Comprehensive Evaluation of High-Quality Economic Development in Tianjin based on Analytic Hierarchy Process

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Abstract

Against the backdrop of China's economy transitioning from high-speed growth to high-quality development, this paper quantitatively analyzes the influencing factors of high-quality economic development in Tianjin by using the Analytic Hierarchy Process (AHP). The research is conducted from four dimensions: innovative development, economic growth, quality of life, and green development. Through the calculation and ranking of weights for each dimension, the importance of each dimension in the process of high-quality economic development in Tianjin is determined. The research results show that, from the perspective of the four dimensions, innovative development and green development play a more significant role in the high-quality economic development of Tianjin, while economic growth and quality of life have relatively lower impacts. From the overall ranking of the indicator layer to the target layer, it can be seen that factors such as the number of innovation projects in large-scale enterprises, the green coverage rate of built-up areas, and per capita regional GDP also have significant influences on the high-quality economic development of Tianjin. The impact of R&D investment intensity and per capita disposable income of all residents cannot be ignored either. Based on the importance of different indicator dimensions, this paper puts forward corresponding policy suggestions to promote the high-quality economic development of Tianjin.

Keywords

High-quality Economic Development, Evaluation Index System, Analytic Hierarchy Process (AHP).

1. Introduction

Since the 1970s and 1980s, China's economy has developed rapidly, with a significant increase in economic volume. However, at the same time, many problems in economic development that were ignored due to the sole pursuit of economic growth have gradually emerged. The international situation has become increasingly severe, the demographic dividend advantage has gradually diminished, and the economic growth rate has slowed down. China urgently needs a new round of reform to promote the development of the national economy[1]. On the other hand, the problems caused by the pursuit of economic growth, such as environmental pollution and excessive resource exploitation, have gradually exposed their harms. The transformation of China's economy towards high-quality development has become an urgent task. The report of the 19th National Congress of the Communist Party of China pointed out that China's economy is currently in a transitional stage, and the period of high-speed growth has passed[2]. At present, to promote high-quality economic development, efforts should be made in transforming the development mode, optimizing the economic structure, and converting the growth drivers. Currently, China's development emphasizes high quality, and the explosive growth that prioritizes quantity over quality is a thing of the past. At the same time, the

country's development philosophy also needs to be adjusted and optimized accordingly. Reform is the new goal of economic development, and innovation is the ignition point for economic development. Only through innovation can we achieve high-quality development and move towards a modern socialist power[3].

Tianjin is a municipality directly under the Central Government, a northern gateway for opening up to the outside world, a node city on the "Belt and Road Initiative", and one of the main battlefields of the coordinated development strategy of the Beijing-Tianjin-Hebei region. It has a profound historical and cultural heritage in modern Chinese history[4]. However, compared with other large cities, Tianjin is facing problems such as the loss of high-level talents, the decline in the level of resources and the environment, and the increase in fiscal burden, which have restricted its high-quality economic development. Therefore, accurately grasping the level of high-quality economic development in Tianjin is particularly important. This paper aims to explore the current situation, characteristics, challenges, and opportunities of high-quality economic development in Tianjin, and put forward corresponding policy suggestions[5-7].

2. Materials and Methods

The Analytic Hierarchy Process (AHP) is a structured decision-making method that helps decision-makers conduct quantitative and qualitative analysis of complex problems[8]. The ultimate goal is for decision-makers to compare the relative importance of various factors and determine their weights in the overall goal. The specific steps of the AHP are as follows:

(1) Establish a hierarchical structure of the problem.

(2) Construct a judgment matrix.

(3) Calculate the weights: By calculating the eigenvector of the judgment matrix, the weight of each factor is obtained.

(4) Consistency check: For each judgment matrix, a consistency check is required.

(5) Calculate the combined weights: For the highest-level goal, multiply the weight of each factor by the corresponding level's weight to obtain the combined weight.

(6) Make a decision: Based on the size of the combined weights, prioritize the factors and make a decision.

The AHP has the advantages of being systematic, flexible, and concise, and can be used for decision analysis of various complex problems. It considers both quantitative and qualitative factors, providing reliable decision-making basis for decision-makers.

3. Model Building

3.1. Determination of Evaluation Indicators

The principles for constructing the evaluation index system for high-quality economic development in Tianjin in this paper are threefold. First, it should reflect the systematicness and hierarchy of the indicators. This means that in the analysis and decision-making process, a series of related indicators need to be considered, and these indicators should be organized and classified according to a certain logic and structure[9]. Such an analysis method can more objectively and accurately assess the problem, avoid partial or biased conclusions, and better reflect the interrelationships and influences among various indicators. Second, it should meet the comprehensiveness and scientificity of the indicators. It is necessary to ensure that the selected indicator system covers all important aspects and is based on scientific methods and theories for the selection and determination of indicators to ensure the objectivity and accuracy of the entire indicator system. Such an indicator analysis result can better support the evaluation work. Third, follow the operability and comparability of the indicators. When

conducting indicator analysis, it is necessary to ensure that the selected indicators are specific, clear, measurable and operable, and that these indicators can be used for comparison and analysis. The results of such indicator analysis can be more easily understood and applied, improving the accuracy and reliability of decision-making[10-11].

Based on these three principles, this article plans to evaluate the hierarchical structure of the high-quality economic development evaluation index system of Tianjin from four dimensions: innovation, economy, people's livelihood, and green development, through 16 specific indicators. The innovation development dimension mainly focuses on Tianjin's performance in scientific and technological innovation, R&D investment, and talent introduction. The economic growth dimension mainly focuses on Tianjin's economic growth rate and quality[12]. The people's livelihood quality dimension mainly focuses on Tianjin's performance in improving residents' living standards and social welfare. The green development dimension mainly focuses on Tianjin's performance in environmental protection and sustainable development. Through the evaluation of these four dimensions, a complete high-quality economic development evaluation index system for Tianjin can be constructed[13]. As shown in Table 1.

Table 1. Evaluation Index System for High-Quality Economic Development in Tianjin

Target Layer A	Criterion Layer B	Indicator Layer C
Evaluation Indicators for the High-Quality Economic Development of Tianjin City (A)	Innovative Development B1	R&D investment intensity C1
		Patent application and authorization volume C2
		End-of-period mobile phone user number C3
		Domestic patent application acceptance volume C4
	Economic Growth B2	Per capita regional GDP C5
		Local general budget expenditure C6
		Local general budget revenue C7
		Retail sales of consumer goods C8
	Quality of People's Livelihood B3	Per capita disposable income of all residents C9
		Local education expenditure C10
		Number of medical and health institutions C11
		Total collection of public libraries C12
	Green Development B4	Green coverage rate of built-up area C13
		Garbage disposal volume C14
		Sulfur dioxide emission volume C15
		Total industrial wastewater discharge volume C16

3.2. Calculation of Indicator Weights

3.2.1. Determination of Indicator Importance

Compare the indicators within the same layer pairwise to determine their importance, and score them according to the 9-level scale table (see Table 2). Taking the criterion layer as an example, based on the results of the investigation and statistics, it can be analyzed that the

innovation development B1 has the highest weight, followed by the green development B4, then the economic growth B2 and the quality of life B3. Combining the mean and the scale, the importance of each indicator in the criterion layer and the scheme layer can be determined. Through the research of other authors in this field, the importance of each factor is summarized, and a judgment matrix is constructed based on this.

Table 2. 9-level scale table

Scale	Meaning
1	Indicating that one factor is of the same importance as the other
3	Indicating that one factor is slightly more important than the other
5	Indicating that one factor is significantly more important than the other
7	Indicating that one factor is strongly more important than the other
9	Indicating that one factor is extremely more important than the other
2,4,6,8	The intermediate value between the two adjacent judgments above
Reciprocal	The ratio of the importance of factor i to factor j is D_{ij}. Then, the ratio of the importance of factor j to factor i is $1/D_{ij}$.

3.2.2. Conduct Consistency Test

For the indicator layers C1, C2, C3, …, C16, the consistency indicators for the criteria layer (Layer B) of the factors Bj (j = 1, 2, …, m) and the four factors B1, B2, B3, B4 in Layer B with respect to the target layer A are CI. The rationality of the constructed judgment matrix is tested through the consistency indicator CI. The larger the CI value, the worse the consistency[14]. The formula for CI is as follows:

$$\boldsymbol{CI = \frac{\lambda_{max} - n}{n - 1}}$$

Based on the numerical table of the consistency index CI and the random consistency index RI of the judgment matrix (see Table 3), the consistency ratios CR of the criterion layer to the target layer and the index layer to the criterion layer are 0.057686, 0.00286, 0.002634, 0.001558 and 0.009118 respectively. All of them are less than 0.1, indicating that the 5 judgment matrices of the constructed criterion layer and index layer have all passed the consistency test.

Table 3. Values of random consistency index RI

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

3.3. Weight Determination

3.3.1. Weights of Criteria Layer Indicators

Table 4. Weights of indicators at the criteria layer

Target Layer A	Criterion Layer B weights	Ranking
Evaluation Indicators for the High-Quality Economic Development of Tianjin City (A)	Innovation and Development B1 (0.3828)	1
	Green Development B4 (0.3126)	2
	Economic Growth B2 (0.1858)	3
	Quality of Life B3 (0.1188)	4

Based on the relevant calculation formulas of AHP, the weights of indicators at the criteria layer were calculated using Excel software. The results are shown in Table 4. Through software

calculation, it can be obtained that, according to the weight values, the four dimensions of the criteria layer are ranked as: Innovation and Development > Green Development > Economic Growth > Quality of Life[15].

3.3.2. Weights of Indicators at the Scheme Level

The weight ranking of the secondary indicators of the innovation development dimension at the scheme level is shown in Table 5. It can be seen that the weight ranking of the secondary indicators of the innovation development dimension is as follows: the number of innovation projects of large-scale enterprises > the intensity of R&D investment > the number of mobile phone users at the end of the period > the number of patent applications and authorizations; The weight ranking of economic growth is shown in Table 6. Thus, the weight ranking of the secondary indicators of the economic growth dimension is as follows: per capita regional GDP > total retail sales of consumer goods > local general budget expenditure > local general budget revenue. Among them, the proportion of informatization is less than 0.1, indicating that this indicator has a relatively weak overall impact on economic growth; The weight ranking of the quality of people's livelihood is shown in Table 7. Thus, the weight ranking of the secondary indicators of the quality of people's livelihood dimension is as follows: the per capita disposable income of all residents > local education expenditure > the number of medical and health institutions > the total collection of public libraries; The weight ranking of green development is shown in Table 8. Thus, the weight ranking of the secondary indicators of the green development dimension is as follows: the green coverage rate of the built-up area > the amount of domestic waste disposal > the sulfur dioxide emission > the total discharge of industrial wastewater.

Table 5. Weight ranking of indicators at the innovation development level

Criterion Layer B	Indicator Layer C Weight	Ranking
Innovative Development B1 (0.3828)	Number of innovation projects by large-scale enterprises C4 (0.5724)	1
	R&D expenditure intensity C1 (0.2908)	2
	End-of-period mobile phone user count C3 (0.1412)	3
	Patent application and authorization volume C2 (0.1014)	4

Table 6. Weight Ranking of Economic Growth Indicators Layer

Criterion Layer B	Indicator Layer C Weight	Ranking
Economic Growth B2 (0.1858)	Per capita regional GDP C5 (0.7405)	1
	Retail sales of consumer goods C8 (0.2628)	2
	General budget expenditure of local finance C6 (0.1314)	3
	General budget revenue of local finance C7 (0.0933)	4

Table 7. Weight Ranking of Quality Indicators Layer for People's Livelihood

Criterion Layer B	Indicator Layer C Weight	Ranking
Quality of People's Livelihood B3 (0.1188)	Per capita disposable income of all residents C9 (0.6807)	1
	Local fiscal expenditure on education C10 (0.2210)	2
	Number of medical and health institutions C11 (0.1478)	3
	Total collection of public libraries C12 (0.1073)	4

Table 8. Weight Ranking of Green Development Indicators Layer

Criterion Layer B	Indicator Layer C Weight	Ranking
Green Development B4 (0.3126)	Green coverage rate of built-up area C13 (0.6807)	1
	Garbage collection volume C14 (0.1945)	2
	Sulfur dioxide emission volume C15 (0.1397)	3
	Total industrial wastewater discharge volume C16 (0.1289)	4

3.3.3. Total Weight of Evaluation Indicators

The comprehensive weight and ranking of the evaluation index system for the high-quality economic development of Tianjin are shown in Table 9.

Table 9. Comprehensive Weights and Ranking of Evaluation Index System

Target Layer A	Criterion Layer B	Indicator Layer C	Total Points(Ranking)
Evaluation Indicators for the High-Quality Economic Development of Tianjin City(A)	Innovative Development B1(0.3828)	R&D investment intensity C1 (0.2908)	0.112644604(4)
		Patent application and authorization volume C2 (0.1014)	0.039299267(11)
		End-of-period mobile phone user count C3 (0.1412)	0.054688028(7)
		Number of innovation projects of large-scale enterprises C4 (0.5724)	0.221683418(1)
	Green Development B4(0.3126)	Green coverage rate of built-up area C13 (0.6807)	0.21525095(2)
		Garbage collection volume C14 (0.1945)	0.061506677(6)
		Sulfur dioxide emission volume C15 (0.1397)	0.044199204(9)
		Total industrial wastewater discharge volume C16 (0.1289)	0.04076205(10)
	Economic Growth B2(0.1858)	Per capita regional GDP C5 (0.7405)	0.139220949(3)
		General budget expenditure of local finance C6 (0.1314)	0.024708106(12)
		General budget revenue of local finance C7 (0.0933)	0.017540191(14)
		Total retail sales of consumer goods C8 (0.2628)	0.049416212(8)
	Quality of People's Livelihood B3(0.1188)	Per capita disposable income of all residents C9 (0.6807)	0.073894473(5)
		Education expenditure of local finance C10 (0.2210)	0.023991164(13)
		Number of medical and health institutions C11 (0.1478)	0.016043859(15)
		Total collection volume of public libraries C12 (0.1073)	0.011647513(16)

3.4. Result

In the evaluation index system for the high-quality economic development of Tianjin, the weight of the number of innovation projects by large-scale enterprises (C4) is the highest. The green coverage rate of the built-up area (C13), the per capita regional GDP (C5), and other factors are also important influences on the high-quality economic development of Tianjin. The rankings of the five indicators - the intensity of R&D investment (C1), the per capita disposable income of all residents (C9), the amount of domestic waste collection (C14), the number of

mobile phone users at the end of the period (C3), and the total retail sales of consumer goods (C8) - are also among the top eight. These indicators also have a significant impact on the high-quality economic development of Tianjin[16-20].

4. Conclusion

Utilizing the advantages of technological innovation and implementing the concept of green development to provide strong support for the high-quality economic development while strengthening the strategic determination for ecological civilization construction. From the overall ranking at the target level, innovation and green development have a significant impact on the high-quality economic development of Tianjin. Therefore, attention should be paid to innovation. In the construction of innovation facilities and carrier platforms, build the National Independent Innovation Demonstration Zone with high standards and strict requirements, cultivate and expand leading enterprises and dominant industries, and create characteristic parks with international influence. Actively promote the introduction and cultivation of scientific and technological innovation talents, continuously improve national and municipal talent programs such as the Outstanding Young Science Fund, the "Innovation Talent Promotion Program", and the "He River Talent" Action Plan, and inject talent power into the improvement of scientific and technological innovation levels. The newly established Tianjin Environmental Protection Bureau has, in accordance with the systematicness and integrity of the environment, clarified the responsibilities for pollution supervision and administrative law enforcement, and enhanced the environmental protection supervision capacity. Continuously strengthen scientific pollution control and precise pollution control, and enhance the control intensity in administrative boundaries and rural areas. Unify the pollutant emission standards of Beijing-Tianjin-Hebei region, further enhance the coordination of regional pollution control, fully exert the responsibility of enterprises in environmental governance, and through the formulation of strict pollutant discharge standards, force enterprises to improve their technical levels.

Strengthen the integrated development of urban and rural areas to ensure and improve people's livelihood. Promote the aggregation of high-end industries such as finance and services in the six urban districts, promote the upgrading of traditional manufacturing in the four suburban districts, advance the manufacturing to a high level, leverage the agricultural advantages of the six suburban districts, process and export green agricultural products, promote tourism and cultural industries to drive the economy, attract population inflow through health care and elderly care, and other characteristic industries. On the basis of promoting the integration of urban and rural economies, promote the integration of urban and rural societies. Form an integrated situation in terms of living standards and spatial resources. High-quality infrastructure such as urban transportation, communication, and water conservancy should flow to rural areas. Further rationalize urban transportation planning, standardize parking order management, and strengthen the governance of illegal parking. Accelerate the construction of smart cities, making the special construction of smartization provide greater convenience for people's lives. Improve the level of equalization of public services, strive to achieve wide coverage of basic public services, support cultural industries with high added value such as digital culture services, adhere to the priority development position of education, and ultimately move towards common prosperity based on the improvement of people's living standards and social benefits.

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