Industrial Agglomeration, IFDI and Economic Growth in Western China

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Abstract. Both industrial agglomeration and inward foreign direct investment (IFDI) are drivers of China's economic development. However, their distributions are unbalanced. Both are large in eastern regions, similar to the distribution of the GDP in China. It indicates there may be a relationship between them. Based on it, the paper selects fixed effects model to analyse the relationships among GDP, IFDI and the industrial agglomeration in China regarding different regions and time horizons, and finds that on the whole, the industrial agglomeration and IFDI do promote the regional economic growth stably during different periods, while both are much stronger in the western regions and central regions. The paper also finds the coefficient of their interaction item is significantly negative, which implies the transmission mechanism between IFDI and industry agglomeration is inefficient. To promote the balanced economy development of different regions, the paper suggests that China should improve the quantity and quality of industrial agglomeration and the IFDI to increase the coordinated development of both in different regions.

1 Introduction

China's GDP has seen a rapid growth over the past four decades, while the growth was mainly driven by the eastern coastal areas-provinces in the west only accounted for 20.86% in 2020. This regional economic development imbalance has hindered the improvement of living standards and sustainable development of China's economy.

Apart from the phenomenon of unbalanced economy development, the distribution of industrial agglomeration and IFDI is also unbalanced in China--especially higher in eastern coastal areas [1-2]. Some scholars find some potential relationships between industrial agglomeration, IFDI and GDP. For industrial agglomeration, Williamson Hypothesis states that spatial agglomeration has a threshold effect on economy [3], mainly through the enrichment of capital, labor and other production factors to specific regions [4-6]. Besides, the IFDI is also concentrated in China's eastern regions. The Yangtze River Delta, Pearl River Delta and Bohai Rim regions have become main places for IFDI. In September 2019, there were about 2000 regional headquarters of TNCs established in Eastern China, including 705 in Shanghai, about 400 in Guangdong and 200 in Beijing. Double Gap Model points out that foreign capital can make up for the shortage of domestic capital, and the spillover effect of IFDI helps promote country's economy [7]. IFDI acts as a significant channel for technology transfer, and its impact is stronger than domestic investment [8-10]. For China, Cui Jianjun and others (2014) finds the correlation between IFDI and GDP is significantly positive. However, from eastern coastal areas to central and western regions, the relationship shows a trend from strong to weak [11].

In open economy, industrial agglomeration may interact with IFDI. The Core-periphery Model proposed by Krugman Paul (1991) points out that the evolution of the industrial production activities' spacial pattern in a region will attract IFDI by economies of scale effect [12]. This view is proven by many other scholars [13]. In turn, IFDI also helps increase industrial agglomeration by providing global vision and advanced technology for industrial clusters [14]. Some scholars find there is a "threshold effect" between IFDI and industrial agglomeration [15-16].

The phenomenon of the similar distribution characteristics of regional GDP, IFDI and industrial agglomeration in China enlightens that China's regional GDP is likely to be impacted by both regional IFDI and industrial agglomeration to a certain extent. However, the existing research is insufficient on this topic. Although the relationship between them has attracted the attention of some scholars, it is still in the starting stage. And there are some differences in empirical results about the relationship of them.

Based on the New Economic Geography framework, we introduce the industrial agglomeration and other factors into the empirical model, and establish an analytical framework of the IFDI, industrial agglomeration and regional economic development under the open economy condition. Then, we focus on

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how the IFDI and industrial agglomeration affect regional GDP in directly and indirectly, and how the effect changes with periods and regions. Lastly, based on the results, we give suggestions for China on improving the balanced development among different regions.

2 Variables and research design

2.1 Main variables

Three sets of variables are used in our empirical analysis.

The dependent variable is the regional GDP of each province in China. Independent variables include IFDI (*IFDI*), agglomeration index (*Agg*), control variables include R&D (*RD*), fixed asset investment (*FAI*), human capital (*HC*), fiscal expenditure (*FE*) and infrastructure (*INF*). The explanations and calculations of these variables are displayed in Table 1.

Table 1. Variables and definitions.

Variable	Definition
Dependent variable	
GDP	The GDP of each province in China (in 100 million RMB).
Independent variables	
IFDI	Actual amount of foreign direct investment inflow in each province (in 100 million RMB).
Agg	We use the Location Entropy Index to measure the industrial agglomeration level of each region, this measure has the advantage of eliminating the impact of area's differences on each province. The calculation of this index is listed below, where e represents the industrial added value, E represents the added value of all industries, i represents the i th province. $$Agg_i = (e_i / E_i)/(e / E) \quad (1)$$ Generally, the larger the index, the higher the level of industrial agglomeration.
Control variables	
RD	*Weighted average number of patents of industrial enterprises*=0.5**number of invention patents granted*+0.3**number of utility model patents granted*+0.2**number of design patents granted*.
FAI	Proportion of fixed asset investment in GDP.
HC	Average education years of employees. $$HC = (0*x_1 + 6*x_2 + 9*x_3 + 12*x_4 + 15*x_5 + 16*x_6 + 19*x_7)/x \quad (2)$$ Where x refers to the number of employees who have never attended school, graduated from primary school, junior middle school, senior middle school, college, bachelor's degree and doctor's degree or above respectively.
FE	Proportion of total fiscal expenditure in GDP.
INF	Sum of railway and highway mileage, divided by the area of each province.

Considering data availability, this paper selects data from 30 provinces (excluding Tibet due to the lack of data) in Chinese mainland from 2006 to 2017. Data sources include the China National Bureau of Statistics, China Statistical Yearbook, China Education Statistical Yearbook and China Industrial statistical yearbook.

Considering the need of logarithm and that the value of many variables is less than 1, we plus them by 1 before logarithm to reduce the amount of negative value. Table 2 shows the descriptive statistical analysis of each variable after logarithm.

Table 2. Descriptive statistical analysis.

Variable	Mean	Variance	Min	Max
LnGDP	9.4090	0.9440	6.4747	11.4043
LnIFDI	4.9701	2.0990	2.8708	7.7219
LnAgg	0.7050	0.1099	0.3060	0.8442
LnHC	2.3350	0.1150	2.0208	2.6835
LnRD	8.1111	1.5682	3.5234	11.4841
LnFAI	0.5240	0.1382	0.2123	0.9081
LnFE	0.1977	0.0751	0.0804	0.4867
LnINF	0.5978	0.2671	0.0663	1.1558

2.2 Research design

Through analysis of the phenomenon and literature, IFDI and industrial agglomeration can not only directly affect GDP through their own mechanism, but also indirectly affect GDP by interacting with industrial agglomeration. Thus, the empirical model of this paper is:

$$LNGDP_{it} = \beta_i + \beta_1 LNFDI_{it} + \beta_2 LNAgg_{it} + \beta_3 LNFDI_{it} \times LNAgg_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (3)$$

Where i represents the i th region and t represents the t th period. In this model, the dependent variable is *LnGDP*, independent variables are *LnIFDI*, *LnAgg,* and the interaction of them, *LnIFDI*×*lnAgg*. X_{it} are the control variables, ε_{it} is the random disturbance term.

2.3 Model choice

Here, through Cross-sectional Correlation Test, LM Test and Hausman Test, we find fixed effects model is more suitable for our data. The test statistics are shown in Table 3.

Table 3. Choice of model.

Test	Test Statistics	Conclusion
Pesaran's test	10.860***	Fixed effects model is better than mixed regression model
Breusch and Pagan Lagrangian multiplier test	1224.41***	Random effect model is better than mixed regression model
Hausman Test	88.55***	Fixed effects model is better than random effect model

3 Empirical results and analysis

First, we study how the independent variables impact China's GDP respectively.

Table 4 shows that both IFDI and industrial agglomeration can significantly promote China's whole GDP, and the positive impact is stable after adding more variables. However, the interaction item, *LnIFDI×LnAgg* has an inhibitory effect on economic growth. In addition, R&D, fixed asset investment, human capital, fiscal expenditure and infrastructure have a positive effect on China's economic growth.

Table 4. Regression results.

Variable	Model 1	Model 2	Model3
LnIFDI	.0410069***)3.18(		.1058566** (2.36)
LnAgg		.6809188*** (5.10)	1.16366*** (3.53)
LnIFDI×LnAgg			-.112394* (-1.84)
LnHC	1.352816***)7.61(	1.198063*** (6.84)	1.21708*** (6.98)
LnRD	.2750186*** (13.75)	.2770507*** (14.26)	.2764625*** (14.19)
LnFAI	.2006642** (2.23)	.1623998* (1.84)	.1610348* (1.83)
LnFE	1.053201*** (3.30)	1.438143*** (4.45)	1.384611** (4.30)
LINF	1.716314*** (8.05)	1.850166*** (9.09)	1.763847*** (8.53)
Constant	2.476401*** (7.78)	2.40892*** (7.74)	1.966966*** (5.28)
Hausman test Chi2= 131.28, P-value=0.0000			

Does the impact change over time? We sub-divide the time period into year 2006-2011 (period 1) and 2012-2017 (period 2). From Table 5, we still find IFDI and industrial agglomeration have a positive effect on economic growth in both periods, and the coefficient and the significance increase with time. This implies that IFDI and industrial agglomeration is playing a more and more important role in China's GDP growth. The interaction item, *LnIFDI×LnAgg*, is not significant at the 90% confidence level in the year 2006-2011, while significant in the next period. This means the interaction of IFDI and industrial agglomeration will offset part of the positive impact on GDP. In addition, the coefficients of control variables are significant and positive in different periods.

Table 5. Regression results by period.

Variable	Period 1 (2006-2011)	Period 2 (2012-2017)
LnIFDI	.0877549* (1.78)	.1058566** (2.36)
LnAgg	1.06682*** (3.03)	1.16366*** (3.53)
LnIFDI×LnAgg	-.0892074 (-1.34)	-.112394* (-1.84)
LnHC	1.226498*** (6.98)	1.21708*** (6.98)
LnRD	.2702717*** (13.08)	.2764625*** (14.19)
LnFAI	.193055** (2.06)	.1610348* (2.39)
LnFE	1.384793*** (4.21)	1.384611*** (4.30)
LINF	1.772934*** (8.16)	1.763847*** (8.53)
Constant	2.076918*** (5.38)	6.976466*** (5.28)

We know IFDI, industrial agglomeration level and regional GDP are larger in the east. To further study how they impact on the economy of different regions, we sub-divide our samples into three parts: western, central and eastern & northeastern regions. The western region includes 11 provinces, that is, Sichuan, Chongqing, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Guangxi and Inner Mongolia. The central region has 8 provinces, including Shaanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan. And the eastern & northeastern region includes 11 provinces, namely Liaoning, Hebei, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian and Guangdong. Results are shown in Table 6.

Table 6. Regression results by region.

Variable	Western	Central	Eastern & Northeastern
LnIFDI	.188569** (2.05)	1.101819*** (5.45)	.0941236 (1.45)
LnAgg	1.915733*** (3.33)	7.544177*** (5.50)	.9849648 (1.61)
LnIFDI×LnAgg	-1.24559* (-1.91)	-1.24559*** (-4.85)	.0058701 (0.08)
LnHC	1.239478*** (4.29)	.6256725** (2.25)	1.556774*** (4.81)
LnRD	.3152253*** (7.92)	.1690119*** (4.30)	.2631092*** (6.80)
LnFAI	.2709893 (1.41)	.0563852 (0.31)	-.198737 (-1.37)
LnFE	.8546968* (3.22)	3.434394*** (3.22)	.1950509 (0.28)
LINF	1.29641*** (3.29)	1.868186*** (5.17)	2.333913*** (6.02)
Constant	1.492135** (2.41)	-1.73234 (-1.51)	.7980335 (0.99)
N	132	72	156

IFDI can promote regional economic growth, however, the empirical results show that the positive effects are different among China's regions: the effect is most significant on Central China, followed by western and eastern & northeastern regions. This may result from Threshold Effect, that is, in the eastern & northeastern region, most provinces, cities and autonomous regions have higher threshold, while most of those in central and western regions have not. IFDI in Eastern China has exceeded the threshold and has no obvious or even inhibitory effect on the regional economy. In contrast, the IFDI in Western China has not yet reached the threshold. Thus, the introduction of IFDI into the western region can effectively promote economic growth.

Similarly, industrial agglomeration can also promote the economic growth in China while the impact is unbalanced. The promoting effect is strongest on the economic development in the central and western

regions, because these regions are in rapid economic development stage. Thus, industrial agglomeration can form Scale Effect and bring industrial specialization, then improve efficiency and eventually promote economic growth. However, in the eastern region, the positive impact is greatly cut down due to Congestion Effect and environmental pollution.

The coefficient of the interaction terms is negative. This may be because China vigorously guides IFDI to high-tech industries with the "Reducing Excess Capacity" policy in recent years, so the increase of agglomeration in industrial field will not effectively attract IFDI and promote economic growth. Besides, IFDI may crowd out labor-intensive and capital-intensive industries.

As for control variables, the level of human capital and R&D investment have a positive impact on promoting regional GDP, while the coefficient of fixed asset investment is not significant. The coefficient of government expenditure is insignificant for the eastern & northeastern region, while significant for the western and central regions. Finally, results show that transportation infrastructure can promote economic growth, especially in the eastern region.

4 Conclusions & Suggestions

Based on the results of empirical analysis above, there are some suggestions for China to consider while developing the economy.

First, increasing the pace of industrial agglomeration in the western region seems essential for China. We suggest Chinese government pay closer concern to industrial agglomeration in economic development, publish favored policy and improve local infrastructure to create a healthy operating environment, so as to promote the regional industrial agglomeration.

Besides, we suggest stepping up the effective utilization of IFDI. China may carefully analyze the complementary relationship between the industrial structure and the "one belt one road" policy in the western regions, and optimize the business environment to attract IFDI, such as in Pilot Free Trade Zones (Chongqing, Sichuan, Shaanxi, Guangxi and Yunnan).

Lastly, coordinating the developments of industrial agglomeration and IFDI may help economic develop better. Forming an industrial environment with advanced technology may attract more IFDI flows, then enhance the ability of industrial agglomeration in turn by providing capital and technology. In this way, China may create a benign circle for the balanced development of Western, Central, Eastern and Northeastern China.

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