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The differential impact of foreign direct investment on regional GDP growth in China

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ABSTRACT
Foreign direct investment plays a more important role in China's economic development. This paper examines the impact of FDI on China's GDP and analyzes regional variability through OLS and quantile regression models. Then the spatial correlation-Moran, I scatter plot is used to visualize the clustering pattern of regional units. The analysis shows that FDI has a significant positive effect on China's high economic growth at the 25% quantile. However, the higher the economic growth rate, the margin of positive effect of FDI on economic growth gradually decreases. China's regional economic development is characterized by a dualistic structure. The elasticity coefficient of FDI in the eastern region is 0.099, and that in the western region is 0.05. Therefore, FDI has a greater impact on the eastern region than on the western region. With the development of China, foreign investment began to discrete, gradually spreading from coastal areas to inland areas.

Keywords: quantile regression model, Moran, I, foreign direct investment, OLS

1. Introduction

With the accelerated development of the world economy, although the capital flow between countries is becoming more and more frequent and the total amount of flowing capital is elevated, there are big differences in the distribution of each region, and a larger proportion of the capital mainly circulates between each developed country, and developing countries compete fiercely in order to seize the total amount of the lesser capital [1-3]. In the process of global economic development, the direct investment among countries provides the material conditions for the unification of the global economic market [4-5]. In the international mutual investment, multinational enterprises occupy the largest share and become the main force of investment [6].

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In recent years, China's regional economic development has shown an unbalanced structural feature, the formation of this structural feature is greatly due to the unbalanced foreign direct investment [7-8]. Foreign capital inflow, especially foreign direct investment (FDI), plays an irreplaceable role in China's economic growth process. It is an important driving force for economic development through the provision of capital, which has an obvious effect on the host country's export scale, employment situation, technological innovation and enterprise management [9-12]. Foreign direct investment can effectively promote local capital formation and economic growth, increase overall fiscal revenue, introduce advanced technology, management and marketing experience, improve production efficiency, and prompt China to quickly embark on the road of modernization and economic globalization [13-16]. However, the massive influx of foreign enterprises and capital, against the background that China's economic system reform is not fully mature, has also brought certain risks and challenges to the healthy development of China's local enterprises and economy [17-19]. Through the analysis of the impact of FDI on regional differences in economic growth, the targeted formulation of effective FDI policies and the narrowing of regional differences in FDI will help China to respond to the changes in the domestic and international environments faced in the post-financial crisis era, and to provide reference when it adopts measures to effectively utilize FDI, promote economic growth, and optimize economic structure [20-24].

This paper takes the 2003-2018 time series and cross-sectional data as the research samples, and empirically tests and analyzes the effect of foreign direct investment on China's economic growth using OLS and quantile regression models. Based on the dichotomous structure characteristics of the Chinese economy, China is divided into the more developed eastern region and the relatively backward western region. From there, the geographical heterogeneity analysis is further conducted for the differential impact of FDI on China's regional GDP growth, and reliable conclusions are presented. Finally, spatial correlation and Moran, I scatterplot are applied to analyze the agglomeration pattern of foreign investment in economic space and geographic space.

2. Research design

2.1. *Sample selection and data description*

According to the time series and cross-section data of each province and city from 2008 to 2024, the data on total investment in fixed assets of the whole society and the number of employed persons are from the database of the National Bureau of Statistics, and the data on the actual utilization of foreign capital are from the China Statistical Yearbook of each year.

2.2. *Variable Selection and Description*

Gross regional product (LNY) is the explanatory variable, and foreign direct investment (FDI) is the explanatory variable. Domestic investment (LnDK) and labor force (LNL) are used as control variables.

2.3. *Model construction*

2.3.1. OLS and quantile regression methods. For a continuous random variable Y, if the probability of $Y \le Q(t)$ is t, then the t th quantile value of Y is said to be $Q(t)$ Given that the distribution function of random variable Y is $F(Y) = P(Y \le y)$, then the t th quantile of Y is $Q(t) = \inf\{Y : F(y) \ge t\} (0 < t < 1)$.

For a general model:

$$y_i = k_i' x_i + a_{ti} + u_{ti} \tag{1}$$

where y_i is the explanatory variable, x_i is the column vector of $k \times 1$, k_i is the column vector of $k \times 1$, which represents the regression coefficients of each explanatory variable corresponding to the

t th quantile of the explanatory variable, a_{ti} is the intercept term, and u_{ti} is the random error term.

It is easy to see that when the weighted absolute deviation $E\left[pY_t\left(Y-t\right)\right]$ is minimized, the value of parameter t is taken as the quantile of Y at quantile t. Thus a regression estimate for a conditional quantile can be found by the weighted least absolute deviation method (WLAD). Similarly, for a linear model $y_i = k_i' x_i + at_i$ the conditional quantile regression equation is: $qt_t\left(y_i \mid k_i\right) = k_i' B(t)$ and so the conditional quantile estimate of the parameter b at quantile t is:

$$\hat{B} = \arg\min \sum_{i=1}^{n} p_t\left(y_i - k_i' B(t)\right) \tag{2}$$

Once the parameter estimate $\hat{B}(t)$ is obtained, immediately there is: $q_t\left(y_i \mid k_i\right) = k_i' \hat{\beta}_i(t)$ and also the residuals: $\hat{e}_t(t) = y_i - k_i' \hat{B}(t)$ can be obtained.

In general, while estimating the coefficients of the conditional quantile regression, the estimation of its asymptotic covariance array is also essential. Under certain assumptions, the coefficients of the conditional quantile regression have better asymptotics, and the asymptotic covariance array of each assumption is also somewhat different.

In case of independent homogeneous distribution, the asymptotic distribution of the coefficients of the CQR is normal, i.e:

$$\sqrt{n}(\hat{B}(t) - B(t)) \sim N\left(0, t(1-t)S^2(t)\right)J^{-1}\Big) \tag{3}$$

where $J = \lim_{n\to\infty}\left(\sum_{i=1}^{n} k_i k_i' / n\right)$, $S(t) = F'^{-1}(t)$.

In this case, $S(t)$ must be estimated, usually by the difference-quotient method $S(t)$. If the assumption of independent homogeneous distribution is not satisfied, the asymptotic distribution of the estimate can also be obtained by appropriately relaxing it to consider the case of independent but different distributions, viz:

$$\sqrt{n}(\hat{B}(t) - B(t)) \sim N\left(0, t(1-t)H(t)^{-1} J H(t)^{-1}\right) \tag{4}$$

where $J = \lim_{n\to\infty}\left(\sum_{i=1}^{n} k_i k_i' / n\right)$, $H(t) = \lim_{n\to\infty}\left(\sum_{i=1}^{n} k_i k_i' f_i\left(q_t\left(y_i \mid k_i\right)\right) / n\right)$.

For a random sample $\{x_1, x_2 \ldots x_n\}$ from aggregate F, the empirical distribution function for aggregate F is:

$$F_n(x) = \frac{1}{n}\sum_{i=1}^{n} I\left(x_i \le x\right) \tag{5}$$

One of the important properties for the empirical distribution function is that it converges to the distribution function with probability, i.e., there is $F_n(x) \xrightarrow{p} F(x)$. The self-help method holds because of this property, and the self-help method can be regarded as continuously sampling in the empirical distribution function. On this basis, the parametric covariance matrix is sampled several times, and each time an estimate of the coefficients is obtained, if the number of samples is A, A estimates are obtained, where the estimate of the i th is noted as $\hat{B}^i(t)$ and the mean is noted as $\overline{B}(t)$. Using the self-help method it is easy to compute an estimate of the asymptotic covariance matrix as:

$$Av\hat{a}\left(\hat{B}(t)\right) = n\left(\frac{m}{n}\right)\frac{1}{A}\sum\nolimits_{i=1}^{A}\left[\hat{B} - \overline{\overline{B}}\right]\left[\hat{B} - \overline{\overline{B}}\right]' \tag{6}$$

In the OLS model, the goodness of fit is based on the sample decidable coefficients, while in the CQR model, the definition of goodness of fit is very similar to that of the CQR model. In CQR, parameter estimates can be obtained using regression equation $q_t\left(y_i \mid k_i\right)=k'iB(t)$. The sample data is divided into two parts and can be made $k_i=\left(1,k_{i1}'\right)'$, $B(t)=\left(B_0(t),B_1'(t)\right)'$, so that the objective function for $q_t\left(y_i \mid k_i\right)=B_0+k'_{i1}B_1(t)$ minimizing the unconstrained CQR is obtained as:

$$\hat{V}(t)=\min\sum_{i=1}^{n}p_t\left(y_i-B_0-k_{i1}'B_1(t)\right) \tag{7}$$

When there are no other explanatory variables in the CQR and it contains only constant terms, the objective function of minimizing the constrained CQR is $\tilde{V}(t)=\sum_{i=1}^{n}p_t\left(y_i-B_0(t)\right)$. The goodness of fit of the CQR model is then defined as:

$$R^*(t)=1-\frac{\hat{V}(t)}{\tilde{V}(t)} \tag{8}$$

As can be seen from the formula, this is very similar to the goodness of fit R^2 in the OLS regression equation because the objective function of the OLS regression equation is the sum of squares of deviations, while the sum of squares of residuals is equal to the smallest unconstrained sum of squares of deviations value, and the sum of squares of total deviations is the smallest value of the sum of squares of deviations when there is only a constant term in the explanatory variable, which is the smallest value of the sum of squares of the constrained deviations, and the goodness of fit in the OLS regression is calculated based on this relationship between the two elements is calculated.

Especially in the case of heteroskedasticity, sometimes we must consider whether its coefficients are the same at each quantile. Such as testing the original hypothesis:

$$H_0:B_i\left(t_1\right)=B_i\left(t_2\right)=\ldots=B_i\left(t_k\right),i=1,2\ldots p-1 \tag{9}$$

The number of constraints on this original hypothesis is $(p-1)\times(k-1)$ (not including the constant term), then using the distribution of the CQR model coefficients it is possible to construct a Wald test statistic to test the original hypothesis, whose asymptotic distribution is a chi-square distribution with $(p-1)\times(k-1)$ degrees of freedom. In contrast, it is sometimes necessary to check the symmetry of the conditional distribution, and if it is symmetric, then there is $(B(t)+B(1-t))/2=B(0.5)$. For example, if one considers a conditional quantile regression at m quantiles, where m is odd, the median $t_{(m+1)/2}=0.5$, and $t_j=1-t_{m-j+1}$, $j=1,2,\ldots(m-1)/2$, then the original hypothesis can be:

$$H_0:\frac{B(tj)+B(tm-j+1)}{2}=B(0.5),j=1,2\ldots,(m-1)/2 \tag{10}$$

This original hypothesis has a number of constraints of $p\times(m-1)/2$. The Wald test statistic can likewise be constructed to test that its asymptotic distribution is a chi-square distribution with $p\times(m-1)/2$ degrees of freedom. If the distribution of the error term is known not to be symmetrically distributed, in which case it is possible to take a check on the intercept term only, then the number of constraints is reduced to $(m-1)/2$.

2.3.2. Benchmark modeling. Foreign direct investment has a positive effect on China's GDP growth. To test the hypothesis, the following benchmark regression model is constructed.

$$\mathrm{LNY}=a_0+a_1FDI+a_n(LnDK,LNL)+\varepsilon_{it} \tag{11}$$

In equation (11), i denotes region; t denotes year. Gross regional product (LNY) denotes the explanatory variable, FDI denotes the explanatory variable, foreign direct investment. x denotes a set of control variables, including domestic investment (LnDK), labor force (LNL), and ε is a random disturbance term. The Hausman test is further utilized to choose either fixed effects or random effects, and the specific test results will be presented in the analysis of empirical results below.

2.3.3. Spatial correlation techniques. Spatial global Moran's I is the autocorrelation of global space, which examines the aggregation effect of a certain property or phenomenon in the whole space. However, some scholars later found that the global Moran's I can only judge the spatial characteristics of the whole region, and if there is a situation where the local area is opposite to the global spatial characteristics, the global Moran's I is no longer applicable, and the spatial Moran's I is proposed to measure the autocorrelation between each spatial unit and its surrounding spatial regions.

Spatial autocorrelation analysis is an analytical method based on measuring the spatial correlation of evaluation objects. In this paper, Moran's index is adopted to analyze the spatial correlation of FDI in 31 provinces, autonomous regions and municipalities in China at both global and local levels. The global Moran'I index identifies whether there is spatial correlation in the study area as a whole, and then reflects its degree of correlation with neighboring areas, and is calculated as follows:

$$\mathrm{I_i} = \frac{\sum_{i=1}^{\mathrm{n}}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \times \frac{n}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{12}$$

In equation (12), it represents the global Moran index, which is the spatial weight matrix, n=31 indicates the number of 31 provinces, autonomous regions and cities studied in this paper, and the FDI in province i and province j respectively. The local Moran index studies the local agglomeration characteristics of FDI in 31 provinces, autonomous regions and municipalities at the spatial level, so as to reflect the spatial heterogeneity of the local region, and is calculated as follows:

$$\mathrm{JI_i} = \frac{\mathrm{n}(x_i - \bar{x})\sum_{j=1}^{n} x_j - \bar{x}}{\sum_{i=1}^{n}(x_j - \bar{x})^2} \tag{13}$$

In Eq. (13), J_{Ij} represents the local Moran index, and the rest of the sign settings are consistent with Eq. (10). From the local Moran's index, the development level of FDI in each province can be classified into four types: high - high agglomeration, high - low agglomeration, low - low agglomeration, and low - high agglomeration.

Subsequently a large number of scholars have conducted applied research using local Moran's I. Measuring the correlation between spatial data relies on spatial weight matrices, which are commonly defined in the following ways: binary neighbourhood spatial weight matrix, geospatial weight matrix, and economic geospatial weight matrix. Assuming that there are n spatial units in a given area, the most common of these is to use the binary adjacency spatial weight matrix $W^* = \left(w_{ij}^*\right)_{n\times n}$, i.e., $w_{ij}^*(i, j = 1, 2, \cdots, n)$ indicates the size of the degree of dependence between spatial unit i and spatial unit j, then $w_{ij}^* = 1$, if spatial unit i is adjacent to spatial unit j; $w_{ij}^* = 0$, if spatial unit i is not adjacent to spatial unit j; and $w_{ii} = 0$. However, in order to unify the extrinsic influences of the spatial units, the spatial weight matrices are matrix normalised, i.e.:

$$w_{ij} = \frac{w_{ij}^*}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}^*}. \tag{14}$$

Usually, the spatial weight matrix $W=\left(w_{ij}\right)_{n\times n}$ after normalisation is referred to as the spatial weight matrix in the strict sense.

Assuming that the observation of n spatial cells in the specified region is $x=\left(x_1,x_2,\cdots,x_n\right)^{\mathrm{T}}$, combined with the above spatial weight matrix, and thus the vector of spatial global Moran's I is defined as follows:

$$I=\frac{z^T W z}{w_0} \tag{15}$$

where $z=\frac{x-\bar{x}}{s}$, $\bar{x}=\frac{1}{n}\sum_{i=1}^{n}x_i$, $s=\frac{1}{n}\sum_{i=1}^{n}\left(x_i-\bar{x}\right)^2$, $w_0=\sum_{i=1}^{n}\sum_{j=1}^{n}w_{ij}$. Spatially localised Moran's I are defined as follows:

$$I_i=\frac{z_i\sum_{j=1}^{n}w_{ij}z_j}{w_0}, i=1,2,\cdots,n \tag{16}$$

Among them:

$$z_i=\frac{x_i-\bar{x}}{s}, z_j=\frac{x_j-\bar{x}}{s} \tag{17}$$

Theoretically the spatial global Moran's I takes the range of $\left[-1,1\right]$. When the sample of observed data is large, the spatial global Moran's I obeys the normal distribution. Therefore, it can be tested for significance by constructing the $Z(I)$-statistic, and the significance test of the spatial local Moran's I is the same.

If the spatial Moran's I passes the test at a certain level of significance, the aggregation of a given region can be categorised according to the range of values of the spatial Moran's I as follows: $I>0$, indicating that there is a spatial positive correlation across the entire spatial region, i.e., the region shows an aggregation effect in which the cells with high (low) observations are surrounded by the cells with high (low) observations. The aggregation effect of the unit with high (low) observations being surrounded by units with high (low) observations. $I<0$, indicating that there is a negative spatial correlation in the entire spatial region, i.e., the spatial region exhibits a clustering effect in which cells with high (low) observations are surrounded by cells with low (high) observations. $I=0$, indicating that there is no spatial correlation in the entire spatial region, i.e., the distribution of the observations of each spatial unit in the entire space shows randomness.

3. Analysis of empirical results

3.1. *Impact of FDI on China's GDP growth*

In this paper, we will take gross regional product as the explanatory variable and foreign direct investment as the explanatory variable. And OLS and quantile regression methods are used for modelling, so as to comprehensively reflect the impact of China's FDI on economic growth at different quartiles, based on the results of the analysis of OLS and quantile regression models as shown in Table 1. In the OLS regression model, the impact of foreign direct investment (FDI) on economic growth is significantly positive at the 10% level, indicating that the large-scale introduction of foreign investment can promote China's economic development. Comparing the differences between different quantile points, it can be seen that at the 25% quantile point, FDI significantly promotes China's high economic growth. While the estimated coefficients of FDI on regional GDP are positive at the 50% and 75% quantile points, but fail the test of significance at the 10% level, and the regression coefficients of

FDI on economic growth decreases sequentially at the 25%, 50% and 75% quantile points. This suggests that when the economic growth rate is low, FDI can significantly promote economic growth. When the economic growth rate is faster, the positive effect of FDI on economic growth is weakened or even becomes insignificant.

Table 1. The impact of foreign direct investment on economic growth

		FDI	LNY	LnDK	LNL	Constant term
OLS	GROW	30.712* (2.03)	0.625 (0.07)	42.784*** (6.12)	-0.425*** (-4.86)	1.471 (0.101)
	PGROW	27.124* (1.86)	4.136 (0.44)	40.102*** (5.62)	-0.402*** (-4.47)	0.603 (0.48)
25%	GROW	40.122** (2.31)	2.194 (012)	30.045*** (4.65)	-0.247* (-1.86)	1.613 (0.64)
	PGROW	32.642* (1.78)	-4.633 (-0.28)	26.122*** (3.76)	-0.115 (-0.64)	2.211 (0.96)
50%	GROW	17.412 (0.79)	6.122 (0.42)	34.516*** (3.11)	-0.387** (-2.24)	0.578 (0.29)
	PGROW	20.846 (1.02)	1.978 (0.13)	23.748* (1.89)	-0.276 (-1.25)	-0.072 (-0.04)
75%	GROW	9.527 (0.46)	9.584 (0.53)	60.032*** (4.12)	-0.549*** (-3.11)	0.665 (0.28)
	PGROW	13.425 (0.57)	16.345 (0.84)	53.147*** (3.32)	-0.542*** (-2.86)	-0.447 (-0.19)

The horizontal lines are the estimated coefficient values and confidence intervals of OLS, and the curves and shaded parts are the estimated coefficients and corresponding confidence intervals of the quantile regression model as shown in Figure 1. At the lower quantile points, FDI has a relatively strong driving effect on economic growth, and at the higher quantile points, the positive impact of FDI on economic growth gradually weakens. In addition, the trends of the changes in the estimated coefficients of other control variables on economic growth at different quartiles are visualised in the figure. Thus, the positive effect of FDI on economic growth decreases at the margin as the economic growth rate increases.

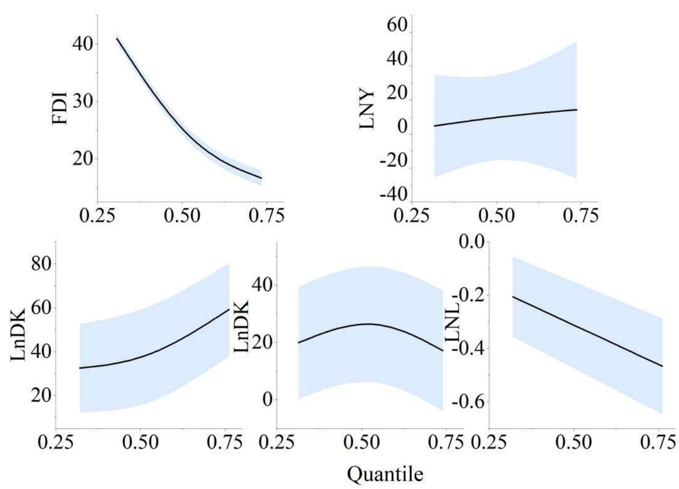


Fig. 1. OLS and QR regression coefficients

3.2. Impact of FDI on China's regional GDP growth

3.2.1. Characteristics of the dual structure of FDI. Since 1979, with the deepening reform of the economic system, the expansion of market openness and changes in economic structure, China's gross domestic product (GDP) has been growing at an average annual rate of about 10 per cent and its per capita GDP at an average annual rate of more than 8 per cent during the period from 2008 to 2024. It is rare in the world that the Chinese economy has been able to maintain such a high average growth rate over a period of 16 years. However, when viewed from a broader regional perspective, China's regional economic growth is characterised by an unbalanced and dualistic structure. This duality in China's regional economic development is mainly reflected in the north-south disparity, which has gradually shifted to an east-west disparity since the reform and opening up. The absolute and relative differences in per capita GDP are shown in Figure 2.

To facilitate the analysis of this dualistic structural feature, we divide China into two parts, namely the more developed eastern region and the relatively backward western region. Typical representatives of the former are Liaoning, Hebei, Beijing, Tianjin, Shandong, Shanghai, Jiangsu, Zhejiang, Fujian and Guangdong (including Hainan), while typical representatives of the latter are Guangxi, Inner Mongolia, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Sichuan (including Chongqing), Guizhou, Yunnan and Tibet. So Guangxi and Inner Mongolia as a relatively backward western region of the typical, mainly because these two provinces and autonomous regions belong to ethnic minorities, and geographically close to the southwest and northwest, the level of economic development is relatively low, enjoying the national western development policy preferential. It is clear from the figure that since the reform and opening up, the absolute and relative gap in per capita GDP between these two types of areas has been tending to widen.

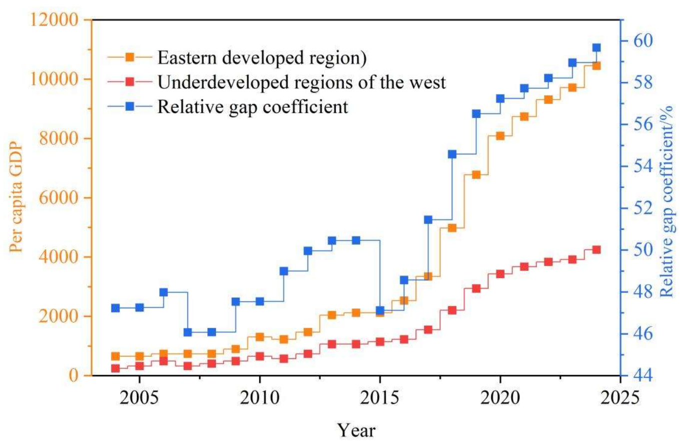


Fig. 2. GDP per capita and relative disparity

This high degree of imbalance in the regional distribution of foreign investment has had a different impact on capital formation, export expansion and economic growth in each region. The distribution of foreign investment in different regions is shown in table 2. In terms of capital formation, during the period 2008-2024, the proportion of foreign direct investment and other investment equivalent to total investment in fixed assets in the developed eastern regions averaged 4.16 per cent, while in the backward western regions it averaged only 0.89 per cent. After 1992, with the continuous promotion of opening up to the outside world, foreign direct investment in China has been increasing, and its role in capital formation has become increasingly important. During the period 2017-2024, the proportion of foreign direct investment and other investment equivalent to the whole society's fixed asset investment in the developed eastern regions has reached 18.51 per cent on average, while the backward regions in the west are still stuck at the level of the developed eastern regions in the 1980s, with the proportion averaging only 4.17 per cent. Obviously, this great difference of foreign investment in regional capital formation has an important impact on the formation of the east-west dual structure. As can be seen from the table, there is a great difference in the proportion of foreign investment equivalent to GDP between the developed eastern regions and the backward western regions.

Table 2. The importance of foreign direct investment and his investment

	Foreign direct investment and his investment ($100 million)		Foreign investment is the equivalent of GDP(%)		Foreign investment is equivalent to the proportion of fixed asset investment(%)	
Year	Eastern developed region	Western undeveloped region	Eastern developed region	Western undeveloped region	Eastern developed region	Western undeveloped region
2008	4.12	0.33	0.21	0.08	1.54	0.38
2009	5.35	0.48	0.39	0.09	1.61	0.41
2010	8.39	0.45	0.58	0.09	2.2	0.34
2011	11.58	1.05	0.82	0.2	2.79	0.66
2012	14.64	1.61	1.08	0.31	3.38	1.07
2013	15.39	1.76	1.03	0.31	3.07	1.08
2014	27.25	2.12	1.42	0.3	4.33	1.09
2015	30.59	1.94	1.44	0.25	5.4	1.05
2016	31.71	1.47	1.74	0.21	6.51	0.92
2017	40.65	1.73	2.12	0.24	7.46	0.95
2018	98.69	3.99	2.93	0.45	12.28	1.62
2019	230.08	20	7.04	1.78	17.86	5.34
2020	283.89	23.15	8.71	2.38	24.46	7.37
2021	319.74	18.79	7.37	1.52	21.88	4.94
2022	358.87	17.4	7.92	1.19	21.63	4.05
2023	390.56	25.48	7.64	1.56	22	5.19
2024	404.53	23.55	7.28	1.35	20.5	3.92

3.2.2. Analysis of geographical heterogeneity. The descriptive statistics of the variables of the regression model are shown in Table 3, with the mean values of the descriptive statistics in the East generally exceeding 5 and the maximum exceeding 8, while the descriptive statistics in the West exceed the maximum of 7.

Table 3. Variable descriptive statistics

		LNY	LnDK	FDI	LNL
Whole country	Mean	7.8356	6.8475	3.6792	7.1461
	Median	8.1247	7.0418	3.8426	7.5249
	Maximum value	10.4825	9.7732	11.8463	8.7924
	Minimum value	4.4127	3.4216	-4.0276	0.7784
	Standard deviation	1.0947	1.2167	2.0148	1.4733
East	Mean	8.3146	7.2418	5.3341	7.3290
	Median	8.5179	7.4122	5.4261	7.7843
	Maximum value	10.4716	9.7285	11.7839	8.7428
	Minimum value	5.2416	4.1221	1.8463	5.2247
	Standard deviation	1.1125	1.2351	1.2378	0.9457
West	Mean	7.2163	6.3347	2.0411	7.2462
	Median	7.3145	6.3224	2.2166	7.4265
	Maximum value	9.4562	8.9241	5.4429	8.8362
	Minimum value	4.5213	3.4572	-4.0176	5.2637
	Standard deviation	1.0347	1.1633	1.8454	0.9145

The descriptive statistics of the variables of the regression model are shown in Table 4. According to the results of regression of time series and cross-section data of each province and city from 2008 to 2024. Regression results show that the R2 and adjusted R2 of the five regression models are all above 0.9, indicating a good fit, and the F-value greatly exceeds the critical value, indicating that the equations are significant as a whole, and the following conclusions can be drawn.

Regarding the regression results of 30 provinces and cities in China, the elasticity coefficients of domestic investment, foreign investment and labour factor inputs to economic growth are all very significant during 2008-2024, among which the largest coefficient of GDP growth is domestic investment, and for every 1% increase in domestic investment, the GDP of the whole country increases by 0.743%, which indicates that the growth of China's economy is still mainly driven by investment. Second is the labour factor, every 1% increase, GDP growth of 0.093%, which from a side that China's sustained economic growth is an important factor is the 'demographic dividend', the elasticity of FDI is the smallest, 0.0875, that is to say, every 1% increase in FDI, the GDP growth of 0.0875%, the elasticity coefficient of domestic investment is the FDI coefficient, the GDP growth of 0.743%, indicating that China's economic growth is still mainly driven by investment. The elasticity coefficient of domestic investment is 7 times of FDI coefficient, of course, from the point of view of the total amount, the amount of domestic investment is far more than the amount of foreign direct investment.

The regression results of 10 provinces and cities in the east show that the input elasticity coefficients of domestic capital, FDI and labour factor are all significant at the level of 0.01. As in the whole country, the biggest contribution to GDP growth in the east is domestic investment, and for every 1% increase in domestic investment, GDP grows by 0.81%, and the elasticity coefficient of the labour force is 0.123. That is to say, for every 1% increase in the labour force, GDP in the east grows by 0.123%. In other words, for every 1% increase in labour force, the GDP of the eastern region grows by 0.123%, and the eastern region has absorbed a lot of labour force from the central and western regions due to the development of the private economy and the foreign economy, and the cheap labour force is the reason for the sustained and rapid economic growth of the eastern region.The FDI is gathered in the eastern region, and it has a very significant positive impact on the economic growth, with an elasticity coefficient of 0.099, and for every 1% increase in the use of FDI in the eastern region, the GDP of the eastern region grows by 0.099%. 0.099 per cent growth, the elasticity is higher than the national level and also higher than the elasticity of FDI in the other three regions.

The impact of the three factors on GDP is significant in the western region, with the largest elasticity coefficient of domestic investment at 0.74. A 1% increase in domestic investment in the west will result in a 0.74% increase in western GDP. The second is the elasticity coefficient of labour at 0.126, which means that for every 1% increase in the labour force in the west, the GDP of the west will increase by 0.126%. The smallest is the elasticity coefficient of FDI of 0.05, which means that for every 1% increase in the absorption of FDI in the west, the GDP of the west grows by 0.05%.

From the elasticity coefficient of regional domestic investment, the east is the highest 0.81, followed by the west is 0.74. This and the regional distribution of the number of China's domestic investment has been, although the scale of China's investment to expand the number of channels of investment, but no matter which type of investment is tilted towards the eastern region, so the eastern region's development is faster than the other regions. From the elasticity coefficient of FDI, the eastern part is 0.099, and the western part is 0.05, which indicates that the economic growth of the eastern part is the biggest among the 2 regions. The elasticity coefficient of labour force is 0.126 in the east and 0.125 in the west.

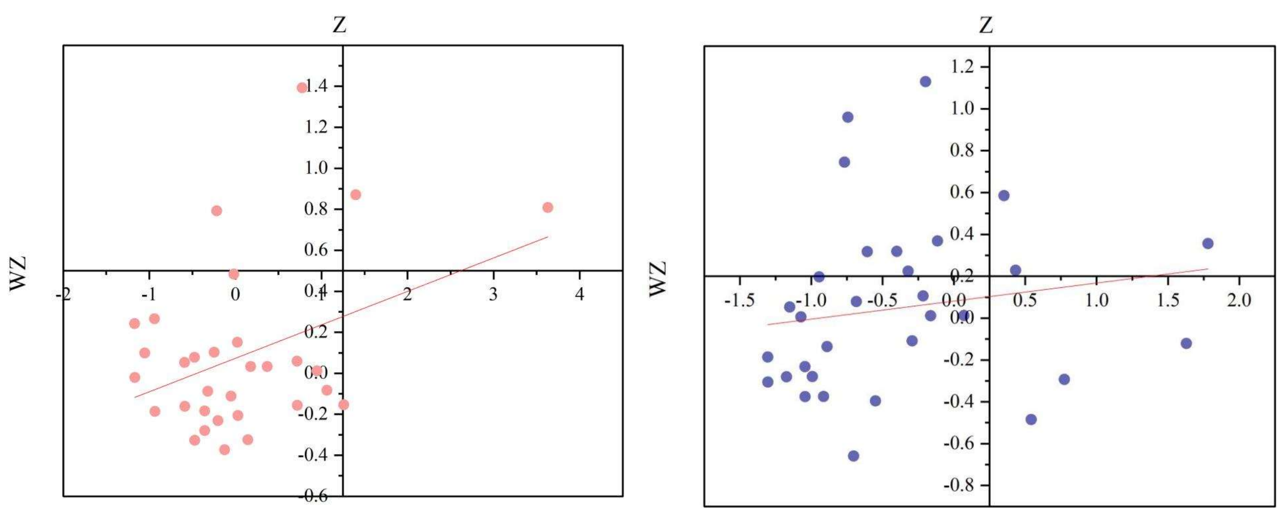
It has a significant role in promoting the economic development of China as a whole and the 2 regions. Foreign direct investment (FDI) has the greatest impact on the eastern region, followed by the western region. A large amount of research literature has proved the role of FDI in regional economic development, and the practice of China's thirty years of opening up has also proved the role of FDI in promoting economic growth. The imbalance in the regional distribution of FDI in China is consistent with the imbalance in China's regional economic development, and many studies have proved that much of this gap in regional economic development can be attributed to the unbalanced distribution of FDI.

Table 4. The statistics are returned

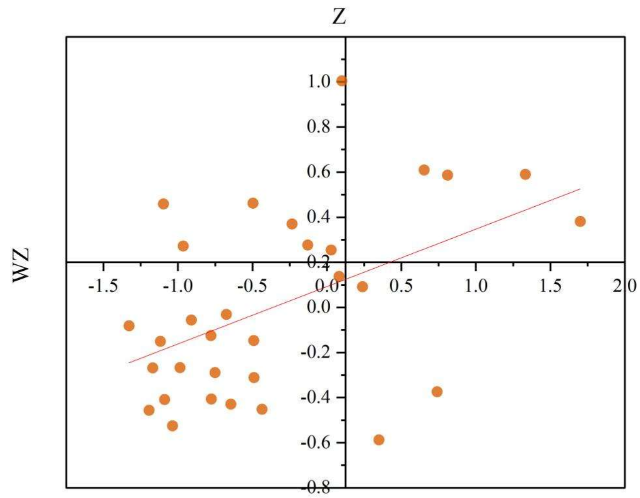
	Whole country	East	West
C	3.0241*** (15.3457)	1.0247*** (6.3246)	1.8942*** (9.1243)
LnDK	0.7425*** (60.2143)	0.8142*** (34.1226)	0.7412*** (42.5378)
FDI	0.08749*** (9.3256)	0.09924*** (5.462)	0.05213*** (4.0146)
LnL	0.09325*** (5.6284)	0.1263*** (5.4368)	0.1254*** (4.9632)
R^2	0.9332	0.9425	0.9537
Adjust R^2	0.9348	0.9449	0.9533
D.W	1.2332	1.2332	1.6128
F	2214.746	863.27	994.28
Sample size	500	180	170

3.3. Spatial correlation test

In order to visually elucidate the imbalance that exists in the space, Moran, I scatterplot is often utilized in practice to represent the agglomeration pattern of regional units.The scatterplot of foreign investment in economic space and geographic space for 2008, 2016, and 2024 is shown in Fig. 3.The Moran I scatterplot is divided into four quadrant dimensions, and the scatters in the first and the third quadrants show high -high (H-H) or low-low (L-L) aggregation of spatial characteristics, which shows that foreign investment in the two dimensions of geographic space and economic space, showing obvious aggregation characteristics. Combined with the analysis above, due to the influence of policy, transportation, preference and other factors, for foreign investment, then prefer the relatively complete industrial chain of coastal provinces. With the passage of time, foreign investment has gradually begun to discrete, no longer limited to the traditional coastal areas, but gradually spread to inland areas, which is basically consistent with the previous analysis. In summary, the core variable of foreign investment has a strong spatial dependence.



(a)2008 (b)2016



(c)2024

Fig. 3. Moran I scatter diagram

In order to gradually narrow the gap between regional economic development and eventually realize common progress, which is the objective requirement for modernization, it is of great significance to introduce foreign capital into the central, western and northeastern regions, improve the use of foreign capital in the regional industries and related industries, adjust the economic structure, and drive the development of the regional economy.

4. Conclusion

This paper uses OLS and quantile regression methods to test the differential impact of FDI on GDP growth in two major regions of China. The spatial correlation test-Moran index is used to analyze the spatial relationship of FDI among provinces, regions and cities. Conclusion:

When the economic growth rate is low, FDI has a significant effect on economic growth. When the economic growth rate is high, the positive effect of FDI on economic growth gradually diminishes. The great difference between the north and the south in regional capital formation by foreign investment creates the unbalanced and dual structure characteristic of China's economic development. The elasticity coefficients of FDI in the east and west are 0.099 and 0.05 respectively.The Moran index shows that the clustering effect of FDI in the east is quite significant. Therefore, foreign investment has a significant impact on the difference in GDP growth between developed regions in the east and backward regions in the west.

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Declarations:

The authors declare no conflict of interest concerning the results and content.

Data availability:

The data is available on request.

Conflict of interest declaration:

The authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

Author contributions

The first and third authors were responsible for the research design, data collection, and data analysis. The first and second authors contributed to the manuscript writing and revision. All authors have read and agreed to the published version of the manuscript.

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