

An Empirical Study on the Impact of Local Financial Capacity on the Supply Efficiency of Ecological Public Goods

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Abstract: Improving the quality and level of ecological public goods supply is crucial for enhancing the public happiness index and ensuring ecological welfare. A high-quality ecological environment generates significant positive externalities, making the provision of such goods a key focus of government expenditure. The ability of local governments to adequately fund the supply of ecological public goods depends on the strength of their financial capacity. Based on the panel data of 30 provincial-level regions in China from 2007 to 2019, this paper uses the super-efficiency Slack-Based Measure (SBM) model and the dynamic Malmquist index to measure the supply efficiency of provincial-level regional ecological public goods including undesirable outputs. Furthermore, the panel Tobit model and the system Generalized Method of Moments (GMM) model are used to empirically test the impact of local fiscal capacity on the supply efficiency of ecological public goods. The results show that fiscal absorption capacity can significantly improve the supply efficiency of ecological public goods, and the economic growth preference of fiscal allocation capacity can also significantly improve the supply efficiency of ecological public goods, indicating that under the influence of the current economic structure transformation and ecological civilization construction, the distortion of local governments in the supply of public goods has been improved, while the administrative consumption preference of fiscal allocation capacity hinders the improvement of the supply efficiency of ecological public goods, and the fiscal self-sufficiency has a lag in improving the supply efficiency of ecological public goods. Fiscal transfer payments have significantly improved the efficiency of the supply of ecological public goods.

Keywords: local financial capacity; ecological public goods; supply efficiency

1. Introduction

Good ecosystem is the foundation of sustainable development. Improving the level of supply of ecological public goods is an important way to comprehensively enhance the index of happiness of public life and to safeguard public ecological welfare. Public finance is based on meeting the basic needs of society and has important functions such as maintaining the allocation of government resources, stabilizing economic and social development, and standardizing the allocation of funds.

This paper, based on an accurate identification of the internal relationship between local fiscal capacity and the supply efficiency of ecological public goods, explores and constructs a super-efficient SBM model and a dynamic Malmquist index model with undesirable outputs. The aim is to comprehensively analyze and measure

the supply efficiency of ecological public goods at the provincial level in China from 2007 to 2019. Furthermore, the study establishes an empirical econometric model to clarify the internal mechanisms by which local fiscal capacity affects the supply efficiency of ecological public goods. Specifically, it examines how and to what extent local fiscal capacity influences the supply of these goods. The Tobit panel model and the system GMM dynamic panel econometric model are employed to empirically investigate the impact of local fiscal capacity on the supply efficiency of ecological public goods, thereby providing both theoretical and empirical foundations for improving the supply efficiency of ecological public goods and advancing the “green revolution” in ecological civilization construction.

2. Basic Model

2.1. Non-Radial, Non-Angular Super-Efficient SBM Model

The Data envelopment analysis (DEA) method was first proposed by Charnes and Cooper et al. in 1978 to solve the problem of the effectiveness of decision-making units under the “multi-input and multi-output” evaluation system [1]. In the traditional DEA analysis, the Charnes-Cooper-Rhodes (CCR) and (Banker-Charnes-Cooper) BCC models only consider the proportional changes of input or output, which are mainly based on the radial perspective, and do not consider the influence of relaxation variables for the invalid decision-making unit, and the results may have errors.

In order to overcome the above shortcomings, this paper refers to the research method of Tone *et al.* and adopts the non-radial and non-angular SBM efficiency evaluation model, which not only introduces the relaxation of input and output into the objective function, but also takes into account the undesirable output of environmental pollution. It can also solve the problem of input-output relaxation and the measurement bias of efficiency evaluation under the presence of undesired output, and further combines the super-efficiency DEA and SBM models, and establishes the following model.

$$\begin{aligned}
 \min \rho = & \frac{\frac{1}{m} \sum_{i=1}^m \left(\frac{\bar{x}}{x_{ik}} \right)}{\frac{1}{r_1 + r_2} \left(\frac{\sum_{s=1}^{r_1} \bar{y}^d}{y_{sk}^d} + \frac{\sum_{q=1}^{r_2} \bar{y}^u}{y_{qk}^u} \right)} \\
 \bar{x} \geq & \sum_{j=1, \neq k}^n x_{ij} \lambda_j, i = 1, 2, \dots, m \\
 \bar{y}^d \geq & \sum_{j=1, \neq k}^n y_{sj}^d \lambda_j, s = 1, 2, \dots, r_1 \\
 \bar{y}^u \geq & \sum_{j=1, \neq k}^n y_{qj}^u \lambda_j, q = 1, 2, \dots, r_2 \\
 \lambda_j \geq & 0, j = 1, 2, \dots, n \\
 \bar{x} \geq & x_k, k = 1, 2, \dots, n \\
 \bar{y}^d \leq & y_k^d, q = 1, 2, \dots, r_1 \\
 \bar{y}^u \leq & y_k^u, u = 1, 2, \dots, r_2
 \end{aligned} \tag{1}$$

n represents the number of decision-making units; m represents inputs; r_1 and r_2 represent expected and undesired outputs; x represents the elements in the corresponding input matrix; y^d and y^u represent the elements in the corresponding expected and undesired output matrices; ρ is the calculated eco-efficiency value, and $\rho \geq 1$ indicates that the decision-making unit is valid. Considering the existence of technological progress, institutional change, and other factors, in order to ensure the accuracy of the results, this paper chooses the super-efficient SBM model under the condition of variable scale reward (VRS) to analyze the supply efficiency of ecological public goods, which is more in line with the actual situation, and at the same time output-oriented, so that the analysis results are more economically significant.

2.2. Malmquist Exponential Dynamic Model

Caves *et al.* incorporated the Malmquist index into the calculation of total factor productivity, and the Malmquist index well reflected the structural drivers of efficiency change, thus forming an efficiency evaluation and analysis method based on the combination of static and dynamic based on DEA-Malmquist [2]. Combining the Malmquist index with DEA makes it possible to describe the dynamic change of efficiency, and its practical application in productivity measurement is becoming more and more extensive [3]. The expression of the Malmquist exponential method is:

$$\begin{aligned}
 M(x^{t+1}, y^{t+1}, x^t, y^t) &= \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \\
 Effch &= \frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \\
 Tech &= \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \\
 Tfpch &= Effch \times Tech = (Pech \times Sech) \times Tech
 \end{aligned} \tag{2}$$

Among them, and represent the input-output vectors in the t period and the $t + 1$ period, respectively, and the Malmquist index is used to measure the dynamic change index of the supply of ecological public goods from t to $t + 1$.

The economic significance of the Malmquist index is as follows:

- (1) $M > 1$, indicating that the supply efficiency of ecological public goods was improved from t to $t + 1$;
- (2) $M = 1$, indicating that the supply efficiency of ecological public goods goes from t to $t + 1$.

(3) $M < 1$, indicating that the supply efficiency of ecological public goods decreased from t to $t + 1$. The comprehensive technical efficiency change index (*TEC*) represents the catch-up trend of each decision-making unit relative to the production frontier from t to $t + 1$, that is, the change of the technical efficiency of ecological public goods supply from t to $t + 1$ when the decision-making unit is from t to $t + 1$. When $TEC > 1$, it indicates that the technical efficiency of the ecological public goods supply has improved. When $TEC < 1$, it indicates that the technical efficiency of the ecological public goods supply deteriorates.

Total factor productivity (*TFP*) represents the change in the productivity of ecological public goods in the two periods before and after the Malmquist index, and the total factor productivity shows the comprehensive productivity of each factor, when the $TFP > 1$, it indicates that the total factor productivity has improved. When $TFP < 1$, it indicates that total factor productivity has deteriorated.

3. Basic Model Empirical Study of the Impact of Local Fiscal Capacity on the Supply Efficiency of Ecological Public Goods Based on the SYS-GMM Method

3.1. Econometric Model Building

The efficiency indicators calculated by the super-efficiency SBM model are truncated data, making the Tobit model the appropriate choice for analyzing the factors influencing the supply efficiency of ecological public goods. Therefore, this paper first employs the panel Tobit model to examine the impact of local fiscal capacity on the supply efficiency of ecological public goods. The Tobit regression model can be expressed as follows:

$$Y = \begin{cases} Y^* = \alpha + \beta X + \epsilon & Y^* > \alpha \\ 0 & Y^* \leq \alpha \end{cases} \tag{3}$$

X is the vector of the independent variable; Y is the vector of the truncated dependent variable; α is the intercept term vector; β is the regression parameter vector; ϵ is the perturbation term. In this paper, the supply efficiency of ecological public goods is taken as the explanatory variable to construct a Tobit regression Model:

$$\begin{aligned}
 SSBMV_{it} &= \alpha_i + \beta_1 CZNL_{it} + \beta_2 CZZG_{it} + \beta_3 PGDP_{it} + \beta_4 GYJG_{it} + \beta_5 CITY_{it} + \beta_6 PEOPLE_{it} + \\
 &\beta_7 HBCP_{it} + \epsilon_{it}
 \end{aligned} \tag{4}$$

In the regression model, *SSBMV* is the supply efficiency of ecological public goods calculated by the super-efficient SBM model. *CZNL* stands for Local Fiscal Capacity Level; *CZZG* stands for Fiscal Self-Sufficiency;

PGDP is based on real GDP per capita in 2007; *GYJG* stands for the level of industrialization; *CITY* stands for the level of urbanization; *PEOPLE* stands for Regional Population Density; *HBCP* indicates the frequency of environment-related words in local government work reports. At the same time, considering the fitting degree of the regression model, some variables are converted into logarithmic form, and the coefficients of each variable after the logarithm is taken have strong economic significance.

3.2. Empirical Results

(1). Panel Tobit estimation

According to the regression results, it can be seen that the coefficient of fiscal absorption capacity is significantly positive, the coefficient of fiscal and economic allocation capacity is significantly positive, the coefficient of fiscal and administrative allocation capacity is significantly negative, and the coefficient of transfer payment is significantly positive, which indicates that the financial absorption capacity of local governments can significantly improve the supply efficiency of ecological public goods, and the economic growth preference of local governments can also significantly improve the supply efficiency of ecological public goods, indicating that under the influence of the current economic structure transformation and ecological civilization construction, Local governments have achieved “all-encompassing” in economic construction and the supply of ecological public goods, and the distortion of “emphasizing the economy and ignoring people's livelihood” in the supply of public goods by local governments has been improved, and ecological public goods are gradually being paid attention to [4]. However, the administrative consumption preference of local governments hinders the improvement of the supply efficiency of ecological public goods [5], and the transfer payment significantly improves the supply efficiency of ecological public goods, which is consistent with the expected assumptions in this paper (as shown in Table 1).

Table 1. TOBIT Regression Results of the Impact of Local Fiscal Capacity on the Supply Efficiency of Ecological Public Goods.

MODEL	(1)	(2)	(3)	(4)
VARIABLES	SSBMV	SSBMV	SSBMV	SSBMV
CZJQ	0.539 ** (0.236)			
CZPZ		0.243 *** (0.084)		
CZFD			-0.014 *** (0.005)	
lnPZYZF				0.047 ** (0.024)
CZZG	0.051 (0.076)	0.120 (0.080)	0.009 (0.077)	0.132 (0.089)
lnPGDP	-0.160 *** (0.058)	-0.156 *** (0.056)	-0.202 *** (0.062)	-0.183 *** (0.062)
CITY	0.863 *** (0.273)	0.870 *** (0.268)	0.909 *** (0.278)	0.934 *** (0.269)
GYJG	-0.346 ** (0.167)	-0.320 ** (0.160)	-0.366 ** (0.169)	-0.302 * (0.162)
lnPEOPLE	-0.063 * (0.033)	-0.067 ** (0.033)	-0.061 * (0.034)	-0.064 * (0.033)

Table 1. Cont.

MODEL	(1)	(2)	(3)	(4)
VARIABLES	SSBMV	SSBMV	SSBMV	SSBMV
lnHBCP	0.040 ** (0.020)	0.036 * (0.020)	0.037 * (0.021)	0.041 ** (0.020)
Constant	2.581 *** (0.526)	2.533 *** (0.507)	3.139 *** (0.607)	2.400 *** (0.509)
Observations	390	390	390	390
Number	30	30	30	30

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Standard errors in parentheses.

Further observation of the regression results of the control variables shows that the per capita GDP coefficient is significantly negative, indicating that economic activities will have a negative impact on the supply efficiency of ecological public goods [6]. The coefficient of urbanization level is significantly positive, indicating that urbanization promotes the improvement of the efficiency of ecological public goods supply, and also verifies the urban bias of public goods supply. The coefficient of environmental regulation is significantly positive, indicating that environmental regulation has a positive role in protecting the environment and improving the supply efficiency of ecological public goods [7]. The coefficient of fiscal self-sufficiency is not significant, and there may be a lag effect on the impact of fiscal self-sufficiency on the supply efficiency of ecological public goods in static regression, which needs to be further studied by using a dynamic regression model.

(2). *The results of SYS-GMM estimator*

In this paper, the GMM model of the dynamic panel system is used to test the relationship between local fiscal capacity and the supply efficiency of ecological public goods. From the regression results, it can be seen that the first-order lag term of the explanatory variable is highly significant, indicating that the supply efficiency of ecological public goods in the previous period will have an impact on the current government decision-making, and then affect the efficiency of ecological public goods in the current period. By comparing the static panel estimation results with the estimation results of the system GMM, except for the slight difference in the significance level of the regression coefficients of individual control variables, especially the other results including the core explanatory variables are basically similar, and unlike the static regression results, the fiscal self-sufficiency is significantly positive, which verifies the effect of fiscal self-sufficiency on the improvement of the supply efficiency of ecological public goods, and further indicates that the financial self-sufficiency has a lag in improving the supply efficiency of ecological public goods. For every 1% increase in fiscal absorption capacity, the supply efficiency of ecological public goods will increase by 0.589%; For every 1% increase in fiscal and economic allocation capacity, the supply efficiency of ecological public goods will increase by 0.145%; For every 1% increase in fiscal and administrative allocation capacity, the supply efficiency of ecological public goods will decrease by 0.023%; For every 1% increase in the level of transfer payment, the supply efficiency of ecological public goods will increase by 0.077%, and the vertical transfer payment of the central government will improve the supply efficiency of ecological public goods, which further supports the need for the central government to play a greater role in the public sector. It can be seen that fiscal absorption capacity has a great impact on the supply efficiency of ecological public goods, and it is significant at the level of 1% (as shown in Table 2).

Table 2. S-GMM Regression Results of the Impact of Local Fiscal Capacity on the Supply Efficiency of Ecological Public Goods.

MODEL	(1)	(2)	(3)	(4)
VARIABLES	SSBMV	SSBMV	SSBMV	SSBMV
L.SSBMV	0.205 *** (0.016)	0.188*** (0.015)	0.168*** (0.024)	0.193 *** (0.022)
CZJQ	0.589 *** (0.092)			
CZPZ		0.145 *** (0.021)		
CZFD			-0.023 *** (0.002)	
lnPZYZF				0.077 *** (0.009)
CZZG	0.085 ** (0.038)	0.241 *** (0.030)	0.060 ** (0.030)	0.302 *** (0.055)
lnPGDP	0.006 (0.030)	-0.028 (0.034)	-0.121 * (0.065)	-0.100 (0.076)
CITY	-0.212 (0.176)	-0.0233 (0.242)	0.0877 (0.369)	0.0582 (0.386)
GYJG	-0.500 *** (0.066)	-0.591 *** (0.098)	-0.629 *** (0.065)	-0.525 *** (0.073)
lnPEOPLE	-0.186 *** (0.017)	-0.173 *** (0.019)	-0.169 *** (0.016)	-0.148 *** (0.028)
lnHBCP	0.012 *** (0.002)	0.014 *** (0.003)	0.009 *** (0.002)	0.012 *** (0.003)
Constant	2.353 *** (0.285)	2.502 *** (0.214)	3.661 *** (0.476)	2.368 *** (0.489)
AR(1)	-2.350 ** 0.019	-2.306 ** 0.021	-2.306 ** 0.021	-2.451 ** 0.014
AR(2)	1.061 0.289	1.066 0.287	1.066 0.287	1.053 0.292
Sargan	0.977	0.992	0.992	0.976
Observations	360	360	360	360
Number	30	30	30	30

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Standard errors in parentheses.

3.3. Robustness Test

In this paper, the Tobit panel regression model is replaced by a linear panel regression model. According to the regression results presented in the table below, the coefficients and significance of the main explanatory variables are largely consistent with those from the Tobit panel regression model, though there are slight differences in coefficient size and significance levels. Similarly, the coefficients and significance levels of the control variables are also generally consistent with the results from the Tobit regression (as shown in Table 3).

Table 3. Panel regression results of the impact of local fiscal capacity on the supply efficiency of ecological public goods.

MODEL	(1)	(2)	(3)	(4)
VARIABLES	SSBMV	SSBMV	SSBMV	SSBMV
CZJQ	0.545 ** (0.242)			
CZPZ		0.242 *** (0.087)		
CZFD			-0.013 ** (0.005)	
lnPZYZF				0.047 * (0.024)
CZZG	0.054 (0.079)	0.123 (0.082)	0.021 (0.076)	0.135 (0.092)
lnPGDP	-0.162 *** (0.059)	-0.157 *** (0.058)	-0.187 *** (0.061)	-0.182 *** (0.064)
CITY	0.867 *** (0.280)	0.869 *** (0.276)	0.867 *** (0.274)	0.934 *** (0.276)
GYJG	-0.349 ** (0.171)	-0.320 * (0.164)	-0.344 ** (0.166)	-0.299 * (0.166)
lnPEOPLE	-0.059 * (0.033)	-0.062 * (0.032)	-0.063 * (0.032)	-0.060 * (0.032)
lnHBCP	0.040 * (0.020)	0.037 * (0.020)	0.044 ** (0.020)	0.041 ** (0.020)
Constant	2.568 *** (0.541)	2.503 *** (0.518)	2.972 *** (0.591)	2.364 *** (0.518)
Observations	390	390	390	390
Number	30	30	30	30

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Standard errors in parentheses.

3.4. Discussion

This paper empirically examines the impact of local fiscal capacity on the supply efficiency of ecological public goods by taking China's inter-provincial panel data from 2007 to 2019 as a sample. Firstly, the panel Tobit regression method is used to test the overall sample, and the regression results show that the financial absorption capacity of local governments can significantly improve the supply efficiency of ecological public goods, and the economic growth preference of local governments can also significantly improve the supply efficiency of ecological public goods, which indicates that with the adjustment of economic structure and the improvement of government incentive mode, the distortion of "emphasizing economy and ignoring people's livelihood" in the supply of public goods by local governments has been improved, and the supply of ecological public goods has gradually been paid attention to. The stronger a local government's financial capacity and the more financial resources at its disposal, the greater its support for public services and people's livelihoods, thereby effectively improving the supply level of ecological public goods. However, the preference for administrative consumption by local governments hinders the improvement of ecological public goods supply efficiency, while transfer payments significantly enhance this efficiency. Secondly, the results of the GMM dynamic panel regression indicate that fiscal self-sufficiency also significantly improves the supply efficiency of

ecological public goods, further suggesting that financial self-sufficiency has a delayed effect on improving this efficiency. Thirdly, the samples were classified based on different levels of fiscal absorption capacity, and the panel Tobit regression method was used to further analyze the differences in regression results across groups. Finally, in the robustness test, a model substitution method was employed to verify the impact of local fiscal capacity on the supply efficiency of ecological public goods.

4. Conclusion

Based on the evaluation method for ecological public goods supply efficiency, which combines the static and dynamic aspects of the super-efficiency SBM-Malmquist model, this paper uses provincial panel data from China spanning 2007 to 2019 as the sample. The measured efficiency of ecological public goods supply is taken as the dependent variable, with fiscal absorption capacity, fiscal allocation capacity, and transfer payments as independent variables, and fiscal self-sufficiency as the control variable. The research hypothesis is tested using the system GMM model and the instrumental variable method. Finally, the following conclusions are drawn:

First, the empirical results indicate that the supply efficiency of ecological public goods in China from 2007 to 2019 exhibited a fluctuating trend. Two-thirds of the provinces were in an efficient state, with provinces displaying low supply efficiency mostly concentrated in the central and western regions. Specifically, the eastern region generally achieved effective supply efficiency, the western region showed a stable and improving trend, while the central region ranked lowest in the country in terms of supply efficiency. Second, the Tobit panel regression results show that the coefficient for fiscal absorption capacity is significantly positive, the coefficient for fiscal and economic allocation capacity is significantly positive, the coefficient for fiscal and administrative allocation capacity is significantly negative, and the coefficient for transfer payments is significantly positive, all of which align with the theoretical expectations of this paper. Additionally, this study finds that the economic growth preference in local government fiscal allocation also significantly improves the supply efficiency of ecological public goods, which adds to the existing theoretical assumptions. Thirdly, the regression results for the control variables show that the coefficients for fiscal self-sufficiency are all significantly positive at the 1% level, indicating that fiscal self-sufficiency can significantly improve the supply efficiency of ecological public goods and exhibits a lag effect, further validating the expected hypothesis.

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Conflicts of Interest

The authors declare no conflict of interest.

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