An Empirical Study of the Grand Canal on Green Total Factor Productivity in Riverside Counties

Based on 10,890 Panel Data from 19 Cities and 55 Counties in 6 Provinces from 2000–2021

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Abstract. The Grand Canal, a jewel in the history of Chinese civilization, has been fully navigated for the first time in a century in 2022. How to measure the impact of this natural resources on the development of the riverside counties' economies and explore the mechanism in order to better utilize it is an urgent question of our time. To address the research questions, this paper selects 10,890 panel data from 19 cities and 55 counties in 6 provinces, constructs a canal green total factor production system and measures the green total factor productivity of all flow curves of the Grand Canal using Malmquist index. It is found that (1) the Grand Canal has a significant effect on the improvement of green total factor productivity in county economies along the route. The interaction term of canal-county distance and canal flow has a significant pulling effect. (2) Green total factor productivity shows a synergistic trend in the county areas along the canal, with positive effects on the level of educational resources and government expenditure. The negative effects on the level of urbanization and service industry development. (3) The decreasing order of green total factor productivity along Jiangnan Canal, Lu Canal, and North-South Canal indicates that canals can be navigated have stronger contribution to green total factor productivity of county economies along the route.

Keywords: The Grand Canal · Green Total Factor Productivity · Tobit Model · Low-Carbon Economy

1 Introduction

With China's rapid economic development, the miracle of economic growth has come at a high cost in terms of environment and energy. Over the past two decades, China's sloppy economic growth has led to increased environmental pollution, severely limiting China's transition to high-quality development. In recent years, the development approach of "green development" and "Clear waters and green mountains are as good as mountains of gold and silver." has been increasingly practiced and recognized. In the speech at the 20th Party Congress, General President Xi Jinping has also repeatedly mentioned

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the "construction of beautiful China" and other development paths of environmental protection. As a great engineering miracle in Chinese history, the Grand Canal has been revitalized in the new era to take on a new historical mission. As the Grand Canal will be opened for the first time in a century in May 2022, the question is how to make good use of the natural resources of the canal in order to better practice the necessary path of win-win economic growth and ecological environmental protection.

2 Literature Review

2.1 Research on Green Total Factor Productivity

Existing research on the impact of environmental regulation on green efficiency of water resources, the findings of different scholars vary widely. Jin Wei et al. [2] found that environmental regulation has a negative effect on industrial water efficiency, and Yang Qian et al. [3] found that environmental regulation can promote the improvement of agricultural water efficiency. In terms of FDI, Kumar et al. [4] concluded that FDI increases the level of clean technology innovation and resource and energy use and promotes green total factor productivity in the region; Yoon et al. [5] emphasized that FDI raises the level of local income, which makes people have higher demands on the environment and thus increases green total factor productivity. In terms of urbanization, Rafindadi et al. [6] point out that urbanization and foreign investment bring about the transfer of highly polluting production, which has a negative impact on green total factor productivity; In terms of environmental regulation, Wang Wei et al. [7] point out that environmental regulation can effectively improve green total factor productivity in the Yangtze River Economic Zone. In terms of spatial differences, Hu Yanxin et al. [8] pointed out that there are geographical differences in the impact of FDI on green development and it has a facilitating effect in some regions; Li Yi et al. [9], on the other hand, argued that the geographical differences in environmental regulations are related to the institutional environment of each place; Qin Teng et al. [10] studied the spatial linkage effect and transmission mechanism of water resource efficiency.

2.2 Research on Canals

Existing studies on the economic impact of canals mainly focus on two aspects, the influencing factors, and the related countermeasure suggestions, among which more attention is paid to the northern section of the Grant Canal in Jiangsu Province, and less research is conducted on the northern. Using the input-output method, Xia Liguo [11] found that an important factor influencing the economic development of northern Jiangsu is the different incomes of various income classes within the town. Shao Aijun [12] analyzed the indirect and direct contributions of the Jianghan Canal to the regional economic development by constructing an input-output model. Yan Jinming et al. [13] find out economic indicators of the cities along the canal are very much correlated with the water transport volume, and the development of canal shipping directly promotes the economic leap of the cities along the canal.

3 Variable Measures and Data Sources

3.1 Variable Measures

Green Total Factor Productivity (GTFP)
As shown in Table 1, this paper selects PM2.5 air pollution concentration and industrial CO2 emissions as unexpected outputs.

Control Variables
As shown in Table 2, this paper selects those variable as the control variables of the model. The selection is based on existing studies, SID and URB are found in the study of Danhong Shen et al. [14], and the rest of them are found in the study of Xuetao Sun et al. [15].

Distance from the Big Canal (DBC)
The core variable of this study is DBC, which is measured by using the shortest spatial distance between the county CDP and the central axis of the canal channel. Considering the contribution of canal resources to regional green total factor growth, it should be more influenced by geographical space compared to technological innovation and digital financial business. This paper also measures DBC2, an indicator based on the multiplication of DBC and unit river flow.

Table 1. Green Total Factor Productivity Input-Output Indicator System for the Grand Canal

Guideline layer	Element Layer	Indicator layer	Unit
Inputs	Capital factor input	Fixed Asset Investment	million yuan
	Labor factor input	Total number of employees	million people
Expected output	Economic output	GDP per capita	Yuan
		Tax revenue	million yuan
Unexpected outputs	Environmental Output	Sulfur dioxide emissions	t/million
		PM2.5 dust intensity	$\mu g/m^3$

Table 2. Symbols and measures of variables

Variable Name	Symbol	Variable Meaning
Industry development	SID	Tertiary sector value added/GDP
Urbanization	URB	Urban population/total resident population
Educational Resources	EDU	Number of schools/administrative land area
Government Revenue	GOV	Fiscal tax revenue/GDP
Industrial output	IND	Total industrial output value above scale/GDP
Consumption level	CSM	Retail sales of goods/population

3.2 Data Sources

For the calculation of GTFP, the air PM2.5 data are obtained from the Atmospheric Composition Analysis Group of Dalhousie University. The CO2 emission data are obtained from NGDC. For the calculation of DBC, the river flow data are obtained from the China Water Resources Bulletin and the China Water Resources Database, and the river-city distance is measured using the Google Map distance tool. For the control variables, all the data are obtained from the local statistical bureaus and the county database of the China Economic Network.

4 Summary Statistics and Empirical Results

4.1 Empirical Strategy

The dependent variable measured result interval is (0.471014, 1.752849), which is a restricted explanatory variable, and the output results using linear least squares regression are highly biased. Thus, a Tobit model is used in this paper.

$$GTFP = \beta_0 + \beta_1 DBC + \beta_2 Control + \epsilon \tag{1}$$

4.2 Baseline Estimates

Table 4 shows the regression results, columns (1) (2), (3) (4) for the mixed regression with random effects, respectively.

As shown in Table 3, the comparison of the regression results for the canal-county distance with water volume considered and the canal-county distance without water volume considered shows that the direction of the effect of DBC or DBC2 on GTFP is positive in either case. In (1)(3) considering water volume, the coefficient of mixed regression DBC2 is 0.0007 and the coefficient before the DBC2 term of random effects is 0.0008, both of which are significant at the 1% level. It is confirmed that the interaction

Table 3. Tobit regression results

Variables	(1)	(2)	(3)	(4)
DBC	–	0.0040* (1.66)	–	0.0011 (0.38)
DBC2	0.0007*** (2.26)	–	0.0008** (2.93)	–
N	1210	1210	1210	1210
Control	Yes	Yes	Yes	Yes
Random effects	No	No	Yes	Yes

Note: t-test statistics are in parentheses; ***, **, * indicate significant at the level of 0.01, 0.05, 0.1, similarly hereinafter

Table 4. Heterogeneity regression analysis

Variables	N-S Canal (1)	Lu Canal (2)	Gangnam Canal (3)
DBC2	0.0283 (0.57)	0.0065* (1.86)	2.0039*** (2.85)
N	324	123	301
F	12.56	55.01	8.50

term between the distance of the county center from the canal, and the flow of the canal section have a positive effect on green total factor productivity. In (2) (4) without considering water quantity, the results are not significant compared to the regression results in (1) (3). The coefficient of the mixed regression DBC is 0.0040 and the coefficient before the DBC term of the random effect is 0.0011. This suggests that the canal-county distance itself has some positive effect on green total factor productivity, but the explanatory power is much less than the indicator under the combined consideration of distance and water volume.

4.3 Heterogeneity Analysis

Considering the averaging of river length grouping, the North Canal and South Canal are divided into a group, a group of Lu Canal, and a group of Middle Canal, the Lu Canal and Jiangnan Canal.

As Table 4 shown, the regression significance of the canal section in the south of the river is better than the other two groups overall, which may be mainly due to the negative impact of the long-term non-navigational use of the canals and cultural and tourism use.

4.4 Robustness Tests

The above study used Malmquist method to measure GTFP, and to prove the robustness this paper replaces with SBM-DEA method to measure GTFP again. The results found that the direction of the effects of DBC, URB, GOV, and CSM do not change. The significance levels of DBC, URB, EDU, and IND decrease, but the direction of effect does not change significantly.

5 Conclusions

The Grand Canal has a significant effect on green total factor productivity improvement in the county economies along the route. Areas where the county economic centers are close to the canal and where the canal flows through a large volume receive a stronger positive effect. As a result of heterogeneity, the shipping function of the canals is of great significance, and the tourism industry helps to bring into full play the economic value of the canals at a deep level.

During 2000–2021, the GTFP of the counties along the canal shows an overall trend of growth first and then decline. In 2000–2008, see continuous improvement, 2008–2012 still grows but the speed slows down, and 2012–2022 shows a decreasing trend. The main reason for the decline is that after 2012, the economy shifted to high-quality development. Under the geographical competition, the county economies are vulnerable to the 'siphoning effect' of the surrounding core cities, quality resources flowed out, and GTFP production efficiency gradually declined.

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