

The Impact of Foreign Direct Investment (FDI) on Urban Economic Resilience: An Empirical Study Based on the Yangtze River Delta Urban Agglomerations

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Abstract. Urban economic resilience can reflect whether cities can sustain high-quality development. Therefore, based on the panel data of 26 cities in the Yangtze River Delta Urban Agglomerations from 2010-2019, this paper measures the city economic resilience index using the entropy method and explores the impact of foreign direct investment (FDI) on the economic resilience of cities in the Yangtze River Delta using the Tobit model. The results show that (1) Shanghai, Hangzhou, Nanjing and Suzhou have higher urban economic resilience than other cities and are more likely to achieve high-quality economic development (2) FDI has a significant negative impact on urban economic resilience (3) the level of urban innovation development can promote the development of urban economic resilience; urban freight capacity, urban greening level and advanced industrial structure hinder the development of urban economic resilience, but the effects of urban greening level and advanced industrial structure are not significant. Finally, this study makes several suggestions on how to improve the economic resilience of the Yangtze River Delta Urban Agglomerations.

Keywords: Urban Economic Resilience; Yangtze River Delta; Entropy Method; Tobit.

1. Introduction and Literature Review

As a reflection of a city's ability to prevent unknown risks and as a driving force for economic growth in the post-epidemic era, the economic resilience of a city plays an important role in increasing the total volume and growth rate of the national economy and promoting the country's sustainable and stable economic development, and is conducive to deepening reform and maintaining a high level of openness. "The concept of "resilient cities" has been included in the 14th Five-Year Plan and the outline of the 2035 Vision. Based on this, the relationship between FDI and economic resilience is of great relevance to this paper, using the entropy value method and the Tobit model.

1.1. Economic resilience of cities

The term resilience, originally meaning restoration to its original state, was first applied to the field of ecology in 1970 by Professor Holling [1], who argued that resilience is "the persistence of natural systems in response to natural or human-induced changes in ecosystems". Since 2001 resilience has been studied in more specific directions, with the relationship with economic resilience being studied from the perspective of specific industries such as the internet [2], productive services [3] and manufacturing exports [4]. There are also scholars who study economic resilience by delineating specific urban agglomerations such as China's eight major urban agglomerations [5], the Yangtze River Delta region [6], and coastal provinces [7]. There are also scholars who use different measurement methods to study economic resilience. Xu Yuan, Zhang Linling [8] used the GMM-SL-SAR-RE model to measure the economic resilience of 230 cities and used 44 industrial indicators to explain the differentiation of economic resilience in different cities, which played a pioneering role and was improved and followed by later scholars; Zhang Zhen, Zhang Yichen and other scholars [9]

used the entropy value method to determine the economic The corresponding weights of the resilience indicators were then used to evaluate and analyse the economic resilience of cities using the TOPSIS model.

1.2. The impact of FDI

FDI, known as Foreign Direct Investment (FDI), is one of the major forms of modern global capital investment.

In the early research literature on FDI in China, the impact of FDI on China's macro economy was mainly studied. In an article by Lin Jiajie [10], the dual effect of FDI on China's balance of payments was fully discussed, arguing that the entry of FDI should not only focus on the positive effects but ignore the damage it brings to China's balance of payments; Yang Lan and Zhang Lei [11] studied the impact of FDI on China's foreign trade and pointed out that the increase of FDI played a facilitating role for China's import and export trade. Since then the literature Chinese scholars have started to focus on the impact of FDI on enterprises, mainly focusing on the following aspects: in one aspect scholars study the impact of foreign capital on the import and export aspects of enterprises, Wang Wenzhi and Lu You [12] use the value added trade decomposition model to argue that overall FDI will inhibit the upgrading of the global value chain position of Chinese enterprises' imports and exports, especially those in China's non-Hong Kong and Macao regions. Hu, Hengsong and Li, Rongjian [13] found that FDI has a facilitating effect on imports and exports based on a state space model, and this effect is increasing. At present, there is no consensus among scholars on the relationship between FDI and total factor production factors of enterprises.

The marginal contributions of this paper include: (1) Most of the existing studies are on the impact of FDI on the Chinese economy and enterprises, but this paper is a pioneering study on the effect of FDI and the economic resilience of cities in the Yangtze River Delta region of China. (2) Most of the studies are national in scope, with few articles delving into the Yangtze River Delta region. (3) The entropy value method is used to measure the comprehensive level of economic resilience of cities in the Yangtze River Delta region of China and the TOBIT model is used for regression analysis, which is more scientific and provides a reference for research in the Yangtze River Delta region and even nationwide.

2. Construction of a comprehensive evaluation system for urban economic resilience

2.1. Entropy method

There have been studies using the entropy method to measure and apply urban resilience [14], and this paper uses this method to measure the economic resilience index of cities in the Yangtze River Delta region. Its calculation steps are as follows.

(1) Indicator selection: with r years, n cities and m indicators, then $X_{\theta ij}$ denotes the value of the j th indicator for the i th prefecture-level city in year θ .

(2) Standardization of indicators.

Standardization of positive indicators.

$$X'_{\theta ij} = \frac{X_{\theta ij} - X_{\min}}{X_{\max} - X_{\min}} \quad (1)$$

Negative indicators are standardised.

$$X'_{\theta ij} = \frac{X_{\max} - X_{\theta ij}}{X_{\max} - X_{\min}} \quad (2)$$

Where $X_{\max}$, $X_{\min}$ denotes the maximum and minimum values of the j th indicator in r years in i cities.

(3) Non-negative translations.

$$X'_{\theta ij} = X'_{\theta ij} + 0.001 \quad (3)$$

(4) Calculation of weights.

$$Y_{\theta ij} = \frac{X'_{\theta ij}}{\sum_{\theta} \sum_i X'_{\theta ij}} \quad (4)$$

(5) Calculating entropy values.

$$S_j = -k \sum_{\theta} \sum_i (Y_{\theta ij} \ln(Y_{\theta ij})), k = \frac{1}{\ln(rn)} \quad (5)$$

(6) Calculate the coefficient of variation. Coefficient of variation for indicator j.

$$E_j = 1 - S_j \quad (6)$$

(7) Calculate the weight of indicator j.

$$W_j = \frac{E_j}{\sum_j E_j} \quad (7)$$

(8) Calculate the composite score for each city under each year. Product of indicator weights and standardised indicator values.

$$H_{\theta i} = \sum_j^m (W_j (X'_{\theta ij})^T) \quad (8)$$

2.2. Tobit regression model

This paper uses the Tobit model for regression analysis. The explanatory variable chosen for the model is FDI and the explanatory variable is urban economic resilience, and the econometric equations are as follows.

$$Y_i = a_0 + a_i X_i + \varepsilon_i, \quad i = 1, 2, 3, \dots, n \quad (9)$$

Where: Y_i - urban economic resilience a_0 - constant term a_i - parameter to be estimated

X_i - Factors affecting urban economic resilience ε_i - random disturbance term.

2.3. Sample selection and data sources

This paper selects 26 cities in the Yangtze River Delta urban agglomeration from 2010 to 2019 as the research sample, and the original data of this paper are obtained from China City Statistical Yearbook and CSMAR. The data of individual cities in individual years are missing, and are filled by the mean difference method and so on.

2.4. Variable settings and descriptions

2.4.1 Explained variables

Urban economic resilience (UER): For the measurement of urban economic resilience, this paper mainly relies on the research idea of Pan Aimin and Wu Youlong (2022) to construct a comprehensive evaluation index system of urban economic resilience of the Yangtze River Delta urban agglomeration from two dimensions of shock resilience and recovery adjustment power, and specifically select 15 secondary subdivision indicators, combined with the entropy value method to measure urban economic resilience, as shown in the following Table I:

Table 1. Comprehensive Evaluation Index System of Urban Economic Resilience.

Tier 1 Indicators	Secondary indicators	Indicator Direction
Impact resistance	Local budget revenue (million yuan)	+
	GDP per capita (yuan)	+
	Year-end savings balance of urban and rural residents (yuan)	+
	Number of urban registered unemployed persons at the end of the year (persons)	-
	Share of tertiary industry in GDP (%)	-
	Number of Internet users (million)	-
Recovery adjustment power	Retail sales of social consumer goods (RMB million)	+
	Balance of RMB loans of financial institutions at the end of the year (RMB million)	+
	Information transmission, computer services and software industry year-end number of employees in urban units (10,000)	+
	Number of hospitals, health center beds (number)	+
	Public library book collection per 100 people (books per 100 people)	+
	Industrial wastewater emissions (million tons)	-
	Industrial smoke (dust) emissions (tons)	-
	Share of education expenditures in public finance expenditures (%)	+
	Science and technology expenditures as a proportion of public finance expenditures (%)	+

2.4.2 Core explanatory variables

Foreign direct investment (FDI): In this paper, the total actual utilized foreign investment (USD million) in each prefecture-level city in the Yangtze River Delta city cluster is used, adjusted according to the average exchange rate of RMB to USD in that year, and then divided by the average population (10,000 people) in that year to obtain the final FDI value per capita to represent the level of foreign direct investment in each city.

2.4.3 Control variables

To synthesize the actual situation of the study, the following control variables are selected in this paper: (1) urban greening level (GC), measured by the greening coverage of the built-up area in the current year; (2) urban freight capacity (RFV), measured by the freight volume of roads in the current year; (3) urban innovation development level (IPA), measured by the number of invention patent applications in the current year; (4) advanced industrial structure (TS), where the industrial structure evolves from low to high level evolution, i.e., the proportion of industrial structure is increasing along the order of primary, secondary and tertiary industries[15]; it is measured below by dividing the proportion of tertiary industries in total GDP by the proportion of secondary industries in GDP. The results of descriptive statistics for all variables are presented in Table II below.

Table 2. Results of descriptive statistics of variables.

Variables	UER	FDI	GC	RFV	IPA	TS
Mean	0.194398	2924.975	3.743324	9.233871	8.420023	-0.122432
Median	0.143397	2341.036	3.743486	9.322686	8.593961	-0.125513
Maximum	0.966771	9312.075	4.353884	10.68759	11.19254	0.990875
Minimum	0.044688	126.4208	3.558771	3.496508	4.110874	-1.161146
Std. Dev.	0.179047	2150.120	0.073899	0.916080	1.395620	0.349472
Skewness	2.807956	0.862820	2.606782	-2.376627	-0.476221	0.041007
Kurtosis	11.54515	3.136792	21.91710	13.51677	3.024906	4.109254
Jarque-Bera Probability	1132.712	32.46258	4171.246	1442.956	9.834138	13.40267
Sum	0.000000	0.000000	0.000000	0.000000	0.007321	0.001229
Sum Sq. Dev.	50.54347	760493.5	973.2643	2400.807	2189.206	-31.83243
	8.302984	1.20E+09	1.414405	217.3537	504.4684	31.63185

3. Analysis of the empirical results

3.1. Analysis of baseline regression results

According to the data processing and analysis by Stata software, the regression results of the benchmark model are shown in Table III below:

Table 3. Tobit regression results.

UER	Tobit
	(1)
FDI	-0.0449*** (0.0163)
GC	-0.0273 (0.0258)
RFV	-0.0048*** (0.0019)
IPA	0.0101*** (0.0024)
TS	-0.0312 (0.0100)
sigma2_u	0.1808*** (0.0252)
sigma2_e	0.0218*** (0.0010)
LR	679.18***

Note: P-values below 0.1*, below 0.05**, 0.01***, standard error in parentheses

Foreign direct investment (FDI) shows a negative relationship with urban economic resilience and is significant at the 1% confidence level, indicating that as the amount of foreign investment increases very significantly reduces the level of urban economic resilience. From the supply perspective, China's tax incentives for FDI make the investment cost of large and medium-sized urban enterprises too burdensome, which weakens the intrinsic motivation of urban growth; from the demand perspective, a large amount of investment in foreign enterprises will increase the gap between domestic and foreign enterprises, which in turn is not conducive to improving the level of national welfare, improving employment and the sustainable development of urban economy.

The level of urban greening (GC) shows a negative relationship with urban economic resilience, but the results are not significant. Theoretically, the level of urban greenery can enhance the ability of cities to withstand external shocks; however, this study shows a negative correlation between the two, indicating that greenery coverage can limit the rapid development of cities, and different forms of greenery have great differences in functional efficiency. The over-zealousness of large areas such as "urban lawns" generates high maintenance costs, worsens budgetary capacity, and leads to a diminishing economic resilience of cities.

RFV is negatively correlated with the economic resilience of cities and is significant at the 1% confidence level, indicating that the freight capacity of cities does not provide a buffer against external shocks. Under the new development pattern, logistics hubs play a significant role in the high-quality development and energy status enhancement of cities, and urban logistics hubs play the role of ballast in the big change; however, excessive freight volume of urban highway trunk roads will cause serious pressure on urban traffic to the extent of deteriorating urban economic development.

The level of urban innovation development (IPA) shows a positive relationship with urban economic resilience and is significant at 1% confidence level, indicating that the level of urban innovation development can significantly weaken the negative impact of adverse shocks on urban economic development. At present, the Yangtze River Delta city cluster vigorously promotes the construction of national innovative cities and intellectual property model cities, actively encourages residents to patent inventions and utility models, and maintains a steady growth of patent applications,

which helps cities win international competitive advantages and fully demonstrates the good trend of urban economic development.

The advanced industrial structure (TS) shows a negative relationship with the economic resilience of cities, but the result is not significant. From a long-term perspective, over-emphasizing industrial structure advancement while ignoring industrial structure rationalization does not promote urban economic resilience; to a certain extent, industrial advancement promotes urban economic growth, but at present, China's overall economy has entered a new normal in which the tertiary industry is dominant, the demographic dividend has disappeared and technological progress has slowed down, so it is difficult to promote China's economic growth by promoting industrial structure advancement. The insignificant results are mainly due to the mutual influence of industrial structures between regions, and there may be some endogeneity among the regions of the urban clusters selected for this study, so it is especially important to further deepen the supply-side reform and optimize the factor allocation structure among industries.

3.2. Robustness tests

In order to ensure the stability and continuity of the results, this paper further tests by transforming the core explanatory variables. The percentage of FDI in fiscal revenue (Pfv) is used as a new explanatory indicator instead of the per capita FDI value (test 2), and the percentage of FDI in GDP of local GDP (Fdi) is used as a new explanatory indicator instead of the per capita FDI (test 3), the test results are shown in Table IV below, the regression coefficients are consistent, and the regression results pass the significance test at the 10% level. The regression coefficients are consistent, and all regression results pass the significance test at the 10% level, indicating that the results are true and reliable.

Table 4. Results of robustness tests.

UER	Tobit	
	(2)	(3)
Pfv	-0.9350* (0.5444)	
Fdi		-0.0010* (0.0006)
GC	-0.0217 (0.0260)	-0.02366 (0.0258)
RFV	-0.0050*** (0.0019)	-0.0049** (0.0019)
IPA	0.0087*** (0.0023)	0.0097*** (0.0024)
TS	-0.0191* (0.0100)	-0.0221** (0.0103)
sigma2_u	0.1766*** (0.0246)	0.1759*** (0.0245)
sigma2_e	0.0224*** (0.0010)	0.0224*** (0.0010)
LR	728.22***	715.75***

4. Conclusions and Suggestions

4.1. Conclusions

Based on 26 cities in the Yangtze River Delta Urban Agglomerations from 2010-2019, this paper uses the entropy method to construct comprehensive indicators of urban economic resilience and the Tobit model to explore the impact of foreign direct investment (FDI) on urban economic resilience. The main findings are as follows: First, the economic resilience of cities in the Yangtze River Delta exhibits uneven development, with more economically developed cities such as Shanghai, Hangzhou,

Nanjing and Suzhou having significantly higher economic resilience than other cities in the Yangtze River Delta Urban Agglomerations. Second, foreign direct investment (FDI) has a significant negative impact on the urban economic resilience, and this finding remains robust after replacing the core explanatory variable with "the share of FDI in fiscal revenue". Third, the level of urban innovation has a significant positive impact on urban economic resilience; urban freight capacity has a significant negative impact on urban economic resilience.

4.2. Suggestions

(1) Guide foreign investment to optimize the investment structure and improve the quality and efficiency of the use of foreign investment. Firstly, we should strengthen the planning and guidance of foreign investment industries and attract foreign investment in a targeted manner, focusing on emerging industries, domestic bottleneck industries and capital and technology-intensive industries, so as to supplement the shortage of domestic investment and realize the rationalization of industrial structure. Secondly, foreign investment projects should be carefully screened and researched and the soft investment environment should be improved according to local conditions to avoid the transfer of low-level industries to the country. Finally, FDI should play the role of demonstration and technology diffusion to domestic enterprises, promote technology spillover, improve the independent development capability of domestic enterprises, and narrow the gap between domestic and foreign enterprises.

(2) Strengthen urban innovation capacity and support technological innovation to drive industrial innovation. On the one hand, we should increase the incentives for local technological innovation. Relevant departments should combine national standards to develop screening criteria for innovative enterprises and select those with technological and technical innovation achievements; encourage patent declarations, give higher one-time cash awards and provide subsidies for local intellectual property financing services and trading platforms to stimulate enterprise innovation enthusiasm. On the other hand, we should strengthen the attraction of foreign innovation resources, and provide differentiated incentives and funding for different aspects such as enterprise settlement, site leasing, project incubation and development.

(3) Promote the transformation and upgrading of the logistics industry to construct a modern logistics system. As the logistics and transportation industry is still small, poorly organized, badly managed and competing viciously, it should continue to optimize the business environment for the development of modern logistics enterprises, promote modern logistics enterprises to use network freight, big data platforms, artificial intelligence and geographic information identification to scientific and technological innovation, and support the development of new business models modern logistics. In addition, we should cultivate modern logistics industry chain and supply chain, promote modern logistics enterprises to take the advantages of digital information technology to become bigger and stronger, improve the efficiency of trade circulation, and create industrial clusters for the development of modern logistics enterprises.

Due to the availability of sample data, this study only considers the impact of foreign direct investment (FDI) on the urban economic resilience from a quantitative perspective, without considering the quality of FDI, and also lacks the analysis of the impact mechanism. In addition, the control variables extracted from the error terms in this paper may not fully reflect the characteristics of cities, so there may still be endogeneity problems of omitted variables. Given the lack of data to measure FDI quality and the limitation of city-level data, there is a need to continue to enrich the research on measuring FDI quality.

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