

Fiscal Decentralization, Export Technology Complexity and Regional Green Total Factor Productivity: Empirical Study based on GML Productivity Index

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Abstract

With the Global-Malmquist-Luenberger (GML) productivity index, we calculate and evaluate the Chinese green total factor productivity and the decomposition, and further take the dynamic GMM method to empirically study the effect of export sophistication, fiscal decentralization and their interaction terms on regional green total factor productivity. The increasing export technology complexity has a significant effect on the regional green total factor productivity growth. Increasing export sophistication degree means the improving status of international vertical specialization division and upgrading of export product structure, which has a positive incentive effect on adoption of regional environmental technology and transformation and upgrading of regional industrial structure. However, this effect will be disturbed by the regional fiscal decentralization. Fiscal decentralization intensifies local government's competition and distorts local factor market and resources misallocation. It will not only distort the incentive of enterprises to increase less technology and the R&D on the export of products, but also will inhibit the upgrading process of regional industrial structure, which would lead to extensive growth trap of "high consumption and high emission". To continue to enhance China's position in the international division of labor is necessary. Moreover, a diversified evaluation system is encouraged in the performance evaluation system of local officials to optimize the resources allocation efficiency, and propose a proper guidance and incentive for local enterprises to promote industrial transformation and upgrading. Ultimately a win-win situation between ecological civilization construction and economic sustainable growth is achieved.

Keywords

Fiscal Decentralization; Export Technology Complexity; Regional Green Total Factor Productivity.

1. Introduction

Since the reform and opening up, China has created a miracle of high-speed growth of economy for more than three decades. According to data released by the National Bureau of Statistics, China's gross domestic product (GDP) in 2015 was 67.67 trillion yuan, with a year-on-year growth of 6.9 percent, making it the world's second largest economy after the United States. With the rapid economic development, China's opening to the outside world is gradually increasing. By actively participating in global vertical specialization and embedding in global value chain, export technology complexity of China is also rising. Some have even reached or approached the level of the developed countries, which realizes the development goal of

improving export status (Rodrik,2006[1]; Schott,2008[2]). However, although the economic gap between China and the developed countries is increasingly narrow, there are still considerable differences in environmental protection performance. In order to pursue economic growth, China is facing more and more severe environmental pollution problems, and the capacity of resource environment has reached or close to the upper limit. To this end, the report of the 19th National Congress pointed out that we should accelerate the reform of the system for ecological civilization to build Beautiful China. With the rapid development of foreign trade in China, how to promote the coordinated development between foreign trade and ecological civilization, to promote a new way of green and low carbon cycle development is imperative.

The increase of regional export technology complexity means the upgrading of regional export trade structure and the optimization of international industrial value chain position. In other words, the proportion of labor-intensive products has been reduced or upgraded to a higher level of technical connotation or added value capability, while the proportion of capital and technology-intensive export products is increasing. Therefore, the increase of export technology complexity should be conducive to the growth of regional green productivity. However, we also find that the role is different for regions with different institutional endowments or degrees of local government competition. Therefore, this paper discusses whether the improvement of export technology complexity is conducive to the improvement of regional green total factor productivity. If so, how does this effect occur? And what factors might interfere this effect? There is no clear answer to this question from existing research. The answers to the above questions will have profound practical significance and theoretical value to adjustment of foreign trade policy and the promotion of the "Beautiful China" in the future.

Based on Global Malmquist-Luenberger(GML index), we empirically analyzes the impact of regional export technology complexity on regional green total factor productivity in China by using dynamic GMM model and provincial panel data. We also discussed the interference effect of local government competition in fiscal decentralization, providing a new theoretical explanation for the construction of ecological civilization.

2. Literature Review

The existing literature on regional green total factor productivity covers the measurement of green total factor productivity and the influencing factors of total factor productivity. From the perspective of the measurement of green total factor productivity, the existing literature focuses on the use of stochastic frontier method, DEA, ML index and other methods for measurement. Zhu et al. (2011) [3] included environmental pollution emission and control factors in the production efficiency measurement framework. After constructing environmental comprehensive index to measure relative green GDP, they used translog stochastic frontier model to study the green growth efficiency of China's economy and its influencing factors under environmental constraints. Kuang and Peng (2012) [4], on the premise of relax returns to scale, comprehensively used the generalized Malmquist index and stochastic frontier function model method to analyze and discuss the growth changes of China's production efficiency and total factor productivity under environmental constraints from 1995 to 2009. The results show that environmental production efficiency can better reflect the economic loss caused by environmental pollution to production efficiency than traditional production efficiency, and can better reflect the efficiency difference in resource utilization among provinces and cities. Based on the green economic growth accounting model of DEA, Yang (2011) [5] decomposed the change of labor productivity considering undesired output into the change of technical efficiency, technological progress and capital deepening. Li et al. (2015) [6] calculated and analyzed the green total factor productivity of different industries,

using the non-radial and non-angular SBM efficiency measurement model considering non-expected output and ML productivity index. Wang (2015) [7] calculated China's green total factor productivity and its influencing factors under the constraints of resources and environment by using two-option remodified Russell model based on the double decomposition of green Lohnberg productivity index. Yuan et al. (2015) [8] used SBM directional distance function and Luenberger productivity index, to calculate industrial green total factor productivity and its source decomposition in various regions of China.

From the perspective of the influencing factors of total factor productivity, relevant literature emphasizes the impact of foreign trade, foreign capital and agglomeration on total factor productivity. Peng and Li (2015) [9] found that the low-level expansion of export trade and the effect of global value chain were not conducive to industrial green transformation. Additionally, they found that foreign investment could not effectively promote industrial green transformation, while import trade was. Liu et al. [10] believed that administrative monopoly has a significant inhibitory effect on urban industrial pollution reduction, and the agglomeration development of producer services promotes urban industrial pollution reduction. Yuan et al (2015) [8] studied that foreign investment does not have a significant direct impact on China's industrial green total factor productivity, but it can force China to strengthen the level of environmental regulation. Jing and Zhang (2014) [11] found that the impact of opening to the outside world on China's green technology progress include positive technology spillover effect and negative product structure effect. With the development of domestic R&D, import has a promoting effect on green technology progress, while export has a negative effect on green technology progress.

The prior literatures provide a good research basis for this paper, however, there are still the following aspects to expand: First, the measurement method of green total factor productivity is still relatively single. The ML index method used in most literatures is not only faced with the potential problem that linear programming has no solution, but also faced with the fact that the ML index expressed in the form of geometric average is not cyclic or transitive. The GML productivity index method proposed by Oh (2010) [12] can effectively overcome the above defects. Second, it's relatively general that the literature on the impact of foreign trade and direct investment on green productivity. Additionally, there are still unclear about the mechanism of the impact of export technology complexity on green total factor productivity and the role of government intervention. Based on this, we will deeply study the effect and mechanism of export technology complexity on green total factor productivity, and the intervention effect of government competition under fiscal decentralization.

3. Model Setting and Variable Description

3.1. Model Setting

According to the research purpose, the following simultaneous empirical model is set up.

$$GML_{it} = \alpha + \beta_1 SC_{it} + \beta_2 FDI_{it} + \beta_3 SO_{it} + \varepsilon_{it} \quad (1)$$

$$GML_{it} = \alpha + \gamma_1 SC_{it} + \gamma_2 FD_{it} + \gamma_3 SC_{it} \times FD_{it} + \gamma_4 FDI_{it} + \gamma_5 SO_{it} + \varepsilon_{it} \quad (2)$$

$$Distort_{it} = \alpha + \vartheta_1 FD_{it} + \varepsilon_{it} \quad (3)$$

In the model, GML_{it} represents the regional green total factor productivity, SC_{it} represents the regional export technology complexity, FD represents the degree of regional fiscal decentralization, and ε_{it} represents the random error term.

3.2. Variable Description

Explained variable. GML is regional green total factor productivity. In this paper, the resource and environmental factors are incorporated into the calculation framework of regional green total factor productivity, and the directional distance function and ML index are used to calculate the regional green total factor productivity under the constraints of resources and environment. Referring to Oh (2010) [12], we construct a global production possibility set containing both "good" output (desired output) and "bad" output (undesired output) and then construct a global directional distance function. Based on this, the input-output oriented global Malmquist-Luenberger productivity index is constructed. Actually we study the input-output data of each province and city from 2002 to 2009. Related indicators and data processing of input, desired output and undesired output are explained as follows. In terms of input, labor input is measured by the annual average number of employees in industrial enterprises above designated size in different industries. The relevant data come from the Statistical Yearbook of China Industrial Economy. The capital input was estimated using the perpetual inventory method (Zhang et al., 2003) [13] based on the relevant data of China Statistical Yearbook. The energy consumption is measured by the total energy consumption of each province and city. The data are derived from the total energy consumption tables of different industries in the China Energy Statistical Yearbook, and converted into tons of standard coal according to the conversion coefficient of standard coal, which is derived from the 2012 China Energy Statistical Yearbook. In terms of output, we select the industrial added value above the scale of each province and city as the expected output of each province and city, and the non-expected output is measured by the total amount of industrial wastewater discharge, industrial waste gas discharge and industrial solid waste in each region.

Explanatory variable. SC represents regional export technology complexity. Drawing on Huasmann et al. (2005) [14], Dean et al. (2008) [15], Hummels et al. (2001) [16], Du and Zhang (2013) [17], after excluding the value of imported intermediate inputs included in export commodities, the degree of participation of Chinese provinces and cities in international vertical specialization can be more truly measured and reflected, so as to measure the technical complexity of export of each region.

Table 1. Variable description and data source

Index	Variable	Symbol	Unit	Data source
Green development	Regional green total factor productivity	GML	%	China Statistical Yearbook, China Environmental Statistical Yearbook, China Energy Statistical Yearbook, China Industrial Economic Statistical Yearbook
Technology development	Regional export technology complexity	SC	dollar	World Bank and United Nations trade databases, China input-output basic table and extended table
Government competition	Degree of regional fiscal decentralization	FD	%	China Fiscal Yearbook
Opening to the outside	The amount of foreign capital actually utilized by the region	FDI	%	China Statistical Yearbook
Opening to the inside	Regional structure of state ownership	SO	%	China Industrial Economic Statistical Yearbook

Explanatory variable. FD represents the degree of regional fiscal decentralization. Drawing on Chen and Gao (2012) [18], they described the proportion of local fiscal revenue in the whole national fiscal revenue. At the same time, in order to avoid the error caused by omitted variables, we also controls the important variables. Among them, FDI is the proportion of the actual utilization of foreign capital in regional GDP, which measures the degree of opening to the outside world of the region. Regarding the effect of FDI on regional green development, there is still no consensus in prior literature, some believe it is positive effect while some believe on the contrary. SO is the state-owned ownership structure of each region, measured by the proportion of the total output value of the state-owned economy above the scale in the total industrial output value of each region. It is generally believed that the structure of state-owned economic ownership distorts the regional competition structure and factor price level, reduces the efficiency of resource allocation, so is not conducive to promoting the green development of regional economy.

The data of this paper mainly come from China Statistical Yearbook, China Environmental Statistical Yearbook, China Energy Statistical Yearbook, China Fiscal Yearbook, Non-competitive Input-Output Table, China Industrial Economic Statistical Yearbook, etc.

4. Empirical Analysis Results

4.1. Test for Stationarity

Table 2. Panel unit root test of variables

Variable	Horizontal sequence value			First difference sequence value		
	LLC	ADF-	PP-	LLC	ADF-	PP-
		Fisher	Fisher		Fisher	Fisher
GTFP	9.958*** (0.000)	261.767*** (0.000)	4.153*** (0.000)	10.025*** (0.000)	93.922*** (0.000)	4.638*** (0.000)
FD	-7.284*** (0.000)	71.554** (0.037)	27.434*** (0.000)	-27.084*** (0.000)	163.921*** (0.000)	28.150*** (0.000)
SC	-27.461*** (0.000)	54.626 (0.375)	57.404*** (0.000)	-23.615*** (0.000)	216.536*** (0.000)	53.179*** (0.000)
FDI	-17.649*** (0.000)	124.048*** (0.000)	130.544*** (0.000)	-17.137*** (0.000)	372.795*** (0.000)	109.243*** (0.000)
SO	-6.191*** (0.000)	118.860*** (0.000)	92.478*** (0.000)	-32.735*** (0.000)	204.134*** (0.000)	104.470*** (0.000)

Note: The corresponding P values are in parentheses in the table. *, ** and *** respectively represent the significance level of 10%, 5% and 1%. The null hypothesis of "unit root" is rejected for the variables.

In order to avoid the "spurious regression" problem caused by the non-stationarity of variables and ensure the scientific rationality of the established model, we carried out panel unit root test before using panel data for empirical research. In this paper, unit root test is carried out on panel data in the sample. LLC test, ADF-Fisher test (unit root test under different root conditions) and PP-Fisher test (unit root test under different root conditions) are mainly used to judge whether the variables are stable. The test results are shown in Table 2.

LLC test method carried out unit root test on GTFP, FD, SC, FDI, SO level values and first difference, and the results showed that none of them contained unit root. The ADF-Fisher test method was used to test the unit root of GTFP, FD, SC, FDI and SO levels, in which SC contained unit root and other variables did not contain unit root. However, the ADF-Fisher test for the first difference of GTFP, FD, SC, FDI and SO showed that all variables did not contain unit root. The PP-Fisher test method was used to test the level values of GTFP, FD, SC, FDI, SO and the first difference, which showed that all variables did not contain unit root. It can be seen that the results show that on the whole, the null hypothesis of "existence of unit root" is not rejected for all variables, and therefore, all variables have stationarity. Therefore, it can be considered that there is a long-term stable equilibrium relationship among variables, and the regression residuals of its equations are stable and can be used for regression analysis.

4.2. Analysis of Regression Results

There may be bias and inconsistency of the estimation results if use traditional estimation methods such as ordinary least square method, instrumental variable method and maximum likelihood method to estimate the parameters. However, Arellano and Bover(1995)[19] and Blundell and Bond(1998)[20] pointed out that the generalized moment estimation method is a robust estimator, which does not need to know the exact distribution information of the random error term and allows its heteroscedastic and serial correlation. Therefore, more effective parameter estimators can be obtained than other estimation methods, that is, GMM estimation can solve the problems in the traditional estimation methods of econometric models. Additionally, Arellano Bover proposed that the use of GMM estimation should also judge the validity of instrumental variables and model Settings. Therefore, we use Sargan test and Arellano-Bond AR(2) test in this paper, to judge the rationality of instrumental variables and model setting. In order to verify the robustness of the conclusions of this paper, the first column of this paper is the basic regression results of regional green total factor productivity, and the next three columns are the decomposition terms of regional green total factor productivity, whose estimation results are used as the robustness test of this paper.

From the results of the second-order serial correlation test of each estimation equation and Sargan overidentification, it can be seen that there is no second-order serial correlation in each test model, and there is no overidentification problem of instrumental variables. Therefore, the establishment of the test model in this paper is effective and the estimation results are reliable. At the same time, the coefficient of green total factor productivity in all regions is significant, indicating that the green total factor productivity of the current period is significantly affected by the green total factor productivity of the previous period. Ignoring this relationship may lead to bias in estimation.

Table 3 reports the results of systematic GMM estimation of the relationship between export technology complexity and regional green total factor productivity. The estimated coefficients of export technology complexity are all significant and positive, and have passed the significance test of at least 10%. This shows that the improvement of regional export technology complexity indicates that the region is the enhanced role of international vertical specialization and the upgrading of export product structure, which is conducive to the region environmental protection technology adoption and transformation and upgrading of industrial structure to form positive incentive effect, eventually to promote its green total factor productivity, realize win-win situation of the region's economic development and environmental protection. The regression results of other control variables show that foreign direct investment has a promoting effect on regional green total factor productivity, while state-owned economic ownership structure has a significant inhibitory effect on regional green total factor productivity.

Table 3. Estimation results of export technical complexity and regional green total factor productivity

	Model 1	Model 2	Model 3	Model 4
L.GTFP	0.14876*** (-68.06)	0.26934 (41.84)	0.05695*** (5.25)	0.10293*** (69.13)
SC	0.00002*** (22.53)	0.00002*** (33.16)	0.00205* (1.91)	0.00477*** (13.87)
FDI	0.69076*** (6.18)	0.36112 (4.46)	0.82495*** (5.37)	0.13162 (7.60)
SO	-0.00210*** (-8.76)	-0.00042** (-2.26)	0.00077*** (3.02)	-0.00001* (1.91)
_cons	0.89002*** (35.82)	0.84818*** (45.24)	1.04383*** (20.93)	1.02358*** (206.45)
AR(1)	0.00	0.04	0.02	0.02
AR(2)	0.23	0.96	0.22	0.58
Sargan	0.24	0.22	0.18	0.43

Note: The values in parentheses are the corresponding Z-statistics, and *, ** and *** denote significance at 10%, 5% and 1% levels, respectively. Same as below.

4.3. Extended Analysis

Table 4. Estimation results of fiscal decentralization, export technology complexity and regional green total factor productivity

	Model 5	Model 6	Model 7	Model 8
L.GTFP	0.22165*** (30.50)	0.29863*** (90.74)	0.14503*** (6.11)	0.10852*** (19.38)
SC	0.00003*** (9.73)	0.00008*** (13.53)	0.00005*** (5.32)	0.00004*** (5.68)
FD	-0.14656* (-1.95)	-2.32833*** (-11.28)	-2.79080*** (-10.17)	-1.13888*** (-4.71)
FD*SC	-0.00001* (1.96)	-0.00012*** (-10.15)	-0.00012*** (-8.64)	-0.00007*** (-4.67)
FDI	0.69499*** (3.61)	0.24372* (1.77)	0.37884* (1.65)	0.16244*** (7.30)
SO	-0.00124*** (-3.71)	-0.00035* (-1.88)	-0.00074* (-1.91)	-0.00461* (-1.91)
_cons	0.88858*** (13.31)	-0.17104* (-1.71)	2.33770*** (12.11)	0.46112*** (4.26)
AR(1)	0.00	0.02	0.03	0.02
AR(2)	0.18	0.46	0.13	0.58
Sargan	0.28	0.29	0.20	0.72

Table 4 includes the cross-term between regional fiscal decentralization and regional export technology complexity. We investigate the interference effect of local government competition under the background of fiscal decentralization on the impact of export technology complexity on regional green total factor productivity. The results of dynamic GMM estimation show that the coefficient of the cross-term is significant and negative, and both of them pass the significance test of at least 10%. It indicates that the impact of export technology complexity on regional green total factor productivity is affected by regional fiscal decentralization. Based on the local government competition under the fiscal decentralization degree of mismatch factor market distortions and resources, not only distorts the enterprises to export products to add more technology adoption and innovation incentives, but also inhibited the regional industrial structure upgrade process in the long term, make it fall into the vulgar growth trap of high consumption and high emissions. Eventually it inhibits its green total factor productivity. The regression results of other control variables did not change substantially. Among them, foreign direct investment promoted regional green total factor productivity, while state-owned economic ownership structure inhibited it.

In order to study how fiscal decentralization affects export technology complexity on regional green total factor productivity and its mechanism, we estimate the relationship between fiscal decentralization and regional factor market distortions. Among them, the estimation of regional factor market distortion refers to the practice of Liu (2015) [21] and Lin et al. (2013) [22], and three measures of factor market distortion are set up. The results show that fiscal decentralization plays a significant role in promoting regional factor market distortion under either measure. In other words, local government competition caused by fiscal decentralization intensifies the mismatching of the elements of the region, distorting the price of resources. State-owned enterprises or politically connected enterprises get more factors at lower prices, while non-state-owned enterprises without political connections get factors at higher prices or even get no factors. As a result, enterprises with high pollution and low efficiency do not normally withdraw from the market, while enterprises with low pollution and high efficiency are more likely to be forced to withdraw from the market due to lack of resources. Therefore, it fall into the trap of "high consumption, high emission" extensive growth and eventually have a negative impact on the improvement of green total factor productivity in this region.

Table 5. Estimation results of fiscal decentralization and regional factor market distortions

	Model 9	Model 10	Model 11
L.Dist	0.78398*** (702.21)	0.44698*** (20.86)	0.35742*** (65.64)
FD	1.19872* (16.27)	18.51876** (2.41)	59.64136* (1.82)
_cons	-0.67778*** (-15.83)	2023.151*** (5.49)	603934*** (33.28)
AR(1)	0.03	0.03	0.02
AR(2)	0.38	0.30	0.08
Sargan	0.18	0.24	0.18

4.4. Endogeneity Test

In order to verify the robustness of the above results, the endogeneity test of the empirical model is needed. It is generally believed that endogeneity problems usually arise from

deviations in model Settings (omission of important variables) or interactions between variables. Referring to the customary practice of prior studies, we replaced the current term with the lag term for regression test, and the results are shown in Table 6. According to the results in Table 6, the results of introducing current period variables and later period variables are basically consistent, and the lag period term has a high correlation with the current term, which can effectively avoid the endogeneity problem caused by the correlation between current period variables and residual terms. After introducing lagged one-term estimation, it can be found that the direction and significance of the main variables have not changed fundamentally. Therefore, the conclusion of this paper is robust.

Table 6. Test results of model endogeneity

	Model 12	Model 13	Model 14	Model 15
L.GTFP	0.13448*** (60.52)	0.29879*** (72.70)	0.05599*** (2.95)	0.11062*** (19.77)
SC	0.00003*** (11.45)	0.00007*** (21.30)	0.00002* (1.62)	0.00004*** (5.20)
L.FD	-0.84889*** (-7.85)	-1.57955*** (-20.61)	-0.06999 (-1.14)	-1.18572*** (-4.31)
L.FD*SC	-0.00003*** (-5.07)	-0.00009*** (-16.57)	-0.00002* (-1.88)	-0.00007*** (-3.96)
FDI	1.03281*** (7.36)	0.09863* (1.93)	1.16675*** (4.67)	0.08308* (1.92)
SO	-0.00160*** (-5.55)	-0.00021* (-1.78)	-0.00067*** (-2.64)	-0.00007** (-2.51)
_cons	0.57776*** (10.13)	0.13251*** (2.85)	1.17005*** (4.80)	0.42252*** (3.58)
AR(1)	0.00	0.03	0.01	0.02
AR(2)	0.17	0.47	0.21	0.58
Sargan	0.38	0.47	0.20	0.91

5. Conclusions and Implications

In this paper, the Global-Malmquist-Luenberger (GML) productivity index is used to calculate and evaluate the green total factor productivity and its source decomposition in each region of China, and the dynamic GMM method is further used for our research. The effects of export technology complexity, fiscal decentralization and their interaction on regional green total factor productivity are also discussed. The empirical results show that the increase of export technology complexity has a significant promoting effect on the growth of regional green total factor productivity. The increasing of export technology complexity improves regional international vertical specialization and the upgrading of export product structure, which is conducive to the adoption of regional environmental protection technology and the transformation and upgrading of regional industrial structure. However, it is subject to the interference of regional fiscal decentralization. Local government competition based on fiscal

decentralization intensifies factor market distortion and resource mismatch. It not only distorts the incentives for enterprises to increase technology adoption and R&D and innovation in export products, but also inhibits the upgrading process of regional industrial structure in the long term, making it fall into the trap of extensive growth with "high consumption and high emissions".

Therefore, we point out the policy enlightenment of this paper. First of all, improve the export technology complexity in various regions of China. This paper shows that the increase of export technology complexity is conducive to the growth of regional green total factor productivity. Therefore, we should continue to strive to enhance the participation degree and the division of labor position of China's global value chain through the channels of technological innovation and human capital accumulation, to continue to optimize the regional industrial structure, constantly reduce the labor intensive industries with high consumption and high pollution, and promote the development of capital and technology intensive industries with low consumption and low pollution. Second, improve the performance appraisal system for local officials. This paper finds that local government competition under fiscal decentralization has a restraining effect on the green growth effect of export technology complexity. Therefore, it is necessary to reasonably guide and motivate the competitive orientation and behavior of local governments and officials, change the narrow performance view based on GDP theory, and build a diversified assessment system. Through the process of marketization, it's useful to deepen and constantly optimize the allocation efficiency of resource factors, to form the correct guidance and incentive for regional economic entities, and drive regional innovation driving and industrial transformation and upgrading. Third, promote the level of foreign capital utilization. It's benefit to strengthen the fundamental role of the market in resource allocation, treat social capital and economic entities equally, and reduce ownership discrimination, so as to make ecological progress a new driving force for transformation and upgrading under the new normal.

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