

The Impact of IFDI On Regional Innovation Capability: Based on The Example of Yangtze River Delta

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Abstract. Based on the data of all prefecture-level cities in the Yangtze River Delta(YRD) region from 2017 to 2021, the author empirically analyzes the impact of IFDI on regional innovation capability in the YRD region of China, finding that IFDI can significantly improve the regional innovation capability of China's YRD region. Moreover, the enhancement effect of IFDI on regional innovation capacity varies with the different levels of economic development of the cities, and IFDI can significantly enhance the regional innovation capacity in the cities with strong and weak economic development, but it is not obvious in the cities with medium economic development.

Keywords: IFDI; Utilization of foreign capital; Innovation capability; the Yangtze River Delta.

1. Introduction

As the two main themes of China's economic development, opening up and innovation have always run through the course of China's socialist economic development. Over the past 40 years of reform and opening up, China's economic growth has been on a fast track, and one of its main driving forces is the absorption and utilization of foreign investment. After its accession to the WTO, China, with its huge market potential and rich resource endowment, has rapidly developed into the world's largest recipient of IFDI among developing countries. While opening its door to the world, China has continuously lowered market access conditions and optimized the international business environment to further remove obstacles for attracting foreign investment. As a result, the scale of China's IFDI has continued to expand. With the continuous expansion of IFDI scale, Chinese domestic enterprises can also learn the advanced production technology, rich management experience and enterprise development concept of foreign enterprises through the technology spillover effect of international investment, thus increasing the competitiveness of Chinese enterprises. However, from the perspective of geographical distribution, China's economic development as a whole shows relatively obvious regional differences, and IFDI also shows obvious regional distribution differences. Compared with the central and western regions, the Yangtze River Delta region has a greater degree of openness and a higher degree of marketization. It is a regional representative of the speed and quality of China's economic development, and its foreign capital inflow is also the most concentrated and active. In terms of actual utilization of foreign capital, since 2001, China's annual total actual utilization of foreign capital has maintained a steady growth, from \$46.878 billion in 2001 to \$173.483 billion in 2021. Among them, since 2007, the proportion of actual utilization of foreign capital in the Yangtze River Delta region has remained at more than half of the national total. In terms of regional innovation, as one of the important regions of the national innovation-driven strategy, the Yangtze River Delta region's R&D expenditure accounts for about 30% of the national proportion, and the number of patent applications and patent grants is far ahead, which can be described as the vitality of China's scientific and technological innovation.

Therefore, this paper selects the data of 41 prefecture-level cities in the Yangtze River Delta from 2017 to 2021 to empirically analyze the impact of IFDI on regional innovation capability. The main marginal contribution of this paper is to study the relationship between IFDI and innovation capability from a regional perspective, to provide a reference for the effectiveness of high-level opening up in the Yangtze River Delta region, and to provide a decision-making reference for the future optimization of IFDI policy in China.

2. Literature review and research hypothesis

2.1. Literature Review

2.1.1 The impact of IFDI on innovation capability

At present, domestic and foreign scholars' research on the impact of IFDI on innovation capability can be mainly divided into two viewpoints—"promotion theory" and "promotion theory". In the early stage, a small number of scholars held the view of "promotion theory": Harris (2004) found that IFDI in different countries inhibited the innovation capability of the host country [1]; Jie He (1999) found that there is a certain "threshold" for the spillover effect of foreign capital in China's industrial sector [2]. In contrast, more scholars hold the view of "promotion theory". Dianchun Jiang (2006) found that IFDI has a significant positive spillover effect on high-tech industries, and the stronger the innovation capability of enterprises, the more significant the spillover effect [3]. Ping Li et al. (2020) found that IFDI can significantly improve the innovation capability of host countries through competition effect [4]. Yongqiang Lin (2023) found that the international knowledge spillover of IFDI and import trade can significantly promote technological innovation in China's service industry [5]. Diyun Peng (2023) found that IFDI has a significant direct promoting effect on China's regional innovation and drives the improvement of regional innovation by promoting the development of regional digital economy [6].

2.1.2 The main ways that IFDI affects innovation capability

Many scholars have studied the specific ways of IFDI's impact on the innovation capability of host countries from different perspectives. Romer (1990) believed that IFDI could improve the knowledge stock level of local enterprises in the host country region through technology transfer, thus improving their innovation efficiency [7]. Kokko (1994) proposed that the technology spillover effect of IFDI to host countries can be realized through competition effect, demonstration effect, talent flow effect and correlation effect [8]. In addition, Yiwen Yang (2023) further found that IFDI can also promote the innovation of local enterprises through the spatial agglomeration of patents [9].

2.2. Research Hypothesis

Based on the existing studies of the above scholars, IFDI does have a certain impact on the host country's scientific and technological innovation, and this impact may be realized through various ways. The Yangtze River Delta region is one of the earliest regions in China to open to the outside world. While attracting a large amount of IFDI, its innovation capability is also far ahead in the country, and the comprehensive innovation-driven index of the core cities ranks among the top in the country. Therefore, this paper proposes the following reasonable hypothesis H1:

H1: IFDI can promote the improvement of regional innovation capability in the Yangtze River Delta region.

3. Research Design

3.1. Sample Source

Since the sample quantity of the Yangtze River Delta region cannot meet the requirements at the provincial level, this paper mainly selects 41 cities in three provinces and one city in China's Yangtze River Delta region during 2017-2021 from the municipal level, including provincial capitals, prefecture-level cities and Shanghai directly under the central government. Among them, the data of the amount of foreign capital actually utilized by each city comes from the CSMAR database, and other data such as population, per capita regional GDP, financial science and technology expenditure, patent grants, and the average annual exchange rate of RMB come from the China City Statistical Yearbook and the China Economic and Social Big Data Research Platform. Due to the variation of the statistical caliber of each city, there may be no data in a certain index of individual cities, this paper simplifies the missing data according to the interpolation method.

3.2. Model Setting

In order to study the relationship between IFDI and regional innovation capability in the Yangtze River Delta region, this paper constructs the following basic regression model.

$$Inno_ability_{i,t} = \alpha_0 + \alpha_1 FDI_{i,t} + \alpha_2 Inno_input_{i,t} + \alpha_3 GRP_{i,t} + \alpha_4 Trans_level_{i,t} + \alpha_5 Tel_level_{i,t} + \alpha_6 Hc_level_{i,t} + \tau_i + \xi_t + \varepsilon_{i,t} \quad (1)$$

Where, $Inno_ability_{i,t}$ is the explained variable, $FDI_{i,t}$ is the core explanatory variable of this paper and the control variables are $Inno_input_{i,t}$, $GRP_{i,t}$, $Trans_level_{i,t}$, $Tel_level_{i,t}$ and $Hc_level_{i,t}$ respectively. τ_i is the individual (city) fixed effect, ξ_t is the year fixed effect and $\varepsilon_{i,t}$ is the random error. Considering that the data presented in this paper is an end-panel data without multicollinearity, it is not suitable to use the bidirectional fixed-effect model, so the random effect model and individual fixed-effects model are adopted in this paper for estimation.

3.3. Variable Definition

3.3.1 Explained variables.

The explained variable in this paper is $Inno_ability$, which measures regional innovation capacity and is expressed as the logarithm of the number of patents granted by each city per year. The number of patents granted is the sum of the number of patents granted for invention, utility model and design, which can represent the strength of regional innovation capability.

3.3.2 Core explanatory variables

The core explanatory variable is IFDI, which is expressed as the logarithm of the amount of foreign capital actually utilized by each city each year. In order to keep the variable units in the model uniform, this paper carried out the corresponding unit conversion according to the average annual exchange rate between US dollar and RMB.

3.3.3 Control variables

Reference to existing studies, this paper mainly selects 5 control variables, including. The names and definitions of each variable are shown in Table 1.

Table 1. Variable names and definitions

VarType	VarName	VarDefinition
Explained Variable	Inno_ability	The ratio of the total number of patent applications in each city in the current year to the government's financial technology expenditure
Explanatory Variable	IFDI	The logarithmic value of the actual amount of foreign investment utilized (after unit conversion)
ControllVariable	Inno_input	The logarithm of local fiscal science and technology expenditure
	GRP	The logarithmic value of per capita gross regional product
	Trans_level	The logarithm of highway passenger volume
	Tel_level	The logarithm of the total telecommunications business volume
	Hc_level	Proportion of ordinary undergraduate and vocational colleges in the total population

4. Empirical Analysis

4.1. Descriptive Statistics of Variables

After data matching and interpolation processing, this paper obtained the balance panel data with a time span of 5 years, with a total of 205 observed values. The descriptive statistical results of the main variables are shown in Table 2. The analysis shows that there are no outliers deviating from the normal range in the simplified data, indicating that the sample data in this paper is reasonable and reliable.

Table 2. Descriptive statistics of variable

VarName	Obs	Mean	SD	Min	Median	Max
Inno_ability	205	0.09	0.084	0.01	0.07	0.79
IFDI	205	13.49	1.294	10.45	13.50	17.35
Inno_input	205	12.01	1.188	9.03	11.85	15.27
GRP	205	11.32	0.495	9.98	11.31	12.14
Trans_level	205	8.01	0.872	5.71	8.04	10.35
Tel_level	205	13.01	0.918	11.39	12.91	15.66
Hc_level	205	0.02	0.020	0.00	0.02	0.12

4.2. Analysis of Basic Regression Results

After the Hausmann test, this paper finally selects the mixed effect model and the individual fixed effect model to perform basic regression on equation (1), and the regression results are shown in columns (1) and (2) of Table 3 respectively. According to the results, under the regression calculation of the two models, there is a relatively significant positive correlation between IFDI and Inno_ability, and the coefficients are 0.0888 and 0.045 respectively. Under the mixed effects model, the positive correlation between the two is more significant. It can be shown that IFDI can significantly improve the regional innovation capability of the Yangtze River Delta region. Furthermore, the coefficient between innovation input and regional per capita GDP of each city in the Yangtze River Delta region is also significantly positive, which indicates that in addition to IFDI, other factors such as financial science and technology expenditure and regional per capita GDP GRP will also have a certain promoting effect on regional innovation capability.

Table 3. Basic regression results

	(1) Mixed effect model	(2) Individual fixed effect model
	Inno_alibity	Inno_alibity
IFDI	0.088*** (3.12)	0.045* (1.81)
Inno_input	0.324*** (5.69)	0.203*** (3.55)
GRP	1.022*** (7.33)	0.368** (2.09)
Trans_level	-0.305*** (-6.79)	-0.485*** (-10.71)
Tel_level	0.360*** (5.92)	0.030 (0.49)
Hc_level	-0.259 (-0.07)	5.706 (1.24)
cons	-9.549*** (-5.96)	5.477** (2.03)
City control	No	Yes
Year control	No	No
N	205	205
R ²	0.578	0.675

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.3. Heterogeneity Analysis

Considering that there is a gap in the level of economic development between different cities within the YRD region, this paper further compares the relationship between IFDI and regional innovation capacity in regions with different levels of economic development. Referring to Huasheng Li (2022) ^[10], this paper categorizes the prefecture-level cities into three groups of cities with strong, medium, and weak economic development based on the total amount of GRP of the region in 2021, and the criteria for grouping are as follows: cities with a GRP greater than 800 billion yuan are categorized as cities with strong economic development; cities with a GRP between 400 billion and 800 billion yuan are categorized as medium cities; and cities with a GRP below 400 billion yuan are categorized as weaker cities. GRP between 400 billion and 800 billion is categorized as cities with weak economic development.

These three groups of subsamples are regressed using random effects model, and the results are shown in Table 4. The coefficients of the core explanatory variable IFDI in the first and third groups are significantly positive at the 5% confidence level, while the coefficients of the second group are positive but not significant, indicating that IFDI promotes regional innovation capacity differently in regions with different levels of economic development. The first group of cities mainly includes Shanghai, Nanjing, Hangzhou, Wuxi, Suzhou and other cities, whose strong economic strength and human resources endowment are more likely to attract foreign R&D institutions and research institutes and other innovation bodies, so these cities are more likely to improve regional innovation capacity through the establishment of R&D institutions, human resources flow and other channels to realize the technological spillover of IFDI. The third group of cities mainly contains many prefecture-level cities with lower economic development level, due to the lagging development of local enterprises and insufficient independent innovation capability, when IFDI flows in, it is more likely that the demonstration effect of foreign-funded enterprises will lead to the enhancement of the whole region's innovation capability. The second group of cities has medium economic strength, local enterprises also have certain independent innovation capability, and the attraction of innovation main body and talent flow is not as good as that of the first group of cities, so the impact of IFDI on its regional innovation capability is not very big.

Table 4. Heterogeneity analysis results

	(1) Strong Group	(2) Media Group	(2) Weak Group
	Inno_alibity	Inno_alibity	Inno_alibity
IFDI	0.119**	0.009	0.107**
	(2.35)	(0.26)	(2.18)
Inno_input	0.130	0.088	0.279***
	(0.96)	(0.90)	(3.58)
GRP	1.362***	0.015	0.890***
	(4.72)	(0.07)	(4.54)
Trans_level	-0.048	-0.241***	-0.404***
	(-0.67)	(-4.28)	(-5.34)
Tel_level	0.366**	1.251***	0.214***
	(2.00)	(7.85)	(2.90)
Hc_level	-0.067	1.389	-9.110
	(-0.04)	(0.23)	(-1.05)
cons	-13.631***	-6.099**	-5.242**
	(-4.45)	(-2.03)	(-2.01)
N	41	53	111
R2	0.817	0.6949	0.632

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Summary

This paper empirically analyzes the relationship between IFDI and regional innovation capacity in the Yangtze River Delta (YRD) region based on the data of 41 prefecture-level cities in the YRD region in the last five years from 2017 to 2021. It is found that IFDI can significantly enhance the regional innovation capacity of the YRD region; in the heterogeneity analysis, it is further found that the enhancement effect of IFDI on regional innovation capacity varies under different levels of economic development, and the enhancement effect of IFDI on the regional innovation capacity of the YRD region is stronger in the cities with strong and weak economic development, while the enhancement effect is not obvious in the cities with intermediate economic development. The effect of IFDI on regional innovation capacity is stronger in cities with strong and weak economic development, while it is not obvious in cities with medium economic development. The reason for this phenomenon may be the difference in the way IFDI enhances innovation capacity under different levels of economic development. The authors will further investigate the specific mechanism that causes this difference in future studies.

Combined with China's high-level open-door policy, this paper proposes the following suggestions for the economic and innovation development of the YRD region. First, the government should promote the integrated development of the YRD region, give full play to the role of Shanghai as a hub of science and technology innovation, and continue to gather high-quality global innovation bodies and a large number of innovation resources, so as to drive the enhancement of the innovation capacity of other neighboring provinces and municipalities in the region through the regional radiation effect. Second, the relevant state departments should further optimize the foreign investment policies in the YRD region, increase the effective guidance of foreign investment through differentiated "negative lists" and other targeted foreign investment policies, and promote the reasonable distribution of foreign investment in the region and the reasonable flow of foreign investment within the industry. Third, the state and local governments should actively build a platform for knowledge exchange and sharing within and between regions, establish a mechanism for mutual assistance among cities and reasonably guide foreign investment to participate in it, so as to promote the enhancement of the innovation capacity of non-economically strong cities through multiple channels, such as industrial transfer and talent mobility.

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