Study on the Theil Index of FDI Regional Differences in the Yangtze River Economic Zone

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Abstract: There are obvious regional differences in FDI among provinces and cities in the Yangtze River Economic Zone of China. Based on the panel data of the Yangtze River Economic Zone from 1985 to 2018, this paper makes a theoretical and Empirical Analysis on the regional differences of FDI based on the Theil index. The results show that technological progress, industrial system, urbanization rate, opening degree and human capital will all have an impact on the regional differences of FDI in the Yangtze River Economic Zone.

1. Introduction and Literature Review

Since China joined the WTO in 2001, the Yangtze River Economic Zone has made tremendous achievements and attracted a large number of FDI. Under the new situation, how to promote the coordinated and high-quality development of the Yangtze River Economic Belt is an important strategy for the overall development of the country. However, in the process of economic development, the differences among provinces and cities in the Yangtze River Economic Zone are inevitable, and there are also many problems. Especially, the unbalanced development of economic strength and speed between provinces or cities has become the main obstacle and bottleneck restricting the coordinated development of the Yangtze River Economic Zone.

The fact that there are significant differences in FDI in the Yangtze River Economic Zone has attracted great attention of scholars. Based on panel data of 104 cities in the Yangtze River Economic Zone, Li Qiang (2019) used panel model to empirically analyze the impact of fiscal decentralization and FDI on regional environmental pollution, pointing out that fiscal decentralization and FDI are substituted for each other, and developing export-oriented economy is conducive to reducing the level of environmental pollution; Tang Yan (2019) selected panel data from 1997 to 2016 and analyzed FDI and trade circulation through dynamic correction error model. The results show that there are obvious differences between FDI and commercial circulation industry in the economic growth effect of China and the east, middle and West regions. The promotion effect of FDI on GDP in eastern region is less than that of commercial circulation industry, the promotion coefficient and efficiency of FDI in central region is higher, and the promotion coefficient and efficiency of commercial circulation industry in western region is higher; Xu Jianzhong and Zhao Yanan (2) 019) Aiming at the problem of regional sustainable transformation and growth, this paper constructs J-SBM model, nuclear density function model and non-linear panel regression model, and points out that the threshold effect of FDI knowledge spillover has obvious spatial-temporal heterogeneity. Jiang Hanming (2019) empirically analyses the innovation promotion effect of FDI knowledge spillover based on the panel data of China from 1997 to 2016, and points out the informatization level of different regions. It is suggested that the western region should improve the efficiency of FDI knowledge spillover by improving the institutional environment and technological innovation ability.

The existing literature on the regional differences of FDI in the Yangtze River Economic Zone of China mainly focuses on the interaction between FDI and other important factors, but seldom separately analyses the regional differences and causes of FDI in the Yangtze River Economic Zone. In order to make up for the shortage of the existing literature, this paper uses the provincial (municipal) regional economic unit to study the economic development level of nine provinces and two cities in the Yangtze River Economic Zone quantitatively. Through the Theil Index and panel data model, this paper investigates the fact that the regional differences of FDI in the Yangtze River Economic Zone

have changed since 1985, and uses the index decomposition to analyze the key factors of the regional differences of FDI. When introducing FDI, the same provinces and municipalities should accurately locate and dislocate the development, and promote the complementary advantages and organic integration between provinces and municipalities.

2. Theil Index of Regional Differences in FDI

2.1 Theil index

Because of the additive decomposability, Theil index can measure the regional differences of FDI in the Yangtze River Economic Zone by decomposition within and between groups, so as to measure the economic differences among the five major urban agglomerations, and analyze the causes of the differences. When the Theil index is greater than or equal to 0, the smaller the absolute value, the smaller the regional difference, and vice versa.

Symbols are set up and specified in the following table:

Table 1 Symbol Establishment and Specific Description

Symbol	Symbolic explanation
i	Urban Agglomeration in the Yangtze River Economic Belt
j	Provinces in Urban Agglomeration
GDP	Gross GDP in the Yangtze River Economic Zone
FDI	Total FDI in the Yangtze River Economic Zone
GDP_{ij}	i Urban Agglomeration j Province's GDP
FDI_{ij}	i Urban Agglomeration j Provincial Flow
T_i	Differences between provinces in Urban Agglomerations
T_{BR}	Differences among Five Urban Agglomerations
T_{WR}	Total Differences within Five Urban Agglomerations
tec	Technological progress (R&D expenditure as a proportion of GDP)
ind	Industrial system (the proportion of added value of tertiary industry to GDP)
urb	Urbanization rate (proportion of non-agricultural population to total population)
$open$	Openness (ratio of total imports and exports to regional gross domestic product)
hum	Human capital (ratio of the number of students in general higher education and postgraduate education to the total population)
ε_{ij}	Random error term

The formula for calculating the Theil index, which reflects the regional differences of FDI in the Yangtze River Economic Zone, is as follows:

$$
\begin{cases}
T = \sum_i \sum_j \left(\dfrac{GDP_{ij}}{GDP} \right) \ln \left(\dfrac{GDP_{ij}/GDP}{FDI_{ij}/FDI} \right) \\[2ex]
T_{BR} = \sum_i \dfrac{GDP_i}{GDP} \ln \left(\dfrac{GDP_i/GDP}{FDI_i/FDI} \right) \\[2ex]
T_{WR} = \sum_i \left(\dfrac{GDP_i}{GDP} \right) T_i \\[2ex]
T_i = \sum_i \sum_j \left(\dfrac{GDP_{ij}}{GDP_i} \right) \ln \left(\dfrac{GDP_{ij}/GDP_i}{FDI_{ij}/FDI_i} \right) \\[2ex]
T = T_{BR} + T_{WR}
\end{cases}
\tag{1}
$$

2.2 Analysis of Theil Index

The total area of the Yangtze River Economic Zone, which accounts for about one fifth of the country, has more than two fifths of the population and nearly one fifth of the country's GDP, is an important engine of China's development. According to the ranking of the comprehensive strength of the five urban agglomerations in the Yangtze River Economic Zone, the Yangtze River Economic Zone is divided into five spatial units: the Yangtze River Delta (with Shanghai, Hangzhou, Nanjing and Hefei as the core), the middle reaches of the Yangtze River (with Wuhan, Changsha and Nanchang as the core), Chengdu and Chongqing as the core, Guizhou (with Guiyang as the core) and central Yunnan (with Kunming as the core). Core). The calculated results and charts of Theil index, which reflect the regional differences of FDI in the Yangtze River Economic Zone, are as follows:
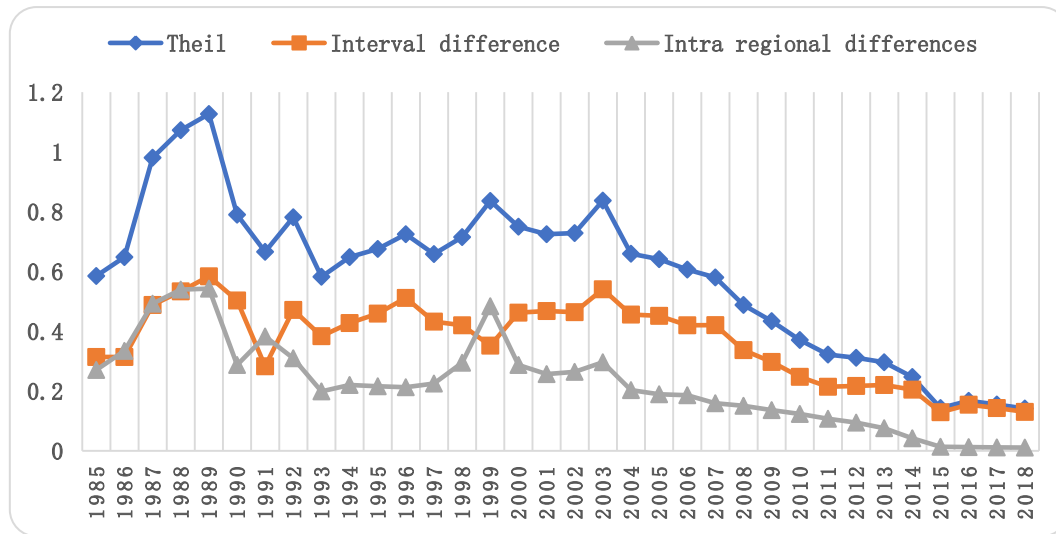

Figure 1 Theil Index Trend Chart

From Fig. 1 and Table 2, we can see that the regional differences of FDI in the Yangtze River Economic Zone have shown a trend of fluctuation and decline under the background of China's expanding opening up since 1985. Among them, 1985-1992 is the most violent period of fluctuation of the Theil index of regional differences in FDI. The regional differences of FDI in 1992-2012 keep a slowly decreasing trend, and the Theil index of regional differences in FDI has been declining since 2012. Through the decomposition of Theil index, it is found that in 1985-1999, the regional difference of FDI in the Yangtze River economic belt was mainly caused by the internal difference of "five major urban agglomerations"; in 2000-2018, the regional difference of FDI in the Yangtze River economic belt was mainly caused by the regional difference of "five major urban agglomerations"; it is worth noting that since 2015, the regional difference of FDI in the Yangtze River economic belt caused by the regional difference of "five major urban agglomerations" The contribution degree is far greater than the regional difference.

The trend of FDI changes accords with the characteristics of economic changes since China's reform and opening up. From 1985 to 1992, China adopted gradual reform. Through the continuous exploration of the objective model and practical path of reform and opening-up, China gradually expanded the space and scope of opening-up to the outside world. As one of the core areas of China's economic development, the Yangtze River Economic Zone, under the influence of location factors, mainly concentrated in the eastern coastal areas. The proportion of FDI in the central and western regions was relatively small, so the FDI region was located in the Yangtze River Economic Zone. From 1992 to 2012, the central and western regions continuously strengthened their industrial matching and factor agglomeration capabilities, relying on the conditions of national policy support, economic restructuring and upgrading, and industrial diversification development, promoted the continuous improvement of the level of FDI utilization, promoted the increase of FDI in the number of central and Western regions, and further reduced the "five cities" in the Yangtze River Economic Zone. The regional differences of FDI among groups; since 2013, on the premise that China's

reform and opening-up has entered a new stage of development, China has continuously carried out structural adjustment and industrial upgrading, attracting a large number of FDI into the "five major urban agglomerations" of the Yangtze River Economic Zone, which has brought the regional differences of FDI in the Yangtze River Economic Zone into a new stage.

Table 2 Static Decomposition of FDI Regional Differences in the Yangtze River Economic Zone from 1985 to 2018

Particular year	Overall difference	Interregional differences	Intra-regional differences	Interregional disparity ratio	Intraregional disparity ratio
1985	0.5851	0.3142	0.2709	53.70%	46.30%
1986	0.6483	0.3140	0.3343	48.43%	51.57%
1987	0.9807	0.4881	0.4926	49.77%	50.23%
1988	1.0730	0.5334	0.5396	49.71%	50.29%
1989	1.1268	0.5840	0.5428	51.83%	48.17%
1990	0.7903	0.5029	0.2874	63.63%	36.37%
1991	0.6658	0.2832	0.3826	42.54%	57.46%
1992	0.7816	0.4717	0.3099	60.35%	39.65%
1993	0.5826	0.3836	0.1990	65.84%	34.16%
1994	0.6483	0.4279	0.2204	66.00%	34.00%
1995	0.6755	0.4594	0.2161	68.01%	31.99%
1996	0.7249	0.5119	0.2130	70.62%	29.38%
1997	0.6582	0.4327	0.2255	65.74%	34.26%
1998	0.7151	0.4203	0.2948	58.77%	41.23%
1999	0.8359	0.3522	0.4837	42.13%	57.87%
2000	0.7497	0.4622	0.2875	61.65%	38.35%
2001	0.7249	0.4680	0.2569	64.56%	35.44%
2002	0.7283	0.4639	0.2644	63.70%	36.30%
2003	0.8372	0.5407	0.2965	64.58%	35.42%
2004	0.6593	0.4559	0.2034	69.15%	30.85%
2005	0.6414	0.4520	0.1894	70.47%	29.53%
2006	0.6065	0.4203	0.1862	69.30%	30.70%
2007	0.5800	0.4208	0.1592	72.55%	27.45%
2008	0.4879	0.3371	0.1508	69.09%	30.91%
2009	0.4338	0.2973	0.1365	68.53%	31.47%
2010	0.3708	0.2475	0.1233	66.75%	33.25%
2011	0.3224	0.2148	0.1076	66.63%	33.37%
2012	0.3117	0.2172	0.0945	69.68%	30.32%
2013	0.2963	0.2202	0.0761	74.32%	25.68%
2014	0.2473	0.2051	0.0422	82.94%	17.06%
2015	0.1432	0.1295	0.0137	90.43%	9.57%
2016	0.1674	0.1546	0.0128	92.35%	7.65%
2017	0.1550	0.1432	0.0118	92.39%	7.61%
2018	0.1415	0.1305	0.0110	92.23%	7.77%

3. Model Establishment and Empirical Analysis

3.1 Model establishment

From the above analysis of the Theil index of FDI regional differences in the Yangtze River Economic Zone, we can see that the regional differences in the Yangtze River Economic Zone are shrinking on the basis of domestic and foreign literature. In order to ensure the integrity and

reliability of empirical research, this paper chooses relevant important factors to construct the following multiple linear regression model:

$$FDI_{ij} = \beta_1 GDP_{ij} + \beta_2 tec + \beta_3 ind + \beta_4 urb + \beta_5 open + \beta_6 hum + \varepsilon_{ij} \qquad (2)$$

Among them, GDP, technological progress, industrial system, urbanization rate, openness to the outside world and human capital are the variables, while the actual FDI of the provinces and cities in the Yangtze River Economic Zone is the explanatory variable. All data in this paper are selected from national and provincial statistical bulletins.

3.2 Empirical analysis

In this paper, we use Excel to carry out multiple regression analysis of variables. The results of calculation of related variables are as follows:

Table 3 Relevant Variables Calculations

Variable	Coefficient	P value
GDP	0.35	0.0000
tec	21.68	0.0020
ind	-2.04	0.0000
urb	-0.82	0.1476
open	0.86	0.0000
hum	6.43	0.3582
R^2	0.853199	
F	185.013	

The multivariate linear regression model is as follows:

$$FDI_{ij} = 0.35 GDP_{ij} + 21.68 tec - 2.04 ind - 0.82 urb + 0.86 open + 6.43 hum + 74.85 \qquad (3)$$

It can be seen from the statistical results and the equations that if other conditions remain unchanged, $\beta_1 = 0.35$ means that every 100 million yuan increase in GDP, FDI increased by an average of \$0.35 billion; $\beta_2 = 21.86$ indicates that for every 1 percentage point increase in R&D expenditure as a share of GDP, FDI increased by 21.86 percentage points; $\beta_3 = -2.04$ indicates that the proportion of added value of tertiary industry to GDP increases by 1 percentage point, while FDI decreases by 2.04 percentage points; $\beta_4 = -0.82$ indicates that for every 1 percentage point increase in urbanization rate, FDI decreases by 0.82 percentage points; $\beta_5 = 0.86$ indicates that the ratio of total import and export to GDP increased by 1 percentage point and FDI increased by 0.86 percentage point; $\beta_6 = 6.43$ shows that the ratio of the number of students in general higher education and postgraduate education to the total population increases by 1 percentage point, and FDI increases by 6.43 percentage points.

The positive coefficients of GNP, technology level, openness to the outside world and human capital on regional differences of FDI in 11 provinces and cities of the Yangtze River Economic Belt indicate that the improvement of the four factors will help to enhance the attractiveness of FDI to a certain extent and provide good development opportunities for foreign investors. Moreover, technological level and human capital have the greatest influence coefficient, which indicates that scientific and technological progress and personnel training have an obvious role in promoting the development of modern economy and society.

The industrial system and urbanization rate of 11 provinces and cities in the Yangtze River Economic Zone have a negative impact on the regional differences of FDI, which shows that the optimization and improvement of the two factors are not conducive to the introduction of FDI in theory, but not in line with practical significance. The upgrading of industrial structure and the improvement of urbanization level will further affect the transformation of FDI from cost-oriented to market-oriented, promote the formation of new FDI models and mechanisms, and further narrow

the regional differences of FDI in the Yangtze River Economic Zone.

4. Conclusions and suggestions

This paper studies the regional differences of FDI in the Yangtze River Economic Zone by using the Theil Index. It is found that since the reform and opening up, FDI has developed rapidly in general and the regional differences in the Yangtze River Economic Zone in China are shrinking. However, it has become an indisputable fact that "the regional differences of FDI are mainly caused by the differences among the five major urban agglomerations". Based on the empirical analysis of the influencing factors of FDI regional differences in the Yangtze River Economic Zone, this paper studies the important roles played by technological progress, industrial system, urbanization rate, openness to the outside world and human capital in influencing FDI regional differences. The results show that technological progress and human capital have the greatest impact on FDI regional differences, while other factors have relatively small impact.

At present, China has become the world's net capital exporter and the world's second largest foreign direct investment country. The Yangtze River Economic Zone has played an important role in the "introduction" and "going out" of capital. However, the long-term existence of FDI regional differences among the "five major urban agglomerations" in the Yangtze River Economic Zone will affect the high-quality economic development of the Yangtze River Economic Zone for a long time. In view of this, it is necessary to continue to play the basic role of macro-control and market mechanism of the central government and local government, rationally guide the distribution and investment of FDI among provinces and cities in the Yangtze River Economic Zone, effectively utilize the role of FDI in promoting economic development, and promote the coordinated development of the "five major urban agglomerations" in the Yangtze River Economic Zone.

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