Analysis and Research on the Impact of Productive Service Agglomeration on Green Total Factor Productivity of Service Industry Based on the Moderating Effect of FDI

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Abstract. This paper selects the GML index to measure the green total factor productivity of China's service industry, and empirically examines the effects of productive service industry agglomeration, service industry FDI and their interaction terms on green total factor productivity after fully controlling for the important variables affecting green total factor productivity in service industry. At the regional level, there is regional heterogeneity in the moderating effect of service industry FDI on green TFP, and the joint effect of the two significantly promotes green TFP in the eastern region and negatively affects the central region.

Keywords: Productive service industry; Industrial agglomeration; Foreign direct investment; Green total factor productivity.

1. Introduction

With the increasing national emphasis on accelerating the construction of ecological civilization, green development is the only way to achieve high-quality development, and more and more scholars have begun to pay attention to the environmental effects of service industry development. The past rough growth of service industry is not sustainable, and improving Green Total Factor Productivity (GTFP) of service industry is an inevitable choice to realize green development of service industry.[1] In addition, with the increasing level of opening up of China's service industry to the outside world, the scale of Foreign Direct Investment (FDI) in service industry is expanding, and the actual use of foreign investment in China's service industry accounts for 78.9% of the actual use of foreign investment in the whole industry in 2021, and FDI in service industry gradually becomes an important factor for productivity improvement and environmental pollution in service industry. Therefore, it is of practical significance to explore whether the agglomeration development approach of productive service industry can improve the GTFP of service industry and what kind of moderating effect of FDI on productive service industry agglomeration affecting GTFP exists in the context of service industry opening and development.

2. Theoretical mechanism and model setting

2.1. Mechanism of the effect of agglomeration of productive service industries on GTFP

The impact of the agglomeration of productive service industries on GTFP is uncertain: on the one hand, a large number of enterprises in the same industry converge together to form a market scale, and the convergence of production factors to the enterprise agglomeration makes the production scale of enterprises expand, and the sharing of public social resources and infrastructure facilities makes the R&D cost of green technology of enterprises lower, thus promoting the green total factor productivity of the convergence area, i.e., the economy of scale effect. In addition, enterprises in the agglomeration area both cooperate and compete with each other, high technology and production knowledge flow among enterprises, and mature management mode and scientific corporate structure are improved through mutual learning of enterprises, i.e. spillover effect.[2] At the same time, in order not to be eliminated in the competition, enterprises increase their output by improving resource utilization in order to enhance their competitiveness, which promotes green total factor productivity,

i.e. the competition effect. On the other hand, the agglomeration of productive services may also inhibit GTFP growth. The scale of agglomeration is still small and the level is low. At this time, the agglomeration area does not give full play to the positive effect, and the enterprises cannot obtain benefits such as cost reduction and productivity improvement from the agglomeration effect.[3][4]

2.2. Model Setting

There are two mechanisms of action of productive service industry agglomeration and service industry FDI on service industry GTFP, while the combination of FDI and productive service industry agglomeration affects GTFP, therefore, in order to further verify the relationship between the three, this paper establishes the basic model as shown in equation (1).

$$\ln GTFP_{i,t} = \alpha_1 + \beta_1 \ln lq_{i,t} + \beta_2 \ln fdi_{i,t} + \beta_3 \ln lq_{i,t} \times \ln fdi_{i,t} + \gamma_1 X_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where subscript i denotes region and subscript t denotes time; the explanatory variable is GTFP; the explanatory variables are productive service industry agglomeration (lq), fdi and its interaction term; Xi, t are control variables, including energy consumption structure (lnes), environmental regulation (lner), degree of government intervention (lniner), and energy price (lnep). εi, t is the stochastic disturbance term.

To investigate the moderating effect of heterogeneous FDI, FDI is grouped according to the investment mode, from which the following model is constructed, with equations as shown in equations (2) and (3).

$$\ln GTFP_{i,t} = \alpha_1 + \beta_1 \ln lq_{i,t} + \beta_2 \ln sfdi_{i,t} + \beta_3 \ln lq_{i,t} \times \ln sfdi_{i,t} + \gamma_1 X_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$\ln GTFP_{i,t} = \alpha_1 + \beta_1 \ln lq_{i,t} + \beta_2 \ln jfdi_{i,t} + \beta_3 \ln lq_{i,t} \times \ln jfdi_{i,t} + \gamma_1 X_{i,t} + \varepsilon_{i,t} \quad (3)$$

The above equation sfdii,t denotes wholly owned foreign direct investment and jfdii,t denotes joint venture foreign direct investment.

3. Data indicator selection and processing analysis

3.1. Description of sample variables and data sources

The sample data in this paper are panel data of 30 provinces from 2006 to 2017, and the variables including prices are deflated to constant prices based on the year 2006. The value added and value added deflator of each province are obtained from the official website of the National Bureau of Statistics, and the data of service industry FDI and productive service industry agglomeration are obtained from the statistical yearbook of each province, and some missing data are queried through the statistical bulletin of each province, and then linear interpolation is used to complete the data. The specific variables are selected as follows.

(1) Green Total Factor Productivity Index of service industry. Adding environmental pollution and energy consumption indexes to the economic model of service industry total factor productivity to obtain service industry GTFP is more in line with the current goal of green development and high-quality development, and improving service industry GTFP means achieving a win-win situation for both environmental and economic performance. In this paper, based on the super-efficient SBM model with "non-expected output" and the global reference GML index, we use MaxDEA7 Ultra software to measure the GTFP index of China's service industry, and convert the GML index into the form of cumulative rate of change with 2006 as the base period. The specific input-output indicators and the corresponding calculation are shown in Table 1.

Table 1. Description of DEA model input and output factors

Variables		Calculation method
Input indicators	Labor input	Labor input was estimated using the year-end number of employees according to the following formula.
	Capital input	Capital input is estimated using the perpetual inventory method, and total investment in fixed assets is deflated according to the fixed asset investment index of each province.
	Energy input	The energy consumption of the service sector in each province is based on the regional energy balance sheet of the China Energy Statistics Yearbook (2007-2018), which sums up the terminal energy consumption of "wholesale and retail trade", "accommodation and catering", "transportation, storage and postal services" and "other industries".
Output Indicators	Desired output	Value added of productive service industry. Taking 2006 as the base period, the original value added of production service industry is deflated according to the "Tertiary Industry Value Added Index".
	Non-desired output	Emissions from the service sector in each province as the non-desired output.

(2) Productive service industry agglomeration index (lq). The measurement methods of industrial agglomeration include HHI index, EG index, Krugman index, location entropy and employment density index. Based on the different data availability and analysis focus, this paper measures the degree of agglomeration of productive service industry with the location entropy index of productive service industry, which fully reflects the difference between the industrial composition of a region and the national average level. See equation (4) for details.

$$lq = \frac{ps_i}{s_i} / \frac{ps}{s} \tag{4}$$

Where psi denotes the total number of employees in the productive service industry in region i, ps denotes the total number of employees in the productive service industry nationwide, and si and s denote the total number of employees in the whole industry in region i and nationwide, respectively. If lq is greater than 1, it means that the share of productive service industry in the region's employment is greater than the share of productive service industry in the whole economy, indicating that the region has a comparative advantage in productive service industry agglomeration compared with the whole country; if lq is less than 1, the opposite is true.

(3) FDI in service industry. this paper adopts the proportion of the actual use of foreign investment in service industry to the value added of service industry to indicate the level of foreign investment in service industry in each province. In the grouping of FDI according to the investment mode, considering that the proportion of cooperative operation does not exceed 10% during the sample period, and many provinces and cities do not have data on other investment modes, only sole proprietorship (SFDI) and joint venture (JFDI) are considered in this paper. Since Liaoning, Jilin, Heilongjiang, Sichuan, and Xinjiang do not publish data on sole proprietorship FDI and joint venture FDI or have more missing values, the above provinces are excluded from the FDI heterogeneity analysis, and the panel data of 25 Chinese provinces and cities from 2006-2017 are selected.

(4) Control variables

The higher the degree of government intervention, the stronger the local government's ability to allocate resources and protect the local market, which is not conducive to regional market integration of service industry and green total factor productivity enhancement. In this paper, the share of regional government fiscal expenditure in local GDP is used as a measure.

3.2. Data processing

In this paper, 30 provinces (municipalities and autonomous regions) from 2006-2017 were selected as the decision-making unit (Tibet, Hong Kong, Macao and Taiwan were excluded due to serious

missing data) as the basic data. The sample data were obtained from China Statistical Yearbook, China Energy Statistical Yearbook, China Tertiary Industry Statistical Yearbook, and regional statistical yearbooks from 2007-2018, and some missing data were obtained by interpolation method. Before the empirical analysis, outliers were processed in this paper, and all data were logarithmized in order to eliminate the interference of heteroskedasticity and the problem of dimensionality. The descriptive statistics of each variable are shown in Table 2.

Table 2. Descriptive statistics of the variables

Variable	Variable Description	Observed value	Average	Standard deviation	Minimum value	Maximum value
GTFP	Green Total Factor Productivity	360	1.063	0.167	0.713	1.933
lq	Productive service industry location entropy	360	1.013	0.348	0.635	2.546
fdi	Foreign Direct Investment	360	0.023	0.022	0.0003	0.124
sfdi	Sole Proprietorship FDI	300	0.019	0.018	0.001	0.108
jfdi	Joint Venture FDI	300	0.008	0.014	0.0001	0.179
es	Energy Consumption Structure	360	0.160	0.156	0.001	0.696
er	Environmental Regulation	360	1.372	0.688	0.300	4.240
iner	Degree of Government Intervention	360	0.222	0.096	0.084	0.627
ep	Energy Price Index	360	1.460	0.213	1.058	2.311
GTFP	Green Total Factor Productivity	360	1.063	0.167	0.713	1.933

3.3. Data processing

The OLS model is used in this paper, where column (1) shows the result of testing the effect of productive service agglomeration on green total factor productivity alone, and column (2) is based on column (1) with the addition of control variables. Column (3) shows the results of adding the interaction term of productive service industry agglomeration and FDI to explore the effect of industry agglomeration and FDI linkage on green total factor productivity. The regression results are shown in Table 3.

Table 3. Econometric Regression Results of Productive Services Agglomeration, FDI Impact on GTFP

Explanatory variables	Variables (1)	Variables (2)	Variables (3)
lnlq	0.227*** (8.04)	0.287*** (11.38)	0.533*** (4.44)
lnfdi			-0.013* (-1.74)
lnlq×lnfdi			0.065* (1.85)
lnes		-0.023*** (-4.58)	-0.025*** (-4.76)
lner		-0.025 (-1.62)	-0.028* (-1.86)
lniner		-0.141*** (-7.81)	0.020*** (-8.24)
lnep		0.280*** (5.39)	0.273*** (5.32)

_cons	0.056***	-0.321***	-0.422***
	(7.63)	(-8.42)	(-6.96)
R^2	0.1506	0.3760	0.3901

From the empirical results in columns (1) and (2), the agglomeration of productive service industries has a significant contribution to service industry GTFP. As the agglomeration of productive service industries increases, enterprises in agglomeration areas benefit from the economies of scale effect, share specialized labor resources, public social resources, and help enterprises open access to information on intermediate inputs such as financing and leasing, R&D and design, information services, logistics channels to enhance the added value of enterprise technology and product quality. The large concentration of production factors, knowledge, technology and information greatly reduces the search cost, production cost, transaction cost and innovation cost of enterprises. The knowledge and technology spillover effect among enterprises in the agglomeration area makes enterprises learn efficient management mode from each other, compete with each other to improve their own innovation ability, and improve the utilization efficiency and allocation ability of production factors, thus promoting the total factor productivity of enterprises. In addition, green technology spillover promotes the research and development and application of green and low-carbon technology and process, reduces the pollution emission of production and the centralized treatment of pollutants to improve environmental pollution.

To further investigate the regional differences in the impact of FDI on GTFP, this paper divides the overall 30 samples into three regional samples of eastern, central and western regions for analysis.

Table 4. Econometric Regression Results of Analyzing Productive Services Agglomeration, FDI Influencing GTFP in Sub-regional Sample

Explanatory variables	Explanatory variables					
	Eastern Region		Central Region		Western Region	
	(1)	(2)	(3)	(4)	(5)	(6)
lnlq	0.247***	0.674***	-0.094	-3.549***	0.105	0.121
	(8.07)	(3.35)	(-0.57)	(-2.75)	(1.20)	(0.33)
lnfdi		-0.031**		-0.119***		-0.024**
		(-2.21)		(-2.74)		(-2.27)
lnlq×lnfdi		0.128**		-0.826***		-0.017
		(2.10)		(-2.68)		(-0.24)
lnes	-0.063***	-0.066***	-0.012	-0.011	0.003	0.001
	(-7.90)	(-8.15)	(-1.21)	(-1.21)	(0.36)	(0.15)
lner	0.062**	0.053**	-0.222***	-0.235***	0.042*	0.032
	(2.43)	(2.03)	(-7.58)	(-8.15)	(1.87)	(1.42)
lniner	-0.040	-0.009	0.100	0.091	-0.241***	-0.280***
	(-1.13)	(-0.24)	(1.27)	(1.17)	(-8.30)	(-8.56)
lnep	0.246***	0.086**	-0.002	0.015	0.273***	0.307***
	(2.92)	(2.60)	(-0.02)	(0.14)	(3.73)	(4.18)
_cons	-0.246***	-0.307***	0.178	-0.350	-0.416***	-0.594***
	(-3.24)	(-3.88)	(1.17)	(-1.46)	(-8.26)	(-6.67)
R^2	0.5331	0.5578	0.4208	0.4573	0.3735	0.3930

Columns (1)-(2) of Table 4 show similar regression results for the eastern region and the overall national sample, differing only in the magnitude of the coefficients, where the introduction of FDI negatively affects the service sector GTFP, but the linkage between FDI and the agglomeration of productive services promotes the growth of GTFP. This may be attributed to the progressively stricter environmental regulatory measures and higher quality standards for attracting FDI in the eastern region.

The results in columns (3)-(4) show a significant difference in the central region, where there is no significant effect of productive service industry agglomeration on service industry GTFP. The coefficients are -3.549 and -0.826, respectively, which may be explained by the "pollution refuge" hypothesis. In 2006, nearly 40% of the capital investment of China's three enterprises was invested in pollution-intensive industries, which brought a significant negative impact on the construction of ecological civilization and green development in China.[5] brought a significant negative impact. In the 21st century, the service industry in eastern provinces of China developed rapidly, and the investment field of FDI gradually shifted from the secondary industry to the service industry, while with the increasingly strict environmental control and rising labor cost in the eastern region, many foreign enterprises shifted their production or industries to inland central cities, resulting in the crude growth in the central region, and the introduction of FDI played a negative impact on the service industry GTFP.[6][7]

4. Conclusion

This paper develops a theoretical framework to analyze the direct and indirect effects of productive service agglomeration and FDI on GTFP, and empirically investigates the direct effect of productive service agglomeration on service GTFP and the indirect effect of productive service agglomeration and FDI on GTFP. At the national level, productive service industry agglomeration has a significant positive effect on service industry GTFP, and service industry FDI significantly suppresses the growth of service industry GTFP, but the combination of service industry FDI and productive service industry agglomeration has a significant promotion effect on service industry GTFP. At the regional level, there is significant heterogeneity in the effects of productive service industry agglomeration and FDI introduction on service industry GTFP in East and West China.

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