper uses the principal component method to measure the social welfare level at the provincial level in China, and observes its spatial distribution by Moran index and spatial panel. The paper analyzes the influence of financial decentralization, environmental decentralization, and local environmental protection fiscal expenditure on the social welfare level by using system GMM and differential GMM and through threshold model analysis the threshold effect of decentralization on the social welfare level by threshold model analysis. The results show that: The social welfare level in China presents the characteristics of spatial aggregation, and the imbalance still exists. Fiscal decentralization, environmental fiscal expenditure, and technological innovation have significantly improved the social welfare level, while environmental decentralization weakens the level of social welfare, and there is an inverse curve characteristic between environmental fiscal expenditure and foreign investment projects. Therefore, we need to optimize the structure of fiscal expenditure, improve the performance of fiscal expenditure, and improve the incentive mechanism of environmental fiscal expenditure. According to the concept of green development, the Pareto improvement of economic and non-economic welfare can be realized in different regions.

Keywords: environmental fiscal expenditure; social welfare; decentralization

[*] Fund: This research was supported by General Project of National Social Science Fund of China (20BJY194), Young and Middle aged Academic Leaders' Funding Project for the "Qinglan Project" in Jiangsu Universities, Talent Introduction and Research Start up Fund Project in Nanjing Institute of Technology (YKJ202328), Central Financial Support for Local University Reform and Development Special Fund Project in Nanjing Institute of Technology, Key Project for High Level Humanities and Social Sciences Research Achievement Award Cultivation Special Project in Nanjing Institute of Technology in 2023 (CGJPYA02) & Research Funding Project after Obtaining a Doctoral Degree While Working at Nanjing Institute of Technology Research Fund (ZKJ202303).
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Received 20 November 2024, Revised 20 December 2024, Accepted 20 January 2025

1 Introduction

Global climate change and pollution are forcing people to find new ways to achieve sustainable development. In 2004, the UN published the first report of the "Millennium Ecosystem Assessment" (MA/MEA) project "Ecosystems and Human Well-being: An Assessment Framework" (Reid, 2005). The core question of this project is the relationship between ecosystems and human well-being. Zhu and Zhang discussed the performance of ecological welfare (Daly, 1974) from the perspective of promoting economic growth and deepening sustainable development (Zhu & Zhang, 2014a; Zhu & Zhang, 2014b).

Over the past 40 years, China's urbanisation and industrialization have progressed rapidly. At the same time, this intensive economic development has caused serious environmental pollution. Water and air pollution have seriously affected people's quality of life and the reformulation of sustainable regional development. As the foundation and important pillar of modern national governance, fiscal policy be integrated into various fields such as politics, economy, culture, social governance, and ecological civilization within the framework of modern national governance. The basic function of the government and its finances is to provide equal public services to citizens and correct externalities. Among them, ecological environmental protection is an important responsibility of the government and its finances, and environmental protection is important to promote the construction of major functional areas and the equalization of basic public services (López, Galinato, & Islam, 2011). The improvement of the ecological environment reflects the level of social welfare that best reflects the requirements for harmony between man and nature (Chaigneau et al., 2022). The state also needs to coordinate the financial investment of the ecological environment to meet the needs for different regions and different classes to gradually enjoy basically equal public services.

Before China adopted the most stringent environmental protection policies, local governments support focused on economic growth. Fiscal decentralization and fiscal expenditure structure did not improve the ecological environment but worsened its quality. Under the "five-in-one" overall layout and the requirements of ecological civilization construction, governments at all levels attach importance to green development, clarify the central and local powers and expenditure responsibilities in the ecological environment, and provide strict environmental regulations and measures to significantly improve the quality of the ecological environment. effect. This article compares the impact of environmental regulation and fiscal decentralization on the welfare of social residents from the perspective of welfare economics, useing the SEN welfare index to measure the level of social welfare, and uses Moran's I to observe the temporal and spatial changes of the social welfare index. Development and welfare in the region from the perspective of improvement, it also examines the governance path and policy direction of green sustainable development from the perspective of fiscal decentralization and environmental decentralization, broaden the fiscal perspective of the ecological environment, and enhance the pertinence and feasibility of policy recommendations.

The remainder of this study is organized as follows. Section 2 presents the literature review and hypothesis development. Section 3 gives the measurement of the social welfare levels, Sections 4 and 5 present the empirical strategy and data, and the results, respectively. Section 6 discusses the results and provides policy implications.

2 Literature Review and Hypothesis Development

2.1 Environment and Social Welfare

Development policy or public policy priority is normative, it is the behavior of serving the people and the whole society through the rational operation of public policy and the system of ensuring social fairness and justice. Economic growth is not the only objective of government. If economic growth is achieved at the expense of the ecological environment and excessive consumption of natural resources as the cost, such growth is "uneconomic growth" . Improving the level of social welfare is not limited to macroeconomic growth and increasing the consumption level of population. It should be built in accordance with a system of governance that focuses on the role of the government and enhances the

people's self-reliance, is people-oriented and takes the people as the basic consideration.

The basic purpose of the government is to provide welfare for the people and improve their livelihood and well-being for the purpose of development. Welfare, well-being and happiness is one of the core issues of economic and social development in the world today. The concepts of well-being include such as quality of life, welfare, good life, the standard of living, life satisfaction, prosperity, progress, needs satisfaction, human poverty, development, empowerment, capacity building, etc. Happiness has been used in relation to well-being without a clear distinction (Binh An et al., 2023). Although the concepts of Welfare and Well-Being have yet to reach a consensus among scholars of different disciplines, this does not prevent them from being a development goal pursued by governments of different countries.

An early study of the economics of happiness is by Easterlin (Easterlin, 1974). Later contributions examine the relationship between income distribution and self-rated happiness (Morawetz et al., 1977) and between unemployment and happiness (Clark & Oswald, 1994; Clark & Oswald, 1996; Winkelmann & Winkelmann, 1998). Although there is a substantial literature on the economics of happiness, applications to environmental economics are rare, although studies have examined the effect of airport noise on subjective well-being (Van Praag & Baarsma, 2005), and others have examined the relationship between climate and happiness (Rehdanz & Maddison, 2005). The link between air pollution and happiness has been examined (Pan, 2023; Welsch, 2006; Levinson, 2012; Yerema & Managi, 2021).

As a public good, the non-exclusive and non-competitive nature of the environment makes it difficult for market allocation to work. The "tragedy of the public land" is most likely to occur in the ecological system. Because the market is difficult to constrain, government intervention is inevitable. For governments, this mean moving towards a decentralized fiscal system in order to improve the efficiency of providing environmentally friendly public goods because local governments can better satisfy residents' demands for such public goods (Carley & Konisky, 2020).

Hypothesis 1 (H1). Fiscal expenditure on environmental protection is conducive to the improvement of social welfare.

2.2 Fiscal Policy and Social Welfare

From the ethical perspective of economic welfare, fiscal public expenditure on environmental protection and the government's regulatory policies on environmental protection are in line with the people's needs for a better life. This development policy that enhances people's capabilities and a public policy that protects people's freedom.

Firstly, an increase in fiscal spending on environmental protection may stimulate the environmental improvement and positively impact social welfare. Greiner (2005), Gupta and Barman (2010) constructed an endogenous growth model incorporating public capital and pollution based on government expenditure (Greiner, 2005; Gupta & Barman, 2010), demonstrating that environmental enhancement leads to increased efficiency in public expenditure. Increase in fiscal expenditures for environmental protection, when coupled with adjustments to the structure of fiscal expenditures, have been demonstrated to be effective in reducing pollution, both in theory and in practice. Some studies have indicated that government public expenditures have external effects on production activities and that there is a positive correlation with pollutant emissions (Murshed et al., 2022; Galinato & Galinato, 2016). Conversely, other studies identified a negative correlation between government public expenditures and environmental pollution (Lin et al., 2012; López & Palacios, 2014; Islam & López, 2013). Ueshina(2018) discusses the impact of government debt and public expenditure on welfare from the endogenous growth theory perspective, concluding that, under the requirement of a long-term balanced budget, to repay debts, the tax rate will increase faster than the level of social welfare.

Secondly, fiscal decentralization is detrimental to the enhancement of environmental quality. In the initial stages of economic development in China, local governments placed a higher priority on achieving economic growth at the expense of environmental protection, resulting in the dissemination of detrimental externalities across different regions (Sun, Gao, & Razzaq, 2023). Local governments, operating within a principal-agent model, are incentivised to prioritise their own interests over those of the larger collective. Consequently, political centralization serves to moderate the competitive impulse engendered by economic decentralization, thereby ensuring a balanced and effective governance framework. The outcome is a fiscal and taxation system that, while decentralized in form, is ultimately subject to the central government's reform intentions.

This dynamic is inherently predetermined to perpetuate a comprehensive deepening of the reform process, characterised by a top-down implementation. The central government assumes the cost of inclusive growth and is also responsible for the direction of reform. A notable shifted in government objectives has been observed, with the original single-focus on economic growth being replaced by a more diversified set of goals, including ecological civilization, people's well-being, and national governance (Zhao, Wang, & Xu, 2023).

The theoretical underpinnings of fiscal decentralization and environmental expenditure and their correlation with welfare are also noteworthy. According to first-generation fiscal federalism (FGFF), fiscal decentralization is conducive to the improvement of environmental quality. The classical theory posits that public decision-makers are benevolent maximisers of social welfare, and that public goods and services are provided uniformly (Renko et al., 2022; Digdowiseiso, 2022). Consequently, fiscal decentralization is hypothesised to enhance the delivery of public good and service, thereby contributing to environmental quality. However, second-generation fiscal federalism (SGFF) is predicated on the assumption that public officials' goals are induced by political institutions that often diverge from maximizing citizen welfare (Qian & Weingast, 1997; Garzarelli, 2004; Oates, 2005).

Recognizing the influence fiscal decentralization on economic growth, it can be hypothesised that there is an implicit effect on environmental sustainability. Investigators have stated that there is an interconnection between economic development and environmental degradation. The reasonable division of central and local powers and management in ecological and environmental protection is identified as a contributing factor to green development (Li & Zhou, 2019; Li & Zong, 2021). Other scholars have adopted a threshold model from the perspective of environmental regulation and environmental decentralization and fiscal decentralization to obtain an inverted U-shaped relationship between China's environmental protection and economic growth (Zheng, Fu, & Liu, 2020).

Hypothesis 2 (H2). Fiscal decentralization is conducive to the improvement of social welfare.

2.3 The effect of Environmental Decentralization and Social Welfare

The concept of environmental decentralization can be defined as the division of environmental protection responsibilities between the central and local governments. Additionally, there is a presence of competition among local governments in the context of environmental assessment (Sigman, 2007). The impetus for this competition emanates from two sources: firstly, from top-down performance assessment requirements, and secondly, from the parallel intergovernmental policy implementation degree of sticky pressure. As the emphasis on ecological and environmental issues has gradually intensified, the level of environmental decentralization has increased concomitantly, thereby conferring greater powers upon local governments have greater powers in the formulation of regional environmental protection policies and have a promoting role in improving the regional environment.

However, within the governance model of political centralization and fiscal decentralization in China, the scale of local government is determined by transfer payments and local fiscal revenues, resulting in a divergent focus on performance evaluation. The local environmental protection department is subject to the oversight of both of the higher-level environmental protection department and the leadership of the local government. While the department's autonomy is constrained, its administrative nature is relatively pronounced. While the budget for environmental protection departments has increased, so too has the budget for administrative expenditures. A notable shift in expenditure has been observed, with greater emphasis on wage costs and associated areas. In the context of stringent environmental control policies, the output of high-polluting and high-energy-consuming enterprises is subject to restrictions or relocation to other regions. The spatial transfer of environment problems has resulted in uneven development of local welfare.

Hypothesis 3 (H3). Environmental revenue decentralization does not improve the social welfare.

3 Measurement of the Level of Social Welfare

3.1 SEN Welfare Index Based on Capability Theory

The field of traditional welfare economics employs utility functions to quantify social welfare, correlating income and consumption with personal welfare, and utilizing economic growth data to assess social welfare. GDP or expanded value based on GDP is commonly employed as an indicator. However, as the concept of social welfare has deepened and its scope expanded, it has become challenging for GDP to adapt to the content of measuring social welfare. Sen's critically reconstruction of traditional welfare economics has sought to address these limitations. According to Sen, the evaluation of welfare should be based on people's feelings of happiness or fulfillment of desires or requirements for primary commodities. Sen's contributions lie in the realm of theoretical innovation, with the formulation of "capability theory" and "partial ordinal theory" being a testament to this. The crux of Sen's capability theory lies in the premise that individuals, in their pursuit of cherished life freedoms, possess the capacity to adopt actions that are valuable to them and thereby attain a valuable state in life (Sen & Nussbaum, 1993). The investigation has been initiated in the domains of housing, health, education, social, psychological, and labor. The measurement of personal or social welfare indices in aspects such as dynamics and family economics has been undertaken, and the model has been utilized to synthesize welfare indices (Martinetti, 2000; Balestrino & Sciclone, 2001; Robeyns, 2003; Bérenger & Verdier Chouchane, 2007). The present study will utilize the PCA method to obtain the measurement value of China's social welfare level, which will then be used to represent the social welfare level.

The index selection process is outlined as follows.

1.Economic factors: Economic conditions are considered a significant factor influencing the level of welfare. In accordance with Wagner's law, economic growth is expected to augment the demand for the environmental quality, health, education, and other such amenities. As a basic factor, this article intends to use three indicators of per capita GDP, average wages and per capita urban disposable income.

2.Economic structure: The structure of economy can be reflected by the composition and structure of a country's nation's economy. The present study has selected industrial structure ratio, per capita energy consumption, and fiscal technology expenditure ratio to reflect the industrial changes undergone by the country in the process of economic transformation. The economic factors under scrutiny are intended to mirror the functional freedom of SEN's feasible capability theory, while the economic structure is intended to mirror the freedom of capability.

3.Living factors: These factors are deemed crucial in gauging the basic living security of the populace. In the context of the shifts in the prevailing contradictions within society, the concept of "backward social production" has evolved into "unbalanced and inadequate development", and the increasing "material and cultural needs" of the populace have transformed into "desires for an enhanced quality of life", impacting both on the demand sides. These transitions have precipitated a fundamental shift in the nature of the prevailing contradiction. Measured from the level of demand or from the scope of demand, the urban-rural duality, basic living consumption, and basic public provision continue to be significant factors influencing residents' psychological well-being perception. The basic national conditions that prevailed in the initial stage of socialism have remained unaltered. The selection of an indicator is imperative for a comprehensive analysis.

4.Social protection: Social protection can be defined as the promotion of social policy concepts and a comprehensive manifestation of responding to social risks. Social protection can be regarded as a broader extension of social security. The World Bank's concept of social protection is very broad, covering the accessibility of macro policies, public governance, and good governance to the people's livelihood. According to China's current states, following the establishment of a moderately prosperous society in a comprehensive manner, we are confronted with the challenges of relative poverty and the accelerated aging of the population. Considering these challenges, this paper has selected health, social security, unemployment, and food security as key indicators.

5.Education level: Education is reflective of a nation's developmental potential and a pivotal element in the pursuit of sustainable growth. It is a fundamental right and a basic welfare enjoyed by citizens. Ensuring the efficacy of education, enhancing its quality, and raising overall level of education are pivotal in nurturing a robust talent base and fostering social welfare. Consequently, the text has indicators in accordance with most documents.

6.Environmental factors: The environment is indicative of the relationship between humans and nature through labor

practices. The expanding of human demand for economic growth, coupled with the limited capacity of natural of demand, is a matter of increasing concern. In the modernization process of various countries, the suppression of environmental pollution and the requirements for green development in economic development have become the focus of national governance in the modernization process of various countries, and have become the path support for sustainable development. This paper selects the main environmental variables from a large number of literatures as welfare measurement indicators.

All data sources cite from "China Statistical Yearbook", "Fiscal Statistical Yearbook", "Environmental Yearbook", "Health Statistical Yearbook", and "China Regional Statistical Yearbook".

Table 1. Social Welfare Level Measurement Index

Project	Index
Economic factors	GDP per (+), average Wage (+), Urban disposable income per (+)
Economic structure	Primary industry ratio(+), Secondary industry ratio (+), Tertiary industry ratio (+), Energy consumption per (-), Technology expenditure ratio(+)
Life factors	Urban-rural consumption expenditure ratio(+), Road per(+), Water per(+), Mobile phone(+), Price of house(-), City drainage pipe length(+), Urban and rural affairs financial expenditure ratio(+)
Social protect	Number of beds per thousand(+), Number of health per 10,000 people(+), Unemployment rate(-), food possession per(+), Number of people participating in medical insurance/old-age insurance(-)
Education level	Primary school teacher-student ratio(+), Junior high school teacher ratio(+), Books per(+), Proportion of 15-year-old illiterate and semi-illiterate(-), Education investment per(+), education fiscal expenditure ratio(+)
Environment factors	Industrial wastewater discharge(-), SO_2 discharge(-),Hazardous waste discharge(-)、Per garbage disposal rate(+),green space per(+)

Notes: (+) Indicate positive indicators, (-) Indicate negative indicators.

3.2 SEN Welfare Index Measurement

The present study utilizes data of 30 provinces and cities in China, with the exclusion of Tibet, Hong Kong, Macau and Taiwan due to the presence of excessive omissions. The original data is subjected to dimensionless standardized through the implementation of the range method. The standardize of the original pollutant data is achieved through the following procedure:

$$K_{ij}'' = \frac{Z_{ij} - \min(Z_{ij})}{\max(v) - \min(Z_{ij})} \tag{1}$$

Where Z_{ij} represent the value of pollutant indicator j of province i, $i \in [1, n]$, and $j \in [1, m]$.

The index variables are extracted by means of PCA, and the coefficients are calculated by the rotation matrix to obtain the original solution value. The KMO (means>0.6, P=0.000), indicating that it is suitable for principal component analysis. The transfer normalization process is carried out to obtain the measured value of the SEN welfare level index.

As demonstrated in Table 2, the levels welfare across different provinces exhibits significant variations within the same year, with the index demonstrating irregular fluctuations. A horizontal comparison between regions reveals that the eastern coastal areas exhibit significantly higher welfare level measurement index compared to other regions within the country. The Yangtze River Delta, the Pearl River Delta and the Beijing-Tianjin region have consistently maintained a relatively high level of welfare. The longitudinal comparison of years reveals that the index changes in various regions are irregular and do not show a linear trend. The changes in welfare levels in the central and western regions have a tendency converge, which is also related to the selection of indicators.

The coastal regions have emerged as leaders in economic development, capital accumulation, human capital development, and technological innovation, a phenomenon attributable to their advantageous geographical positioning, the implementation of preferential policies, and the opening of modern history. The utilization of local financial resources, which are relatively abundant in coastal regions, facilitates a symbiotic relationship between expenditures on public services, environmental protection, and pollution control, and investments in economic development. Consequently, economic development and social welfare are optimized, ensuring the maintenance of a high level of social welfare. Despite maintenance of a consistent economic growth in the central region, there has been a conspicuous absence of substantial growth in social welfare in recent years. The

primary factor contributing to this phenomenon is the substantial and rapid escalation in investment in human livelihoods, which has not been accompanied by effective adjustments in the scale and structure of investment. Consequently, the industries in the central region are undergoing a period of adjustment in the transition to green and sustainable development, due to the limitations in capital accumulation, human capital and technological innovation and other factors. This has resulted in a gradual improvement in the welfare index. The western region is a key area for transfer payments, and the requirements for industrial development take priority over the development of people's livelihoods. The foundation of these elements remains fragile. The accumulation of capital accumulation, human capital and technological innovation in the region are contingent on the support of the central government and the transfer of resources from eastern and central regions. The relationship is still in the stage of straightening out the relationship, so there is a partial decline in the welfare index.

Table 2. 2007-2017 SEN Welfare Measurement Index by Province

Province	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Beijing	0.560	0.821	0.674	0.625	0.764	0.769	0.388	0.915	0.805	0.709	0.820
Tianjin	0.399	0.562	0.524	0.417	0.371	0.419	0.396	0.294	0.514	0.558	0.479
Hebei	0.239	0.203	0.275	0.276	0.417	0.269	0.380	0.348	0.212	0.318	0.244
Shanxi	0.224	0.256	0.249	0.262	0.379	0.219	0.337	0.340	0.180	0.145	0.185
Nei menggol	0.097	0.253	0.251	0.308	0.417	0.313	0.371	0.424	0.349	0.340	0.289
Liaoning	0.265	0.273	0.406	0.463	0.495	0.364	0.425	0.512	0.405	0.315	0.298
Jilin	0.073	0.090	0.130	0.196	0.119	0.169	0.262	0.221	0.261	0.260	0.217
Heilongjiang	0.113	0.082	0.138	0.219	0.134	0.140	0.220	0.274	0.197	0.174	0.139
Shanghai	0.675	0.779	0.917	0.918	0.746	0.658	0.529	0.689	0.777	0.836	0.709
Jiangsu	0.600	0.456	0.565	0.491	0.419	0.572	0.447	0.498	0.583	0.533	0.595
Zhejiang	0.665	0.527	0.593	0.456	0.491	0.555	0.453	0.479	0.565	0.570	0.624
Anhui	0.272	0.257	0.240	0.230	0.215	0.281	0.321	0.177	0.250	0.284	0.278
Fujian	0.400	0.294	0.337	0.246	0.259	0.322	0.353	0.253	0.349	0.406	0.392
Jiangxi	0.267	0.197	0.246	0.192	0.152	0.217	0.281	0.143	0.171	0.228	0.220
Shandong	0.427	0.356	0.469	0.414	0.506	0.468	0.432	0.497	0.419	0.426	0.440
Henan	0.386	0.296	0.299	0.274	0.381	0.243	0.343	0.278	0.161	0.152	0.218
Hubei	0.247	0.177	0.258	0.318	0.254	0.300	0.315	0.304	0.341	0.270	0.331
Hunan	0.237	0.218	0.279	0.303	0.212	0.243	0.305	0.223	0.272	0.292	0.235
Guangdong	0.765	0.561	0.549	0.493	0.658	0.631	0.450	0.502	0.476	0.493	0.565
Guangxi	0.371	0.321	0.350	0.258	0.199	0.266	0.275	0.156	0.227	0.222	0.271
Hainan	0.139	0.128	0.184	0.102	0.021	0.201	0.128	0.223	0.252	0.233	0.265
Chongqing	0.337	0.300	0.340	0.325	0.411	0.420	0.338	0.343	0.322	0.368	0.320
Sichuan	0.339	0.216	0.351	0.370	0.309	0.296	0.349	0.308	0.340	0.354	0.311
Guizhou	0.389	0.487	0.201	0.250	0.355	0.261	0.272	0.263	0.185	0.209	0.233
Yunnan	0.262	0.347	0.179	0.192	0.244	0.159	0.276	0.204	0.167	0.169	0.174
Shaanxi	0.288	0.291	0.222	0.422	0.249	0.237	0.277	0.222	0.231	0.200	0.251
Gansu	0.237	0.304	0.090	0.189	0.155	0.171	0.201	0.197	0.103	0.067	0.104
Qinghai	0.231	0.334	0.256	0.135	0.201	0.272	0.317	0.186	0.287	0.267	0.235
Ningxia	0.324	0.374	0.224	0.293	0.317	0.365	0.328	0.232	0.340	0.416	0.330
Xinjiang	0.172	0.239	0.202	0.364	0.153	0.201	0.232	0.293	0.259	0.187	0.227

3.3 Spatial Clustering Trends of Social Welfare Levels

Figures 1 provides a preliminary evaluation. As time progresses, the equalization effect of public policies becomes evident, with the imbalance between regions in the country being alleviated. furthermore, the level of social welfare among regions exhibits a spatial agglomeration effect.

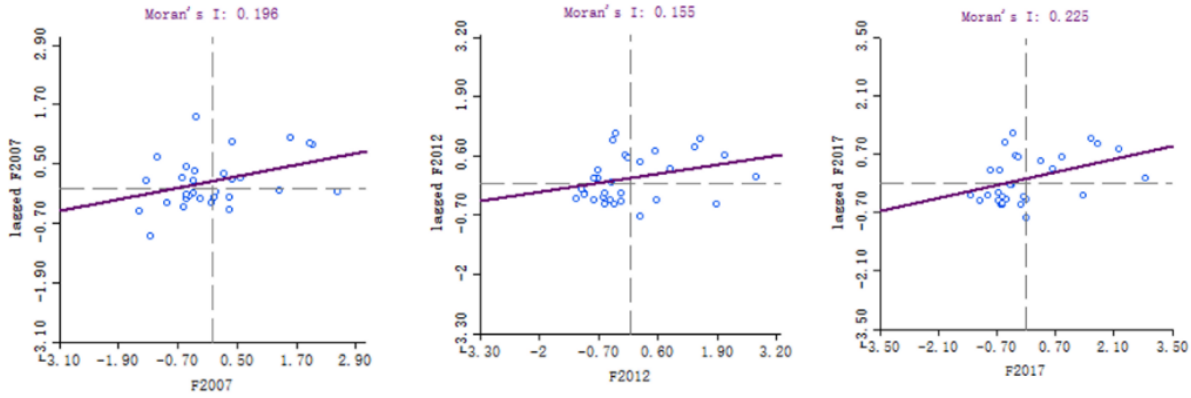
As demonstrated in Table 3, Moran's Index of spatial autocorrelation reveals statistically significant positive spatial clustering in provincial social welfare levels across China. The persistent significance ($P<0.05$ throughout 2007-2017) confirms strong spatial interdependence, indicating that high-welfare provinces tend to cluster with neighboring high-welfare regions (HH clusters), while low-welfare areas form spatially contiguous LL clusters.

Table3. Spatial Geographic Weight Matrix Moran Index

Year	Moran's I	Sd	Z-value	P-value
2007	0.1963***	0.0939	2.4559	0.01
2008	0.0378***	0.0892	0.8028	0.01
2009	0.2399***	0.0997	2.6955	0.01
2010	0.0651***	0.1077	0.9272	0.02
2011	0.1261***	0.0981	1.7016	0.01
2012	0.1552***	0.0972	1.9793	0.05
2013	0.2823***	0.1095	2.9458	0.01
2014	0.1640***	0.1037	1.9518	0.02
2015	0.1825***	0.1065	2.0857	0.01
2016	0.2677***	0.1077	2.7984	0.01
2017	0.2249***	0.0987	2.6134	0.01

Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

The enhancement of the level of social welfare is inextricably linked to the equalization of public provision by the government, and the spillover of the provision of public goods also promotes the regional balance of the level of social welfare in the spatial expression of the level of social welfare. A visual representation of the distribution of social welfare levels in 2007 is provided in Figure 1, which utilizes a scatter plot analysis of Moran's index, the distribution of social welfare levels was relatively dispersed. However, in 2012, there was a shift in the distribution, with low-welfare areas moving closer to the center and the sparse first-quadrant high-welfare areas in the first quadrant also showing an increasing trend. This shift indicates a greater degree of balance in the levels of social welfare across regions, with an increase in the number of regions falling within the high welfare quadrant.



Figures 1. 2007, 2012, 2017 Social Welfare Moran's Index Scatter Plot

According to Sen's capability approach, which encompasses both function and ability, welfare is a "set" rather than a single-dimensional variable, incorporating a multitude of economic, social, environmental and other factors. The government's financial expenditure and control of the ecological environment can be regarded as a component of social welfare. Local government are thus empowered to formulate tailored environmental protection policies, considering the diverse environmental preferences of residents and the prevailing environmental governance dynamics within their respective jurisdictions. This approach is designed to enhance environmental quality and, by extension, the overall of social welfare. It is important to acknowledge that during in the initial phase of redressing imbalanced development, the growth rate of administrative expenditures for environmental protection departments will surpass that of pollution control expenditures. Consequently, environmental governance regulations may not elicit the anticipated response from local governments in the initial stage. This will result in a shift in the structure of environmental protection fiscal expenditures towards the administrative level. Conversely, an emphasis management may impede progress in enhancing welfare.

4 Model setting and data description

4.1 Model Setting

There are multiple factors affecting the level of social welfare. Firstly, a benchmark model is established to test the impact of environmental fiscal expenditure, fiscal decentralization and environmental governance decentralization on social welfare effects. (*SENindex*) is the explained variables use the SEN welfare index.

$$senindex_{i,j} = \alpha + \beta_1 X_{i,t}^{j} + \beta_2 j_{i,t} + \sigma_{i,t} + \lambda_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where i represents the province, t denotes time, $X_{i,t}^{j}$ is the Core explanatory variables. $j_{i,t}$ represents other control variables, $\sigma_{i,t}$ represents time effect, $\lambda_{i,t}$ represents regional effect and $\varepsilon_{i,t}$ is a random error term.

Secondly, the first-order lag term of the explained variable is to be employed in order to establish the system GMM and differential GMM models.

$$senindex_{i,j} = \alpha + \beta_1 senindex_{i,j} + \beta_2 X_{i,t}^{j} + \beta_3 j_{i,t} + \sigma_{i,t} + \lambda_{i,t} + \varepsilon_{i,t} \quad (3)$$

Finally, to address the inherent limitations of conventional regression approaches in capturing cross-jurisdictional spillover effects, we employ spatial econometric analysis to formally test interprovincial welfare interdependence. This article uses the spatial autoregressive model (SAR), the spatial error model (SEM) and the spatial Dubin model (SDM). The SDM model is the most widely used, and its model is as follows:

$$senindex_{i,j} = \delta W senindex_{i,j} + \alpha I_N + \beta X_{i,t} j_{i,t} + \nu W X_{i,t} + \mu + \zeta_t I_N + \varepsilon_{i,t} \quad (4)$$

Among them, W is the geographical adjacency matrix, ν, δ are the endogenous and exogenous interaction coefficients. If the exogenous interaction effects are ignored, the model changes to SAR.

$$senindex_{i,j} = \delta W senindex_{i,j} + \alpha I_N + \beta X_{i,t} j_{i,t} + \mu + \zeta_t I_N + \varepsilon_{i,t} \quad (5)$$

If endogenous interaction effects are not considered, the model changes to SEM.

$$senindex_{i,j} = \alpha I_N + \beta X_{i,t} j_{i,t} + \nu W X_{i,t} + \mu + \zeta_t I_N + \varepsilon_{i,t} \quad (6)$$

In empirical research, which model is most suitable should be selected through methods such as LR test. And it is also necessary to use Hausman's test to choose between fixed effects and random effects.

4.2 Variable Selection

4.2.1 Core Explanatory Variables

Three theoretically-grounded indicators were operationalized to explicate social welfare determinants: per capita environmental governance fiscal expenditure (*Pen*), fiscal decentralization index (*Fis*), and environmental governance decentralization index (*Wageenfi*).

1.per capita environmental governance fiscal expenditure (*Pen*): Per capita fiscal expenditure for environmental in areas with greater population density is expected to have a significant impact on residents' social life and environmental pollution, which in turn will affect each other. Therefore, the per capita fiscal expenditure on environmental governance is selected as the explanatory variable for the government's environmental public policy on social welfare. The factors influence the level.

2.Fiscal decentralization index (*Fis*): It is acknowledged that there are numerous calculation methods for the selection of fiscal decentralization index. This article adopts the ratio of provincial fiscal revenue per capita budget to fiscal expenditure per capita as the fiscal decentralization index to elucidates the capacity of local governments to assume public policy expenditure responsibilities.

3.Environmental decentralization index (*Wageenfi*): Environmental decentralization signifies the distribution of environmental governance powers and expenditure responsibilities across various levels of government in accordance with the principles of decentralization. The dynamic changes in the scale of the environmental protection system and the number of personnel to measure environmental decentralization (Qi, Lu, & Xu, 2014). this paper chooses to use the dynamic change of the average salary of environmental protection personnel to describe environmental decentralization. Compared with environmental law enforcement and monitoring indicators, which can reflect the structural problem of environmental fiscal

expenditure from another perspective. The specific calculation formula is:

$$wageenfi_{i,t} = \left[\frac{Lwage_{i,t}/wage_{i,t}}{Nwage_t/wage_t}\right] \times \left[1 - GDP_{i,t}/GDP_t\right] \quad (7)$$

Among them, $wageenfi_{i,t}$ is the decentralization of environmental income, $Lwage_{i,t}$, $wage_{i,t}$ and $GDP_{i,t}$ represent the annual average wages of environmental protection personnel, the average wages of state-owned enterprises and the GDP in the province. $Nwage_t$, $wage_t$ and GDP_t, are the annual national average wages of environmental personnel, the national average wages of state-owned enterprises and GDP.

4.2.2 Control Variables

Based on the extant literature and considerations pertaining to robustness, this paper selects the following factors that exert an influence on the level of social welfare and the ecological environment.

1.Consumption factors. Per capita consumption (*Pcom*) is utilized as a metric to gauge the impact of economic factors on the social welfare level index. The total amount of local social retail goods per capita is employed to reflect the current direct consumption capacity.

2.Technical factors. The number of patents granted per thousand people (*Tec*) is used as an indicator to measure technical factors.

3.Investment factors. The promotion effect of investment on the economy in considered, and three factors are considered: (1) foreign direct investment ratio (*Fdi*), (2) environmental investment ratio (*Engdp*) and (3) residential investment ratio (*Fi*).

The existing literature suggests that the foreign direct investment (FDI) ratio is measured as the ratio of RMB-denominated FDI converted into RMB at the current exchange rate to local GDP. The environmental investment ratio (*Engdp*) is measured according to the ratio of local environmental pollution control investment to the local GDP. The proportion of residential investment (*Fi*) is measured by the proportion of local residential investment in the total investment expenditure of the local society.

4.Institutional factors: The primary consideration is the government's capacity and pressure to implement public policies, with the tax burden index (*Taxgdp*) and fiscal expenditure index (*Fegdp*) serving to reflect the impact of public policies on the level of social welfare. The tax burden index (*Taxgdp*) is measured by the ratio of local tax revenue to local GDP, and the fiscal expenditure index (*Fegdp*) is measured by the ratio of total local fiscal expenditure to local GDP.

5 Empirical Results and Discussion

5.1 Empirical Results

5.1.1 Model Specification and Validation

The empirical analysis commenced with establishing a benchmark panel model, followed by conducting the Hausman test (χ^2 =15.32, p<0.01) to determine the appropriateness of fixed effects specification. Three-tiered modeling strategies were employed: Model 1 examined baseline relationships between social welfare (*SENindex*) and key predictors (environmental fiscal expenditure, fiscal decentralization, and environmental regulation). Models 2 and 3 progressively incorporated provincial fixed effects and time-fixed effects to control for spatial heterogeneity and temporal trends.

To address potential intertemporal dynamics, we implemented dynamic panel data modeling using both system GMM (Model 4) and difference GMM (Model 5) estimators with first-order lagged dependent variables. Diagnostic tests confirmed model validity: Sargan tests (p=0.004 for SYS-GMM; p=0.001 for DIF-GMM) indicated no over-identification issues, while Arellano-Bond AR(2) tests (p=0.539 and 0.115 respectively) confirmed the absence of second-order serial correlation. These results collectively demonstrate the estimators' effectiveness in addressing endogeneity concerns and dynamic panel biases.

5.1.2 Static Panel Analysis

As Table 4 demonstrates, fiscal decentralization (*Fis*) exhibited significant positive associations with social welfare across all static models (β=0.414, p<0.05 in Model 2), supporting **Hypothesis 2**. This suggests that enhanced fiscal autonomy enables

local governments are no longer obsessed with GDP growth, and are instead paying more attention to people's well-being., aligning with China's high-quality development agenda. Environmental fiscal expenditure per capita (*Pen*) demonstrated robust welfare enhancing effects ($\beta = 1.704$, $p < 0.01$ in Model 3), validating **Hypothesis 1**. This reflects the institutionalization of ecological governance expenditures under China's "Ecological Civilization" framework, where sustained investments in environmental protection generate positive spillovers to public service provision.

Contrary to expectations, environmental decentralization (*Wageenfi*) displayed significant negative coefficients (β=-0.043, $p<0.05$ in Model 2), which became statistically insignificant after controlling for time effects. Supplementary analysis of departmental expenditure patterns revealed that environmental agencies' wage growth substantially outpaced both SOE average wage growth and environmental governance expenditure growth during 2007-2017. This misalignment of fiscal priorities implies that excessive administrative costs may crowd out substantive environmental investments, thereby attenuating potential welfare gains, a finding consistent with **Hypothesis 3**.

Table 4. Panel Model Regression Results

Explanatory variables		Static panel		Dynamic panel	
	Model 1	Model 2	Model 3	Model 4	Model 5
	nonF	AF	TF	S-GMM	D-GMM
L.senindex	-	-	-	0.481*	0.348**
				(0.247)	(0.134)
Fis	0.298**	0.454**	0.447**	0.316***	-0.375
	(0.129)	(0.179)	(0.199)	(0.121)	(0.329)
Wageenfi	-0.025**	-0.043**	-0.049	-0.032*	-0.032
	(0.012)	(0.018)	(0.045)	(0.018)	(0.020)
Pen	1.024***	1.107***	1.704***	0.660	-1.129
	(0.201)	(0.394)	(0.407)	(0.826)	(1.159)
Pcom	-	0.042**	0.143***	0.011	0.002
		(0.017)	(0.034)	(0.033)	(0.031)
Tec	-	-0.842*	-1.885***	-0.550	-1.226
		(0.426)	(0.453)	(1.095)	(1.447)
Fdi	-	0.004	0.003	0.009	0.026**
		(0.004)	(0.006)	(0.007)	(0.010)
Fi	-	0.068	-0.093	-0.020	0.023
		(0.235)	(0.211)	(0.314)	(0.538)
Engdp	-	0.005	0.007	0.011	0.075*
		(0.011)	(0.011)	(0.024)	(0.043)
Fegdp	-	0.087	0.021	-0.595	0.257
		(0.759)	(0.931)	(1.150)	(1.341)
Taxgdp	-	-1.120	-0.243	0.796	2.525
		(1.307)	(1.388)	(2.155)	(2.533)
_cons	0.164**	0.092	-0.003*	0.018*	
	(0.069)	(0.104)	(0.112)	(0.123)	
R-squared	0.044	0.069	0.132	-	-
Regional fixed	-	Yes	Yes	-	-
Time fixed	-	-	Yes	-	-
AR(1)P V	-	-	-	0.066	0.001
AR(2)P V	-	-	-	0.539	0.115
Hansen P V	-	-	-	0.903	0.276
Sargan P V	-	-	-	0.004	0.001

Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

5.1.3 Dynamic Panel Insights

The dynamic models revealed significant persistence in welfare outcomes, with lagged *SENindex* coefficients of 0.481 (SYS-GMM) and 0.348 (DIF-GMM), suggesting path-dependent welfare accumulation. This "inertia effect" aligns with the

observed spatial autocorrelation patterns (Moran's, $p < 0.05$). Notably, while SYS-GMM confirmed fiscal decentralization's enduring significance (β=-0.316, $p<0.01$), DIF-GMM estimates highlighted the predominant role of foreign direct investment (β=-0.317) and environmental governance investment ($\beta = 0.182$). This divergence underscores the importance of model robustness checks and suggests that fiscal decentralization effects may operate through longer-term institutional channels rather than immediate investment mechanisms.

5.1.4 Policy Implications

The system GMM and differential GMM dynamic panel models are established using the lagging first-order term of the social welfare index (*SENindex*). The results carry three key policy implications: (1) Fiscal recentralization-redistribution mechanisms could optimize environmental expenditure efficiency, and (2) Performance evaluation systems should de-emphasize administrative cost metrics in environmental governance, (3) Intergovernmental transfer systems need strengthening to prevent subnational fiscal distortions.

5.2 Regional Heterogeneity Test of Social Welfare Effects

In consideration of the long-term objective disparities amongst China's regions, in conjunction with the disparate economic development and income levels among regions, local governments are endowed with a certain degree of capacity to orchestrate the harmonization of environmental protection and economic development. The present study employs a regional grouping perspective, this paper to examine the distribution trend of Moran's index and the impact mechanism of regional heterogeneity. The regression results are presented in Table 5.

Table 5. Regional division and spatial panel model results

Variables	SAR	SEM	Coastal	Non-coastal	West and northeast
Fis	0.503***	0.511***	0.067	0.676***	0.707***
	(0.064)	(0.065)	(0.323)	(0.176)	(0.209)
Wageenfi	-0.062***	-0.059***	-0.020	-0.044**	-0.055**
	(0.016)	(0.015)	(0.030)	(0.019)	(0.023)
Pen	0.898**	0.889**	2.080**	1.045***	0.866**
	(0.367)	(0.364)	(0.896)	(0.300)	(0.334)
Pcom	0.027*	0.025*	0.029	0.094**	0.122***
	(0.015)	(0.015)	(0.021)	(0.035)	(0.032)
Tec	-0.330	-0.297	-1.470*	-3.293	-4.482*
	(0.439)	(0.439)	(0.696)	(1.942)	(2.339)
Fdi	0.006*	0.006*	0.004	-0.026	-0.023
	(0.004)	(0.004)	(0.004)	(0.017)	(0.022)
Other Control Variables	YES	YES	YES	YES	YES
_cons	0.046*	0.025*	0.542*	-0.027*	-0.031
	(0.051)	(0.047)	(0.245)	(0.076)	(0.085)
rho	-2.081***	-	-	-	-
	(0.240)				
lambda	-	-2.068***	-	-	-
		(0.278)			
sigma2_e	0.005***	0.005***	-	-	-
	(0.000)	(0.000)			
Obs.	330	330	110	220	154
R-squared	0.715	0.719	0.100	0.156	0.205

Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

The model is divided into coastal areas, inland areas, and separate analyses of the western and northeastern regions according to the static panel fixed effects. In order to further study the spatial heterogeneity of fiscal decentralization and environmental fiscal expenditures, as well as the impact of environmental decentralization on social welfare levels, this paper uses a spatial-geographical adjacency matrix to establish a spatial panel. The LLC test of panel data reveals the absence of a

unit root(P=0.000). The utilization of fixed effects was informed by the Hausman test. The LM, LR, and Wald tests demonstrate that the spatial proximity matrix is more appropriate for the SEM and SAR models.

5.2.1 Core Spatial Spillover Effects

The empirical finding reconfirms the validity of theoretical hypotheses. Fiscal decentralization and environmental fiscal expenditure demonstrate significant (β=0.503, $p<0.01$; β=0.898, $p<0.05$) spatial spillover effects on the level of social welfare, generating positive externalities across regional boundaries. Conversely, wage-oriented environmental decentralization exhibits regional institutional inertia, thereby exerting negative impacts (β=-0.062, $p<0.01$) on social welfare development. Notably, most control variables remain statistically insignificant in the spatial heterogeneity, indicating limited explanatory power for regional welfare variations.

Empirical analysis reveals that the negative impacts of environmental decentralization align consistently with panel regression outcomes, particularly exhibiting heightened significance in western and northeastern regions (β=-0.055, $p<0.05$). This spatial heterogeneity SEM from two structural constraints: (a) stronger wage rigidity in environmental protection agencies within these less-developed regions. (b) suboptimal allocation efficiency of environmental fiscal expenditures due to economic development disparities. These dual mechanisms collectively depress social welfare enhancement in western and northeastern China.

5.2.2 Regional Heterogeneity Decomposition

The empirical analysis reveals pronounced regional heterogeneity in fiscal decentralization outcomes. For non-coastal areas, it further proves that under the fiscal framework with increasingly clearer powers and expenditure responsibilities, there has been significant (β=0.676, $p<0.01$; β=1.041, $p<0.01$) improvement in the governance capabilities of local governments, which has had a significant effect on improving people's well-being. Its outcome demonstrates that local governments have effectively implemented the stipulations of fiscal and taxation system reforms, meticulously adhering to the principles of optimizing the division of government powers and financial powers authorities between government. In contrast, fiscal decentralization is less significant(β=0.607) in coastal areas, primarily due to the relatively balanced development of these regions, which facilitates the balanced development of economic and non-economic well-being. Consequently, scientific and reasonable fiscal decentralization exerts a positive incentive effect for local governments to improve the level of social welfare and has a certain promoting effect on alleviating regional disparities.

At the level of regional groupings, environmental expenditures demonstrate complete significance($p<0.01$), indicating that environmental fiscal expenditures have a certain impact on regional social welfare. A numerical analysis reveals that environmental fiscal expenditures in coastal regions exert a more substantial influence social welfare compared to non-coastal regions. The compared to of the level is more effective. The central government has increased the general transfer payments and special transfer payments to the ecological environment, and the environmental fiscal expenditures of local governments and the effect of policy implementation have also influenced the improvement of influence improving the level of social welfare.

In summary, the spatial impact of fiscal decentralization (*Fis*) and environmental fiscal expenditures (*Pen*) on the level of social welfare has been verified the empirical results of the Moran's Index, and the results of the level of regional social welfare meet requirements of the national regional development policy.

5.3 Threshold Effect Test

According to the above empirical analysis, under the influence of local government competition, the decentralization of environmental revenue weakens the level of local social welfare, and under the scale of different levels of fiscal expenditure, there may be a "threshold effect" in the degree of local government governance of environmental regulation. Therefore, in further analysis, the panel threshold model is used to explore the impact of environmental revenue decentralization on social welfare under the different levels of environmental protection fiscal expenditure. Following established methodological procedures, this paper test threshold hypotheses through sequential bootstrap sampling (300), examining no-threshold, single-threshold, and multiple-threshold scenarios. The results indicate statistically significant threshold effects($P<0.01$).

When using per capita environmental protection expenditure as the threshold variable, we identify a significant single

threshold at CNY 320 (95%, CI [300, 360]). This suggests a structural break where welfare impacts reverse when expenditure exceeds 0.032% of regional GDP (converted from original 0.030-0.036 ten thousand RMB interval). Beyond this critical value, increased fiscal capacity enables more effective ecological governance, generating positive social welfare externalities.

The FDI per capita threshold emerges at CNY 110,261 (95% CI [98,356, 113,666]), revealing developmental trade-offs. Below this level, local governments prioritize growth-oriented competition through investment expansion, resulting in environmental degradation that outweighs regulatory benefits. This "growth-first" equilibrium persists until regions reach sufficient economic development to internalize environmental costs.

Table 6. Threshold Identification Test

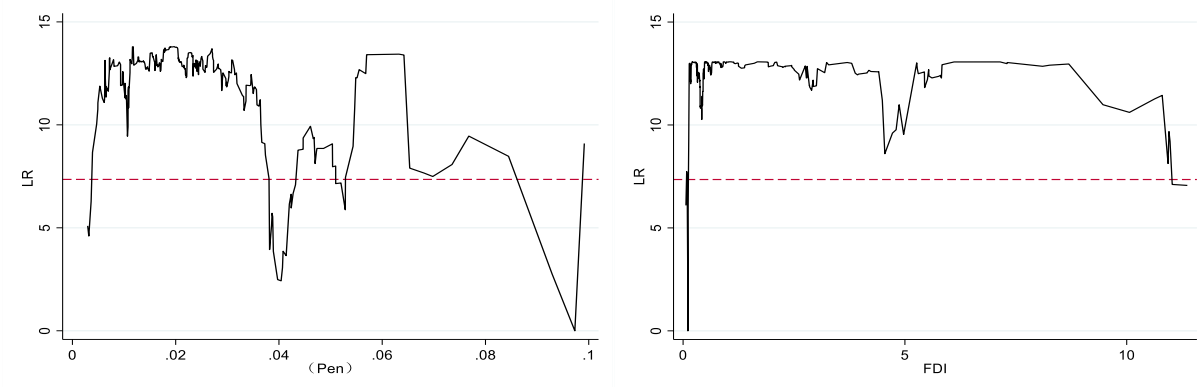
Main variables	Threshold variables	model	F	P	10%	5%	1%	Threshold
Wageenfi	*Pen*	single	14.25*	0.05**	12.1638	14.2411	16.9119	0.032
		double	8.43	0.1867	11.0215	14.8760	28.4291	-
Wageenfi	*Fdi*	single	13.30**	0.0367*	10.3761	12.2010	15.0685	11.0261
		double	8.98	0.2167	13.9812	20.3238	28.3920	-

Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Methodologically, these findings advance fiscal decentralization theory by demonstrating how expenditure thresholds mediate the decentralization-welfare relationship. The dual-threshold structure particularly highlights the developmental dilemma facing local governments: (1) environmental investments become welfare-enhancing only after overcoming initial growth constraints, while (2) FDI-driven growth initially exacerbates environmental welfare losses.

From a policy perspective, our results suggest the necessity of differentiated decentralization strategies. For less-developed regions below the FDI threshold, central environmental mandates may be preferable to local discretion. Conversely, more developed regions beyond expenditure thresholds could benefit from enhanced fiscal autonomy in environmental governance. These findings align with recent theoretical work on second-generation fiscal federalism while providing empirical evidence for optimal decentralization design in developing economies.

The threshold regression results demonstrate statistically significant positive effects of fiscal decentralization and per capita social consumption expenditure on social welfare, consistent with the theoretical framework. This suggests that the effective implementation of fiscal decentralization of expenditure responsibility allocation has mitigated the trend of "race to the bottom" phenomenon in regional competition, while increased public spending has simultaneously enhanced household consumption capacity and social welfare outcomes.



Figures 2. Illustration of the threshold effect

Notably, foreign direct investment has an inverted L-shaped relationship with social welfare, indicating diminishing marginal returns after reaching critical thresholds. Contrary to the hypothesized Porter effect, technological innovation manifests a significant negative impact on welfare indicators, suggesting environmental regulations have not yet induced sufficient innovation offsets at current development stages. Conversely, the pollution haven effect associated with foreign investment reveals a U-shaped relationship, implying a "pollution haven".

Table 7. Panel Threshold Regression Result Estimation

Variables	Fdi-threshold	Variables	Pen-threshold
	Model 6		Model 7
Fis	0.434***	*Fis*	0.358**
	(0.142)		(0.143)
Pen	1.210***	*Pen*	-
	(0.418)		
Pcom	0.033**	*Pcom*	0.054***
	(0.017)		(0.017)
Tec	-0.836*	*Tec*	-0.895*
	(0.475)		(0.476)
Fdi	-	*Fdi*	0.006
			(0.005)
Other Control Variables	YES	*Other Control Variables*	YES
Wageenfi	1.522***	*Wageenfi*	-0.044**
Fdi<11.0261	(0.503)	*Pen<0.032*	(0.018)
Wageenfi	-0.040**	*Wageenfi*	0.069*
Fdi>11.0261	(0.018)	*Pen>0.032*	(0.038)
_cons	0.019*	*_cons*	0.096*
	(0.081)		(0.079)
R-squared	0.125	*R-squared*	0.103

Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

5.4 Robustness Test

To validate the robustness of the above results, this paper implemented two methodological strategies: (1) alternative measurements of core explanatory variables, and (2) systematic mitigation of endogeneity concerns. The original fiscal decentralization index was replaced with a fiscal autonomy index (*Fisown*), calculated as local government revenue/local government expenditure, to better capture subnational fiscal capacity.

Table 8. Panel Regression Robustness Test

Variables	Replacement variables	Instrumental variable (LIML)	Instrumental variable (GMM)
	Model 8	Model 9	Model 10
Fisown	0.355*	-	-
	(1.79)		
Enfi	-0.023*	-	-
	(-1.86)		
Fis	-	0.377**	0.377**
		(2.22)	(2.22)
Wageenfi	-	-0.248*	-0.248*
		(-1.66)	(-1.66)
Pen	1.092**	1.261***	1.261***
	(2.55)	(2.74)	(2.74)
Other Control Variables	YES	YES	YES
_cons	0.197*	0.185*	0.185*
	(1.76)	(0.85)	(0.85)
R-squared	0.054	0.843	0.843

Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

We reconceptualized the wage-based environmental decentralization metric by constructing a dual-index system: (1) Regulatory-driven decentralization: Measured by the ratio of environmental regulatory staff to total public sector employees. (2) Incentive-driven decentralization: Operationalized as environmental governance expenditures per capita.

To address potential simultaneity bias, we adopted the following procedures: (1) Instrumental Variable (IV) Design: The first-order lag of environmental revenue decentralization was employed as an IV, satisfying the exclusion restriction through temporal precedence. (2) Robust Estimation: Limited Information Maximum Likelihood (LIML) and Generalized Method of Moments (GMM) estimators were applied to jointly address endogeneity and heteroskedasticity, with standard errors.

As evidenced in Table 8, the robustness checks yield three principal findings: (1) The fiscal decentralization coefficient in Model 8 demonstrates marginal attenuation relative to Model 3 (β: 1.99→1.79, $p<0.01$), yet maintains strong statistical significance, indicating measurement-invariant policy effects. (2) Wage-based environmental revenue decentralization (*Wageenfi*) remains statistically insignificant (β=-0.248, $p<0.1$) across specifications, suggesting its exclusion from welfare-enhancing mechanisms. (3) Both LIML and GMM estimators confirm that fiscal decentralization (*Fisown*) and environmental protection expenditures persistently enhance social welfare.

6 Conclusions and Policy Implications

6.1 Discussion of Results

Social welfare emerges as a synergistic outcome of the integrated economic-society-financial-environmental system. The empirical analysis examines the tripartite contributions of economy, fiscal and environment sectors to welfare enhancement. Furthermore, employing dynamic panel analysis with provincial fiscal policy covariates, we investigated threshold effect of environmental revenue decentralization on social welfare using nonlinear modeling.

6.1.1 Spatiotemporal Heterogeneity

The analysis revealed that provincial social welfare exhibited aggregate growth (2007-2017) with pronounced spatial disequilibrium. Western regions exhibited the most significant welfare gains, while central region showed spatial clustering with limited improvement. Conversely, northeastern provinces exhibited sluggish progress, and coastal eastern regions-maintained leadership yet failed to leverage comparative advantages due to constrained capital allocation efficiency. Notably, high fixed asset investment premiums emerged as a binding constraint, with national spatial gradients remaining statistically insignificant.

6.1.2 Fiscal Policy Efficacy

Fiscal decentralization and eco-environmental expenditures significantly enhanced social welfare. The analysis indicates that centralisation optimization through the delineation of expenditure responsibilities has a beneficial effect on regional welfare outcomes. However, However, it is important to note that structural inefficiencies persisted, with welfare gains derived from expenditure scale expansion rather than structural optimization. This suggests a misalignment between fiscal governance systems and livelihood policy implementation.

6.1.3 Nonlinear Threshold Effects

Wage-based environmental revenue decentralization exhibited welfare-diminishing properties, revealing an inverted-U relationship with environmental protection expenditures. This outcome serves to confirm the dual nature of local governments' ecological roles, which has been identified as being effective in basic environmental improvement yet structurally deficient. Furthermore, the joint demonstration of a flattened inverted-U effect on welfare by economic growth and environmental decentralization indicates that investment-driven strategies primarily enhance economic welfare while eroding non-economic welfare through regulatory relaxation. It is notable that only 23% of provinces have achieved simultaneous economic-ecological-welfare optimization.

6.2 Policy Implications

6.2.1. Accelerating Fiscal System Reforms for Ecological Governance

The expeditious implementation of administrative authority and expenditure responsibility frameworks for ecological and environmental governance below the provincial level necessitates systematic optimization of intergovernmental divisions regarding administrative mandates and fiscal authorities. This reform imperative centers on establishing institutionally coherent

fiscal relations characterized by unambiguous delineations of rights-obligations, coordinated fiscal capacities, and interregional equilibrium. Such institutional recalibration aims to standardize intergovernmental accountability structures in ecological conservation, thereby institutionalizing mechanisms through which administrative jurisdictions, expenditure obligations, and fiscal endowments maintain mutual adaptability across governance tiers.

Strategic reorientation of fiscal resource allocation priorities should be pursued to enhance expenditure performance metrics, while leveraging fiscal instruments to amplify environmental governance efficacy. Central transfer payment mechanisms require structural reinforcement to ensure precision in ecological fund deployment toward remediation and restoration initiatives, thereby catalyzing equilibrium between ecological stewardship obligations and fiscal expenditure architectures. Progressive fiscal coordination must advance the development of general budgetary and transfer payment systems for ecological conservation that align scale with structural imperatives. Regional disparities in fiscal capacity-environmental governance congruence necessitate rectification through enhanced compatibility between ecological expenditure policies and localized environmental challenges.

6.2.2 Innovating Ecological Fiscal Incentive Mechanisms

The progressive augmentation of budgetary allocations across governmental tiers must be systematically pursued to achieve strategic expansion in environmental fiscal resource endowments, ensuring sustained increments in ecological protection investments that align with evolving governance requirements. Institutionalizing robust ecological compensation frameworks becomes imperative to reconcile developmental imperatives with conservation priorities, necessitating explicit delineation of accountability parameters for subnational governments in fiscal transfer processes. This entails transitioning local authorities from primary compensation providers to regulatory stewards of cooperative compensation mechanisms, while demarcating operational boundaries for governmental engagement in ecological reparation initiatives. Urgent implementation of standardized Gross Ecosystem Product (GEP) accounting protocols is required to formalize vertical fiscal transfer criteria and compensation modalities from central to local jurisdictions, thereby establishing perpetual incentive structures that ensure adequate subnational commitment to ecological preservation. Such fiscal-environmental policy integration must ultimately align with broader developmental objectives, facilitating provision of eco-benign public goods while safeguarding foundational societal well-being parameters.

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