Vol. 6 (2025): Proceedings of the 2025 International Conference on Business, Management and Sustainability (ICBMS 2025)
E-ISSN: 3105-0522 P-ISSN：3105-0514
DOI: https://doi.org/10.70267/icbms.202511

Research on the Influencing Factors of Beijing's Economic Growth via Multiple Regression Analysis

Naiwen Zhang[1], Ziyu Luo[2,*] and Guohua Ren[3]

[1]*Faculty of Business, Macao Polytechnic University, Macao 999078, China*

[2]*Faculty of Liberal arts, Macau University of Science and Technology, Macao 999078, China*

[3]*Faculty of Business, Macau University of Science and Technology, Macao 999078, China*

**Corresponding author: Ziyu Luo.*

Abstract

In recent years, academic circles have continued to discuss and study the factors influencing internal economic growth in typical regions. On the basis of the existing theoretical basis of regional economic growth research, the Cobb–Douglas production function, this paper combines the influencing factors of Beijing economic growth with economic level indicators (Zhang et al., 2018). Using multiple regression methods, this study investigates the factors influencing economic growth in Beijing from 2003--2022. Eleven indicators, including per capita fixed asset investment (FAI) and the employment level (LR), were selected to measure the annual per capita GDP growth rate of Beijing across 11 dimensions, such as capital input, labor force input, and globalization. The research results were validated by constructing a multiple linear regression equation. The key findings indicate that the proportion of service industry output in total output (IDU) and per capita retail sales of consumer goods (CGP) significantly positively correlate with the per capita GDP growth rate (RG). On the basis of these findings, the study proposes adjusting industrial structures and formulating policies to vigorously develop the service sector and driving consumption upgrades through targeted campaigns to stimulate domestic demand. The model demonstrates good fit, providing valuable references for analyzing regional economic factors.

Keywords

economic growth, influencing factors, Beijing, multiple regression model, Cobb–Douglas production function

1. Research Context

With the development of the global economy, China has maintained stable and rapid economic performance since joining the World Trade Organization. The economic growth rate has been far ahead of others, owing to the three engines driving China's economic growth: investment, consumption, and import–export trade (Ye, 2023).

Since 1978, the Chinese economy has experienced rapid development, creating an "economic miracle" with a growth rate of 10%, which has stunned both domestic and international communities. The economic development of Chinese cities has gradually entered the industrialization era, with total economic output and per capita income entering a new phase. However, influenced by misguided theories such as GDP-centric theories and extensive high-speed growth, a series of issues have emerged, including environmental pollution, economic structural imbalances, disproportionate input–output ratios, and inefficiency.

Socialism with Chinese characteristics has entered a new era. To explore ways to overcome the challenges in urban economic development, it is necessary to transform development models, enhance efficiency, upgrade industrial structures, and achieve high-quality economic growth. This consensus on urban economic development holds that firmly choosing healthy and sustainable economic development will remain the fundamental logic for urban economic progress in the coming years (Zhang, 2021).

2. Research Motivation

Since 1978, economic growth in Beijings has undergone remarkable transformations. Since 2003, with the deepening of reform and opening-up policies and improved policy environments, the city has maintained steady economic expansion and sustained growth in per capita GDP. According to statistical data, the Beijings regional GDP is projected to exceed 4 trillion yuan in 2022, with the per capita GDP reaching 180,000 yuan, demonstrating robust economic momentum. However, amid economic globalization and domestic economic restructuring, Beijing faces three major pressures: external industrial uncertainties, insufficient domestic demand, and transformation challenges. Therefore, in-depth analysis of growth drivers helps identify key factors, providing governments with precise policy references to promote high-quality development.

3. Aims of the Study

3.1 Identifying Key Influencing Factors:

Through systematic analysis of the influencing factors affecting Beijing's economic growth, including the policy environment, industrial structure, scientific and technological innovation, consumer demand, etc., this paper comprehensively understands their interaction and influence mechanism and identifies the key influencing factors.

3.2 Evaluate the Effectiveness of Existing Policies:

Through quantitative analysis, the actual effect of existing policies on economic growth is evaluated to provide some support for the next policy adjustment and optimization.

3.3 Development Suggestions:

On the basis of the research findings, this paper proposes concrete recommendations to promote the sustainable and healthy development of the Beijing economy, with the aim of enhancing urban economic quality and optimizing industrial structure upgrading. This study provides a scientific basis and strategic guidance for Beijing when facing new challenges, ensuring stable economic growth amidst complex and ever-changing circumstances.

3.4 Policy Guidance:

As the capital of China, Beijing plays an important guiding role in the development direction and policy formulation of major cities across the country (Wang et al., 2020).

4. Research Questions

This study focuses on Beijing as a representative region to theoretically and practically explore 11 dimensions of indicators: the capital dimension (FAI), i.e., per capita fixed asset investment; the labor dimension (LR), i.e., the number of employed personnel; the globalization dimension (FFE), i.e., the proportion of foreign-funded industrial enterprise output value in total industrial output; the urbanization dimension (UR), i.e., the nonagricultural population ratio; the industrial structure dimension (IDU), i.e., the tertiary industry output value share; the marketization dimension (FRE), i.e., the fiscal budget revenue-to-expenditure ratio; the capital dimension (DP), i.e., per capita savings deposits of urban and rural residents; the labor dimension (PD), i.e., the population density; the market dimension (CGP), i.e., the per capita retail sales of consumer goods; the transportation dimension (HD), i.e., the highway density; and the communication dimension (PHP), i.e., average telephone users per household. Does this research significantly impact economic growth indicators such as the GDP growth rate (GR)?

5. Review of the Literature

Because the economy plays an important role in national and regional development, the study of the relevant factors affecting economic growth has always been a key issue for economic experts and scholars.

In terms of theoretical research, Yang and Zhang (2009) used econometric methods to conduct empirical analysis on fixed asset investment, fiscal expenditure and GDP to demonstrate the relationships among the three. Gao (2009) proposed feasible suggestions for the construction of three industries in Shaanxi Province by means of quantitative research to promote the growth of GDP in Shanxi Province. Guo et al. (2012) studied the relationship between economic growth and new energy utilization from an empirical perspective and identified their internal connection. Li and Zhou (2013) established a VAR model to analyze per capita GDP, pollution levels and other relevant data in Shandong Province and empirically studied the impact of environmental pollution on economic growth.

In terms of research content, in recent decades, many domestic and foreign experts and scholars have explored and found such content (Li, 2007). Foreign direct investment and research and experimental development expenditure, total import and export trade, household consumption level (Bai, 2019), fixed asset investment (Li, 2019), number of employed persons. It is a major factor affecting economic development. To verify whether a cointegration relationship and causal relationship exist between energy consumption and GDP, Wu et al. (2008) analyzed Chinese economic data from 1986--2005 and ultimately concluded that Chinese GDP growth has a unidirectional causal relationship with energy consumption. Ni et al. (2014) conducted a quantitative analysis on the impact of capitalization of R&D expenditure on the economy and reported that R&D expenditure on R&D was positively correlated with GDP. Li et al. (2018) studied the impact of fixed asset investment on the economy through the least squares method and reported that it has an impact.

To study evolving economic trends across different countries and cities accurately, international scholars have increasingly focused their research. Their analytical frameworks have shifted from absolute indicators such as per capita income or output value that reflect economic scale to relative growth metrics. In analyzing the factors influencing U.S. economic disparities, Martin and Sunley (1998) have identified significant impacts from social capital, technological advancement, and income distribution systems. Woo et al. (2014) analyzed the income trend of CLUB in downtown and residential areas in the United States since 1980 and reported that the selected per capita output value growth rate index showed opposite development trends. Wei (2015) noted that economic analysis should not only start from the perspective of multiple mechanisms, such as health, education and political participation but also include the analysis of economic spatial differentiation, environmental equity and social justice.]

In terms of research methods, many experts and scholars use a variety of models and algorithms to analyze data. The mainstream methods include the neural network prediction model and gray prediction model (Liu & Tang, 2015). Bai (2019) employed methods such as multiple linear regression prediction. Specifically, the study developed a multivariate linear regression model for key indicators to forecast economic trends, achieving an error margin below 5% between the theoretical predictions and actual values. Li (2019) conducted a linear regression analysis of Jiangsu Province gross domestic product (GDP) data from 2017, revealing a discrepancy of 2905.97 yuan compared with actual figures, with an average deviation of 3.38%.

This paper selects the data of Beijing from 2003--2022, selects 11 indicators from different dimensions as variables through a literature review, uses a multiple linear regression model for empirical analysis, explores the influencing factors of economic growth in Beijing, and verifies the research conclusions to draw final conclusions.

6. Theoretical Study

6.1 Cobb–Douglas Production Function

The Cobb–Douglas production function, a cornerstone of microeconomics, was first formulated by Knut Wicksell. Using data from the U.S. manufacturing sector spanning 1899--1922, mathematician C.W. Cobb and economist P.H. Douglas statistically validated and ultimately established this model between 1900 and 1928.

The Cobb–Douglas production function is used to reflect the relationship between output and input. Only when the technological level does not affect the marginal rate of substitution can the theoretical model be established. The general expression is as follows: $Q=AK^{\alpha}L^{\beta}$. where Q refers to the total output size, A refers to the total factor productivity (constant, K or L does not affect its size), K refers to the amount of capital input (≥0), L refers to the amount of labor input (≥0), α refers to the capital productivity elasticity, and β refers to the labor productivity elasticity (Wang et al., 2019).

6.2 Economic Theory

(1) Marginal output theory:

The theory emphasizes that in the production process, increasing a unit of a factor of production (such as labor or capital) will bring about incremental changes. The Cobb–Douglas production function adds the elasticity coefficient of capital and labor to quantify the contribution of each factor to total output.

(2) Factor alternative theory:

The Cobb–Douglas production function assumes that labor can replace capital to a certain extent, although this substitution is limited. The model shows that labor can replace capital to a certain extent, and vice versa, but they are not completely substitutable.

(3) Theory of returns to scale:

This function reflects different cases of scale returns, including increasing, decreasing and constant scale returns. This theory helps analyze how production efficiency changes under different input combinations.

(4) Theory of technological progress:

In the Cobb–Douglas model, the comprehensive technological level (A) is an independent variable and an influencing variable. This part reflects the role of technological progress in improving production efficiency, which is an important research field in modern economics.

(5) Classical economic theory:

The productive value of Cobb–Douglas inherits the ideas of classical economists such as Adam Smith and David Ricardo to some extent, emphasizing the importance of labor and capital in creation.

7. Research Methodology

7.1 Multiple Linear Regression Analysis Model:

Let the random variable y and the general variables x_1, x_2, etc.

The linear regression model is as follows:

$$y=\beta_0+\beta_1x_1+\beta_2x_2+...+\beta_px_p+\varepsilon$$

In the model, y is the explained variable; x_1, x_2, etc., x_p is an explanatory variable that can be measured and controlled with precision; β_0, β_1, β_2, etc., and β_p is a p+1 unknown parameter, where β_0 is a constant, β_1, β_2, etc. β_p is the regression coefficient; and ε is the random error. Assumptions:

$$\begin{cases} E(\varepsilon) = 0 \\ var(\varepsilon) = \delta^2 \end{cases}$$

Fit:

$$E(y)=\beta_0+\beta_1x_1+\beta_2x_2+...+\beta_px_p+\varepsilon$$

It is a theoretical regression model.

If n groups of observed data (x_{i1}, x_{i2}, …, x_{ip}; y_i) (i=1, 2, ..., n), then the linear regression equation can be expressed as:

$$\begin{cases} y_1 = \beta_0 + \beta_1 x_{11} + \beta_2 x_{12} + \ldots + \beta_p x_{1p} + \varepsilon_1 \\ y_2 = \beta_0 + \beta_1 x_{21} + \beta_2 x_{22} + \ldots + \beta_p x_{2p} + \varepsilon_2 \\ \cdots \\ y_n = \beta_0 + \beta_1 x_{n1} + \beta_2 x_{n2} + \ldots + \beta_p x_{np} + \varepsilon_n \end{cases}$$

Write as a matrix:

$$y = X\beta + \varepsilon$$

X is a n* (p+1)-order matrix, known as the data matrix or regression design matrix (Peng, 2010).

8. Research Models

8.1 Research Area

As the capital of China, Beijing plays an important guiding role in the development direction and policy formulation of major cities across the country. Therefore, the research area of interest in this paper is Beijing.

8.2 Research Data

The original data collection period of this paper is 1978--2022. Owing to the large time span and lack of some data, to ensure the integrity of the data and consider the availability of the data, after data cleaning, the sample interval of the empirical research was 2003--2022. In addition, owing to the large amount of data, this paper adopts logarithmic processing.

All the research data were sourced from official statistics, including the Beijing Municipal Statistical Yearbook (2003--2022), China County Statistical Yearbook (1978--2022), China City Statistical Yearbook (1978--2022), Beijing Statistical Yearbook (1978--2022), and other statistical bulletins published by the Beijing Municipal Bureau of Statistics, National Bureau of Statistics, and Beijing Municipal Peoples Government.

8.3 Selecting Variables

To further analyze urban economic growth disparities, Li et al. (2008) conducted a factor decomposition of GDP changes across cities. Following the methodology of the OECDs National Statistical Office Working Group on Statistics and Indicators, they broke down regional GDP share variations into six dimensions. Each dimension was represented by an indicator reflecting regional economic performance: capital productivity, capital stock per worker, industrial specialization level, employment rate, working-age population ratio, and total population. Wei (2015) suggested that the factors affecting regional economic inequality include economic structure (the existing industrial types of a region affect its economic performance), investment mode (regions that attract more investment tend to experience faster economic growth), policy intervention (government policies can alleviate or aggravate regional differences), etc. Wang et al. (2015) used the following independent variables in their analysis of the influencing factors of economic development in Guangdong since 1990: globalization (foreign direct investment), marketization (nonstate-owned economy), streamlining administration and delegating power (local budget expenditure), investment level (fixed asset investment), urbanization rate (urbanization level), and savings level (savings deposits of urban and rural residents). Li et al. (2016) employed a multivariate regression model to analyze the mechanisms behind regional economic disparities in Henan Province, with relative per capita GDP serving as the dependent variable and explanatory variables, including marketization, decentralization, and regional development strategies. Decentralization was measured by the ratio of local per capita fiscal expenditure to provincial per capita fiscal expenditure, reflecting both fiscal decentralization levels and financial transfers from higher-level governments to local authorities. Marketization was assessed via indicators such as marketization indices and market development maturity, but owing to data availability constraints, the ratio of county-level per capita retail sales of consumer goods to provincial averages was selected as a proxy. Fixed asset investment, a key indicator of regional strategic orientation, was chosen to represent regional development strategies. Li and Fang (2018) reported that the integration speed varies across different regions due to factors such as local policies, investment levels and industrial structure.

By reading the research and discussion of experts on the factors affecting the economic development of domestic cities and based on the Cobb–Douglas production function, this paper selects the following variables and indicators, and the relevant explanations of the variables and indicators are shown in Table 1.

Table 1: Variable index description table

Number	Name	Variable indicators (Units)	Study latitude	Expected impact
1	FAI	Per capita fixed asset investment (yuan/person)	Capital investment	+
2	LR	Number of employees (ten thousand)	Labor input	+
3	FFE	The proportion of output value of foreign-funded industrial enterprises in the total output value of industrial enterprises (%)	Globalization	+
4	UR	Proportion of nonagricultural population (%)	Urbanization	+
5	IDU	The proportion of the output value of the tertiary industry in the total output value (%)	Industrial structure	+
6	FRE	The ratio of fiscal budget revenue to fiscal budget expenditure	Marketization	+
7	DP	Per capita balance of savings deposits of urban and rural residents (yuan per person)	Capital status	+
8	PD	Population density (people per square kilometer)	Labor force abundance	+
9	CGP	Per capita retail sales of consumer goods (yuan/person)	Market capacity	+
10	HD	Highway density (kilometers per square kilometer)	Transportation accessibility	+
11	PHP	Average number of telephone users per household (units/households)	The condition of communication facilities	+

9. Setting Hypotheses

Hypothesis 1: FAI has a significant effect on GR.

Hypothesis 2: LR has a significant effect on GR.

Hypothesis 3: FFE has a significant effect on GR.

Hypothesis 4: UR has a significant effect on GR.

Hypothesis 5: IDU has a significant effect on GR.

Hypothesis 6: FRE has a significant effect on GR.

Hypothesis 7: DP has a significant effect on GR.

Hypothesis 8: PD has a significant effect on GR.

Hypothesis 9: CGP has a significant effect on GR.

Hypothesis 10: HD has a significant effect on GR.

Hypothesis 11: PHP has a significant impact on GR.

10. Model Building

The following basic assumptions are made to simplify the parameter estimation of the regression equation:

1. Explanatory variables x_1, x_2, etc., It is a deterministic variable, not a random variable, and must satisfy the condition that rank (X) = p+1 <n. Here, rank (X) = p+1 <n indicates that the independent variables in the matrix X are not correlated, the number of samples is greater than the number of explanatory variables, and X is a full-rank matrix.

2. The random error term has the characteristics of zero mean and equal variance, that is:

$$\begin{cases} E(\varepsilon_i) = 0, i = 1, 2, \ldots, n \\ \mathrm{cov}(\varepsilon_i, \varepsilon_j) = \begin{cases} \delta^2, i = j \\ 0, i \neq j \end{cases} i, j = 1, 2, \ldots, n \end{cases}$$

This hypothesis is called the Gauss–Markov condition $E(\varepsilon_i) = 0$. Assuming that the observed values have no systematic error and that the average value of the random error term ε_i is also zero and that the covariance of the random error term ε_i is zero, the random error term is not correlated among different samples, there is no sequence correlation, and they have the same accuracy.

3. The normal distribution assumes the following conditions:

$$\begin{cases} \varepsilon_i \sim N(0, \delta^2), i = 1, 2, \ldots, n \\ \varepsilon_1, \varepsilon_2, \varepsilon_n \text{ are independent of each other} \end{cases}$$

In the model of the multiple linear regression matrix, this condition can be expressed as:

$$\varepsilon_i \sim N(0, \delta^2 I_n)$$

According to the above assumption and the properties of the multivariate normal distribution, the random variable y obeys the normal distribution, and the expected vector of the regression model is as follows:

$$E(y)=X\beta$$

$$\mathrm{var}(y) = \delta^2 I_n$$

On the basis of the introduced variables and under the condition of data availability, a multiple linear regression model was constructed to reflect the factors influencing economic growth in Beijing. The dependent variable is the per capita GDP growth rate, whereas the independent variables include 11 economic growth factors or potential influencing factors such as per capita fixed asset investment and workforce size. The standard model after logarithmic transformation of all the variables is as follows:

$$lnGR_t=\beta_0+\beta_1 lnFAI_t+\beta_2 lnLR_t+\beta_3 lnFFE_t+\beta_4 lnUR_t+\beta_5 lnIDU_t+\beta_6 lnFRE_t+\beta_7 lnDP_t+\beta_8 lnPD_t +\beta_9 lnCGP_t+\beta_{10} lnHD_t+\beta_{11} lnPHP_t+\varepsilon$$

where β_0 is a constant term; t represents the year; GR_t represents the per capita GDP growth rate in year t; and ε is the error term.

11. Empirical Analysis

11.1 Descriptive Statistical Analysis

This paper selects the relevant data of Beijing from 1978--2022 and conducts descriptive statistical analysis on each variable index. The results are shown in Table 2.

The minimum per capita GDP growth rate of the GR was -1.55%, the maximum was 27.86%, and the average was 12.27%. Although economic growth experienced drastic turbulence during this period, it was stable overall, and this volatility needs to be understood through more in-depth analysis to understand the reasons behind it and its potential impact on future economic development.

Among the 11 variables, we found that except for FRE, FFE, DP and LR, the number of other variables was 45, so there were 20 valid data points.

The fluctuations in the DP, CGP and FAI values were the largest; the PD and LR values were the second largest; the fluctuations in the other variables were small.

The variables of DP and FRE had large skewness, and the data were highly skewed, which may affect the subsequent statistical analysis; UR had slight negative skewness; CGP had slight positive skewness; and the distributions of the other variables were normal.

The FRE peak was positive, the data had a spike shape, and extreme values appeared at intervals; the DP peak approached 0, and the data were normally distributed; the kurtosis values of the other variables were less than 0, and the data distribution was relatively uniform and stable.

11.2 Regression Analysis

In this paper, the least squares method is used to estimate the model. The regression results of the model obtained after data standardization are shown in Table 3.

According to the data obtained via SPSS, the multiple regression model is as follows:

$$\ln GR_t\text{^}=45.854+0.958\ln FAI_t\text{^}-0.035\ln LR_t\text{^}-0.466\ln FFE_t\text{^}+4.566\ln UR_t\text{^}+9.162\ln IDU_t\text{^}+1.105\ln FRE_t\text{^}-2.750\ln DP_t\text{^}-16.753\ln PD_t\text{^}+10.245\ln CGP_t\text{^}+2.858\ln HD_t\text{^}-1.191\ln PHP_t\text{^}$$

Economic significance of variable indicators:

β_1^=0.958: For every 1% increase in per capita fixed asset investment, the growth rate of per capita GDP increases by 0.958%, assuming that other factors remain constant.

β_2^=-0.035: For every 1% increase in the number of employees, the per capita GDP growth rate decreases by 0.035%, assuming that other factors remain constant.

β_3^=-0.466: For every 1% increase in the proportion of the output value of foreign-funded industrial enterprises in the total output value of industrial enterprises, the per capita GDP growth rate decreases by 0.466%, assuming that other conditions remain unchanged.

β_4^=4.566: For every 1% increase in the proportion of the nonagricultural population, the per capita GDP growth rate increases by 4.566%, assuming that other factors remain constant.

β_5^=9.162: For every 1% increase in the proportion of the output value of the tertiary industry in the total output value, the growth rate of per capita GDP increases by 9.162%, assuming that other conditions remain unchanged.

β_6^=1.105: For every 1% increase in the ratio of budget revenue to budget expenditure, the growth rate of per capita GDP will increase by 1.105%, assuming that other conditions remain unchanged.

β_7^=-2.750: For every 1% increase in the per capita balance of urban and rural savings deposits, the per capita GDP growth rate decreases by 2.750%, assuming that other conditions remain unchanged.

β_8^=-16.753: For every 1% increase in population density, the per capita GDP growth rate decreases by 16.753%, assuming that other factors remain constant.

β_9^=10.245: For every 1% increase in total retail sales per capita, the growth rate of GDP per capita will increase by 10.245%, assuming that other factors remain unchanged.

β_{10}^=2.858: For every 1% increase in highway density, the per capita GDP growth rate increases by 2.858%, assuming that other factors remain constant.

β_{11}^=-1.191: For every 1% increase in the average number of telephone users per household, the growth rate of GDP per capita decreases by 1.191%, assuming that other factors remain constant.

Table 2: Variable descriptive statistics

Descriptive Statistics												
Variable	N	Scope	Least value	Crest value	Mean		Standard deviations	Variance	Skewness		Kurtosis	
	Statistics	Statistics	Statistics	Statistics	Statistics	Standard error	Statistics	Statistics	Statistics	Standard error	Statistics	Standard error
t	45	44	1978	2022	2000	1.96	13.13	172.50	0.00	0.35	-1.20	0.69
GR	44	29.41%	-1.55%	27.86%	12.27%	0.93%	6.14%	37.70	0.19	0.36	0.20	0.70
FAI	45	40517.65	259.32	40776.98	15566.42	2172.16	14571.32	212323245.98	0.48	0.35	-1.37	0.69
LR	41	719.80	444.10	1163.90	782.53	32.59	208.68	43547.27	0.33	0.37	-1.24	0.72
FFE	20	17.32%	21.75%	39.08%	30.06%	1.06%	4.75%	22.52	0.25	0.51	-0.25	0.99
UR	45	32.61%	54.96%	87.57%	75.67%	1.66%	11.15%	124.34	-0.63	0.35	-1.11	0.69
IDU	45	55.08%	15.87%	70.96%	37.05%	2.72%	18.24%	332.61	0.47	0.35	-1.24	0.69
FRE	38	1.21	0.47	1.68	1.00	0.03	0.21	0.04	1.26	0.38	4.01	0.75
DP	34	267975.67	400.66	268376.32	72588.59	12359.68	72068.71	5193899598.16	1.02	0.40	0.41	0.79
PD	45	819	519	1338	896.07	44.91	301.27	90762.43	0.40	0.35	-1.46	0.69
CGP	45	68273.71	507.17	68780.88	22964.54	3511.19	23553.75	554778981.00	0.81	0.35	-0.87	0.69
HD	45	0.96	0.40	1.36	0.90	0.05	0.35	0.12	0.17	0.35	-1.64	0.69
PHP	45	9.35	0.04	9.39	3.44	0.52	3.48	12.09	0.39	0.35	-1.55	0.69
Number	20											

Table 3: Least squares regression results table

Coefficient [a]

Model		Uncorrelation coefficient		Standardization factor	t	Conspicuousness	95.0% confidence interval for B		Relativity			Correlation statistics	
		B	Standard error	Beta			Lower limit	Superior limit	Zero-order	Inclined to one side	Part	Tolerance	VIF
1	(Constant)	45.854	55.576		0.825	0.433	-82.303	174.012					
	ln (FAI)	0.958	2.928	0.442	0.327	0.752	-5.794	7.709	-0.440	0.115	0.040	0.008	125.084
	ln (LR)	-0.035	3.686	-0.007	-0.009	0.993	-8.535	8.465	-0.256	-0.003	-0.001	0.028	35.844
	ln (FFE)	-0.466	3.629	-0.110	-0.128	0.901	-8.835	7.904	0.364	-0.045	-0.016	0.020	50.168
	ln (UR)	4.566	26.636	0.196	0.171	0.868	-56.857	65.989	-0.450	0.060	0.021	0.011	89.567
	ln (IDU)	9.162	3.046	2.531	3.008	0.017	2.138	16.185	0.560	0.729	0.364	0.021	48.407
	ln (FRE)	1.105	2.662	0.100	0.415	0.689	-5.034	7.244	0.187	0.145	0.050	0.255	3.928
	ln (DP)	-2.750	1.901	-2.305	-1.447	0.186	-7.133	1.633	-0.580	-0.455	-0.175	0.006	173.554
	ln (PD)	-16.753	10.321	-3.755	-1.623	0.143	-40.553	7.047	-0.452	-0.498	-0.196	0.003	366.054
	ln (CGP)	10.245	4.114	7.107	2.490	0.037	0.759	19.731	-0.448	0.661	0.301	0.002	557.078
	ln (HD)	2.858	2.044	0.624	1.398	0.200	-1.857	7.572	-0.377	0.443	0.169	0.073	13.624
	ln (PHP)	-1.191	1.960	-0.429	-0.607	0.560	-5.712	3.330	-0.355	-0.210	-0.073	0.029	34.067

a. Dependent variable: ln (GR)

12. Model Testing

12.1 1. Fit Test

Table 4: R square results table

Model Summary[b]										
Model	R	R^2	Adjusted R^2	Error in standard estimation	Change statistics					Durbin-Watson
					Change in R^2	Change in F	Degree of freedom1	Degree of freedom2	Change in significant F	
1	.940[a]	0.883	0.722	0.355	0.883	5.491	11	8	0.011	2.491

a.Predictor variable: (Constant), ln(PHP), ln(FRE), ln(FFE), ln(HD), ln(LR), ln(UR), ln(IDU), ln(FAI), ln(PD), ln(DP), ln(CGP)
b.Dependent variable: ln(GR)

Table 5: ANOVA table

ANOVA[a]						
Model		Sum of squares	Degree of freedom	Equal square	F	Significance
1	Return	7.601	11	0.691	5.491	.011[b]
	Residual	1.007	8	0.126		
	Total	8.608	19			

a.Dependent variable: ln(GR)
b.Predictor variable: (Constant), ln(PHP), ln(FRE), ln(FFE), ln(HD), ln(LR), ln(UR), ln(IDU), ln(FAI), ln(PD), ln(DP), ln(CGP)

$$R^2 = \frac{\text{Regression sum of squares}}{\text{The sum of the total squares}} = \frac{7.601}{8.608} = 0.883$$

According to Tables 4 and 5, R^2=0.883, indicating that the model can explain 88.3% of the variability of the dependent variable, and the remaining 11.7% should be explained by other factors that have not been considered. The regression model has a high degree of fit.

12.2 Significance Test of the Regression Equation

According to the data in Table 4, the double-tailed test in the F test is used to check whether all explanatory parameters are significantly different from 0 at the 5% significance level:

(1) The null hypothesis and alternative hypothesis are as follows:

$$H_0: \beta_1=0, \beta_2=0, \beta_3=0, \beta_4=0, \beta_5=0, \beta_6=0, \beta_7=0, \beta_8=0, \beta_9=0, \beta_{10}=0, \beta_{11}=0$$

$$H_1: \beta_1\neq0, \beta_2\neq0, \beta_3\neq0, \beta_4\neq0, \beta_5\neq0, \beta_6\neq0, \beta_7\neq0, \beta_8\neq0, \beta_9\neq0, \beta_{10}\neq0, \beta_{11}\neq0$$

(2) Calculate the verification statistic: $F=\frac{R^2/k}{(1-R^2)/(N-k-1)}=5.491$

(3) Critical value: $F_{0.05}(k,N\text{-}k\text{-}1)=F_{0.05}(11,20\text{-}11\text{-}1)\infty3.3$

(4) The statistic F=5.491> the critical value 3.3, and H_0 is rejected. B is significantly different from 0 at the 5% significance level, indicating that all explanatory variables have a significant effect on the per capita GDP growth rate.

12.3 Significance Test of the Regression Coefficient

According to the data in Table 3, the t-test-double-tailed test was used to detect whether each estimated parameter was significantly different from 0 at the 5% significance level (taking β_1 as an example):

(1) Set the null hypothesis and alternative hypothesis:

H_0: β_1=0

H_1: $\beta_1\neq0$ (per capita fixed asset investment is correlated with per capita GDP growth)

(2) Calculate the verification statistic: $t = \frac{\beta1\text{^}}{se(\beta1\text{^})}$=0.327

(3) Threshold: $t_{0.025}(N\text{--}k\text{--}1)=t_{0.025}(20\text{--}11\text{--}1)\infty2.306$

(4) The statistic t=0.327 is less than the critical value of 2.306, and H_0 cannot be rejected. β_1 is not significantly different from 0 at the 5% significance level, and it cannot be proven that the impact of per capita fixed asset investment on the per capita GDP growth rate is significant.

Using the double-tailed t-test, we check whether each estimated parameter is significantly different from 0 at the 5% significance level, as shown in Table 6:

Table 6: Regression coefficient t-test-double-tailed test results

Model		Uncorrelation coefficient		t statistics	Critical value $t_{0.025}(18)$	Whether to reject H_0 (Whether the t-statistic is greater than the critical value)
		B	Standard error			
1	ln(FAI)	0.958	2.928	0.327	2.306	no
	ln(LR)	-0.035	3.686	-0.009		no
	ln(FFE)	-0.466	3.629	-0.128		no
	ln(UR)	4.566	26.636	0.171		no
	ln(IDU)	9.162	3.046	3.008		yes
	ln(FRE)	1.105	2.662	0.415		no
	ln(DP)	-2.750	1.901	-1.447		no
	ln(PD)	-16.753	10.321	-1.623		no
	ln(CGP)	10.245	4.114	2.490		yes
	ln(HD)	2.858	2.044	1.398		no
	ln(PHP)	-1.191	1.960	-0.607		no

According to the data in Table 3, the P test is used to detect whether each estimated parameter is significantly different from 0 at the 5% significance level (taking β_1 as an example):

(1) The null hypothesis and alternative hypothesis are as follows:

H_0: $\beta_1=0$

H_1: $\beta_1 \neq 0$ (per capita fixed asset investment is correlated with the per capita GDP growth rate)

(2) P value of parameters β_1: p value =0.752

(3) Significance level α: α=0.05

(4) P value 0.752> Significance level 0.05; H_0 is not rejected. It is not significantly different from 0 at the 5% significance level, and it cannot be proven that the impact of per capita fixed asset investment on the per capita GDP growth rate is significant.

The results of using the P-test to check whether the estimated parameters are significantly different from 0 at the 5% significance level are shown in Table 7:

Table 7: Regression coefficient P test results

Model		Conspicuousness p	Conspicuous level α	Whether to reject H_0 (Whether it is significant p <significant level α)
1	ln(FAI)	0.752	0.05	no
	ln(LR)	0.993		no
	ln(FFE)	0.901		no
	ln(UR)	0.868		no
	ln(IDU)	0.017		yes
	ln(FRE)	0.689		no
	ln(DP)	0.186		no
	ln(PD)	0.143		no
	ln(CGP)	0.037		yes
	ln(HD)	0.200		no
	ln(PHP)	0.560		no

In conclusion, the conclusions of T-test and P-test on the significance of regression coefficients are consistent, and the specific results are as follows:

Hypothesis 1: The results β_1 was no significant difference from 0 at the 5% significance level, and it could not be proved that FAI had a significant effect on GR.

Hypothesis 2: The results β_2 was no significant difference from 0 at the 5% significance level, and LRs effect on GR could not be proved significantly.

Hypothesis 3: The results β_3 was not significantly different from 0 at the 5% significance level, and it cannot be proved that FFE has a significant effect on GR.

Hypothesis 4: The results β_4 was no significant difference from 0 at the 5% significance level, and it could not be proved that UR had a significant effect on GR.

Hypothesis 5: The results β_5 was significantly different from 0 at the 5% significance level, proving that IDU has a significant effect on GR.

Hypothesis 6: The results β_6 was no significant difference from 0 at the 5% significance level, and it could not be proved that FRE had a significant effect on GR.

Hypothesis 7: The resultsβ_7 was no significant difference from 0 at the 5% significance level, and it could not be proved that DP had a significant effect on GR.

Hypothesis 8: The results β_8 was no significant difference from 0 at the 5% significance level, and it could not be proved that PD had a significant effect on GR.

Hypothesis 9: The results β_9 was significantly different from 0 at the 5% significance level, proving that CGP has a significant effect on GR.

Hypothesis 10: The results β_{10} was not significantly different from 0 at the 5% significance level, and it could not be proved that HD had a significant effect on GR.

Hypothesis 11: Results β_{11} was no significant difference from 0 at the 5% significance level, and it could not be proved that PHP had a significant effect on GR.

According to the data in Table 3, this paper further uses the T-test-right-tailed test to detect whether β_5 and β_9 are significantly different from 0 at the 5% significance level:

Does the higher the proportion of the output value of tertiary industry in the total output value, the faster the growth rate of per capita GDP?

(1) The null hypothesis and alternative hypothesis are as follows:

H_0: $\beta_5 \leq 0$

H_1: $\beta_5 > 0$ (the proportion of the output value of tertiary industry in total output value has a positive correlation with the growth rate of per capita GDP)

(2) Calculate the verification statistic: $t = \frac{\beta_5^\wedge}{se(\beta_5^\wedge)}$=3.008

(3) Threshold: $t_{0.05}(N{-}{-}k{-}{-}1)$=$t_{0.05}$(20--11--1)∞1.86

(4) The statistic t=3.008> the critical value of 1.86, rejecting H_0. β_5 is significantly different from 0 at the 5% significance level. This indicates that the higher the proportion of the output value of the tertiary industry in the total output value is, the faster the growth rate of per capita GDP.

Does the greater the total retail sales per capita, the faster the growth rate of per capita GDP?

(1) The null hypothesis and alternative hypothesis are as follows:

H_0: $\beta_9 \leq 0$

H_1: $\beta_9 > 0$ (the total retail sales of consumer goods per capita have a positive correlation with the growth rate of GDP per capita)

(2) Calculate the verification statistic: $t = \frac{\beta_9^\wedge}{se(\beta_9^\wedge)}$=2.49

(3) Threshold: $t_{0.05}(N{-}{-}k{-}{-}1)$=$t_{0.05}$(20--11--1)∞1.86

(4) The statistic t=2.49> the critical value of 1.86, and H is rejected. β_9 is significantly different from 0 at the 5% significance level. This means that the greater the per capita total retail sales of social consumer goods are, the faster the per capita GDP growth rate.

13. Inspection Results

Hypothesis 1: It cannot be proved that FAI has a significant effect on GR.

Hypothesis 2: It cannot be proved that LR has a significant effect on GR.

Hypothesis 3: FFE has no significant effect on GR.

Hypothesis 4: It cannot be proved that UR has a significant effect on GR.

Hypothesis 5: It is proved that IDU has a significant influence on GR, and the influence of IDU on GR is positively correlated.

Hypothesis 6: It cannot be proved that FRE has a significant impact on GR compared with fiscal budget expenditure.

Hypothesis 7: It cannot be proved that DP has a significant effect on GR.

Hypothesis 8: It cannot be proved that PD has a significant effect on GR.

Hypothesis 9: prove that CGP has a significant influence on GR, and the influence of CGP on GR is positively correlated.

Hypothesis 10: It cannot be proved that HD has a significant effect on GR.

Hypothesis 11: There is no evidence that PHP has a significant impact on GR.

14. Research Conclusions

This study analyzes the Beijing per capita GDP growth rate via the Cobb–Douglas production function. We identified 11 influencing factors across multiple dimensions by compiling official data from various levels of statistical bureaus and the Beijing Municipal Government from 1978--2022. After processing the data, we obtained per capita GDP growth rates and corresponding indicators from 2003--2022 for statistical analysis. The resulting multiple regression model is formulated as follows:

$$\ln GR_t\text{^}=45.854+0.958\ln FAI_t\text{^}-0.035\ln LR_t\text{^}-0.466\ln FFE_t\text{^}+4.566\ln UR_t\text{^}+9.162\ln IDU_t\text{^}+1.105\ln FRE_t\text{^}-2.750\ln DP_t\text{^}--16.753\ln PD_t\text{^}+10.245\ln CGP_t\text{^}+2.858\ln HD_t\text{^}--1.191\ln PHP_t\text{^}$$

The regression analysis reveals the following conclusions: while the proportion of the tertiary industrial output in total output (IDU) and the per capita retail sales of consumer goods (CGP) significantly influence the growth rate of per capita GDP (RG), no other factors have a significant impact. Notably, both the tertiary industry output ratio and per capita retail sales of consumer goods are positively correlated with per capita GDP growth.

The results of the parameter estimation show that the model has a high degree of fit, the prediction of the Beijing per capita GDP growth rate has an error within the specified range, the model has a high degree of credibility, the research results are in line with economic significance, and other cities can learn from this model to analyze regional economic influencing factors.

15. Economic Impact

Since the implementation of reform and opening-up in 1978, Beijing has actively promoted economic system reforms, optimized the business environment, attracted foreign investment and technology, and driven rapid economic growth. Since the 1980s, cities have transitioned from secondary industry transformation to tertiary industry development, with the tertiary sector gradually rising. Over the past two decades, the economic structure of Beijings has undergone significant changes. By 2023, the tertiary sector accounts for 84.8% of the economy, becoming the primary driver of economic growth and demonstrating its crucial contribution to Beijing’s economic expansion.

Since 1978, Beijing's per capita retail sales of consumer goods have shown steady growth. Since 2007, the city's consumption rate has consistently surpassed the investment rate, making consumption the primary engine of economic development. In 2022, consumption accounted for 55.7% of the economy, whereas investment made up 14.5%, highlighting the growing importance of household consumption in driving economic growth.

16. Research Recommendations

16.1 Industrial Restructuring

Special support policies can be formulated to provide tax incentives, financial support and incentives for innovation in key areas of tertiary industry, such as information technology, financial services, cultural creativity and tourism, to encourage enterprises to invest and develop.

16.2 Consumption Upgrading Drive

We can stimulate and increase consumer demand by maintaining consumption promotion activities and improving the consumer experience, especially in the fields of culture, tourism and health, to accelerate the transformation of consumption to high quality and high value added.

17. Research Evaluation

This study comprehensively evaluates the factors influencing economic growth, identifies the most suitable economic indicators through screening, and employs relevant statistical variables. On the basis of the Cobb–Douglas production function and economic theories, we conduct multiple linear regression analysis and parameter estimation using identified statistical data to analyze the factors affecting Beijing economic growth. This research proposes targeted strategies for Beijing's economic development. The findings reveal patterns in economic growth in Beijing, providing valuable guidance for formulating future development strategies. The theoretical framework and multiple regression model developed in this study offer reference value for economic development research in other Chinese cities.

While this study has certain limitations, such as its broad scope in examining factors influencing the city economy, future research could refine the analysis via district-level segmentation. By integrating spatial differentiation patterns and growth drivers, we aim to establish unique spatiotemporal mechanisms for economic differentiation. Furthermore, considering each district's distinct economic conditions, actionable strategies are proposed to increase development effectiveness.

References

Bai, Y. (2019). Empirical analysis of China's GDP influencing factors based on multiple regression analysis. *SME Management and Technology (Late Issue),* (2), 55-57.

Gao, J. (2009). *Empirical study on the relationship between industrial structure change and economic growth in Shaanxi province* [Master's thesis, Northwest University]. CNKI. https://kns.cnki.net/kcms2/article/abstract?v=sfGpRh49pdH8OqHLe3nn9lGrbWBxAvrcHIY_kL2fJiqRxtQ6hjl7ZG93LS269H7nTrW2Xjx1RQxG963mtABNBgRJS051IFpyba_DDu1lDwR3kh1bqPIfDhK5oWwD3mJUpAp-0YEnoaBfl1gORZBEz-liX0a4kdwV_QAx9vwvofSJrMupNlY4pg==&uniplatform=NZKPT&language=CHS

Guo, S. D., Chen, G., & Du, N. S. (2012). Empirical analysis of the relationship between new energy consumption and economic growth in China. *Enterprise Economy,* (5), 35-37.

Li, B. R. (2007). Econometric analysis of Beijing GDP and residents' consumption behavior. *Journal of Beijing Technology and Business University (Social Science Edition), 22*(5), 87-90.

Li, G. D., & Fang, C. L. (2018). Spatial econometric analysis of urban and county-level economic growth convergence in China. *International Regional Science Review, 41*(4), 410-447.

Li, J. J., Miao, C. H., & Ye, X. Y. (2016). Multi-scale evolution mechanism of core-periphery structure in regional economy: A case study of Henan province. *Economic Geography, 36*(10), 9-17.

Li, L., Liu, H., Liu, W. D., & Liu, Y. (2008). Regional economic growth differences and factor decomposition in China at the urban scale. *Geographical Research, 27*(5), 1048-1058.

Li, R., Wang, A. Y., & Kang, Y. Q. (2018). Empirical study on the impact of fixed asset investment on GDP in Changzhou. *Journal of Changzhou Institute of Technology, 31*(3), 70-74.

Li, Y. F. (2019). Study on influencing factors of Jiangsu GDP growth based on multiple linear regression model. *Special Economic Zone Economy,* (4), 84-88.

Li, Z. G., & Zhou, D. T. (2013). Empirical analysis of the relationship between economic growth and environmental pollution based on VAR model: A case study of Shandong province. *Enterprise Economy,* (8), 11-16.

Liu, H. L., & Tang, T. (2015). Mathematical model and influencing factors analysis of GDP prediction in Hubei province. *Practice and Understanding of Mathematics, 45*(5), 262-269.

Martin, R., & Sunley, P. (1998). Slow convergence? The new endogenous growth theory and regional development. *Economic Geography, 74*(3), 201-227.

Ni, H. F., Zhang, S. Y., & Xie, H. Y. (2014). R&D capitalization and its impact on China's GDP and structure. *Studies in Science of Science, 32*(8), 1166-1173.

Peng, Y. (2010). Empirical analysis of regional economic development based on multiple regression model: A case study of Chang-Zhu-Tan urban agglomeration. *Journal of Jishou University (Social Science Edition), 31*(4), 105-107.

Wang, C. H., Li, Y. F., & Gong, W. F. (2019). Study on economic growth and the contribution rate of scarce talents. *China Collective Economy,* (23), 19-21.

Wang, S. J., Wang, Y., & Zhao, Y. B. (2015). Spatial spillover effects and driving factors of regional development in Guangdong province since 1990. *Acta Geographica Sinica, 70*(6), 965-979.

Wang, Y., He, F. L., & Tian, R. H. (2020). Analysis of influencing factors of Beijing's economic vitality. *Business Information,* (13), 1-5.

Wei, Y. D. (2015). Spatiality of regional inequality. *Applied Geography, 61*, 1-10.

Woo, M., Ross, C. L., & Boston, T. D. (2014). Do megaregions produce greater regional convergence or divergence? Implications for spatial planning and infrastructure investment. *Journal of Urban Planning and Development, 141*(1), Article 04014013.

Wu, Q. S., Chen, L., Zhang, Y. T., & Cheng, J. (2008). Re-examination of the relationship between China's energy consumption and GDP: An empirical analysis based on provincial panel data. *Quantitative and Technical Economics, 25*(6), 27-40.

Yang, D. Y., & Zhang, M. (2009). Empirical analysis of fiscal expenditure, fixed asset investment and GDP: Based on VAR and ECM. *Consumer Guide,* (11), 22-24.

Ye, Q. L. (2023). Empirical study on influencing factors of regional GDP: Based on multiple regression analysis. *Sustainable Development, 13*(6), 2032-2044.

Zhang, G. W. (2021). Regional differences in high-quality urban economic development in China and analysis of influencing factors. *Administration and Law,* (9), 1-14.

Zhang, X. B., Yu, W., Zhang, Y. L., Song, J. P., & Wang, Z. B. (2018). Spatial differentiation and influencing factors of economic growth in the Beijing-Tianjin-Hebei region. *Acta Geographica Sinica,* (10), 1985-2000.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Open Access