AHP-SWOT Analysis method under the new economic situation for China Northeast Economies Development

Jin Liu*

{liujin_jrgz@163.com}

Changchun Finance College, Changchun, China

Abstract. The development strategy of China's Northeast is now very important for China under new situation, and scholars usually use the SWOT framework to analyze the internal and external environment and access to assess the strengths, weaknesses, opportunities and threats, then develop a trend strategy. However, the traditional SWOT framework is subjective and insufficient for obtaining an objective evaluation. Unfortunately, there is no completely objective method for SWOT strategy analysis. To avoid the excessive subjectivity and consistency problem of normal SWOT analysis, this article utilizes the Analytic Hierarchy Process (AHP) and develops a comprehensive framework that combines qualitative and quantitative factors. The analysis materials for SWOT in Northeast China are based on a deep questionnaire survey. Only the results with a qualified consistency ratio (CR) are used for the SWOT quadrilateral strategic choice. Finally, this study identifies the key factors that influence economic development in Northeast China. The total ranking table is calculated at the decision level, and a SWOT Quadrilateral is constructed based on the computational result of the total ranking table. Finally, constructive countermeasures are proposed, focusing on a defensive strategy (WT). By using the AHP-SWOT Analysis to process the questionnaire data and internal validate for SWOT, we can obtain more objective conclusions than with a normal SWOT Analysis. The AHP-SWOT algorithmic tool also makes the strategic analysis process more efficient. This research holds high significance, as evaluated by the Jilin Financial Security Research Center and Jilin Office of Philosophy and Social Science.

Keywords: China Northeast; SWOT Analysis; Analytic Hierarchy Process (AHP), Economies

1 Introduction

The Northeast economy has a more serious tendency to slow down its growth rate compared to other regions. To study the economic development of the Northeast region, it is necessary to analyze the internal and external environment, the industrial structure and economic development characteristics of the Northeast region itself. The "Theory of comparative advantage" should not be the guiding principle for the formulation of strategies in each region. In recent years, scholars in China have conducted studies on foreign trade and regional

Liu Jin, female, Master of School of Management, Jilin University, Assistant Professor of School of Economics and Management, Changchun Finance College, Member of Jilin Financial Security Research Center; * corresponding author

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economic growth in Northeast China, East Asian economic cooperation [1], the industrial structure of the three northeastern provinces [6], but most of them have focused on a certain direction or influencing factors, and there are few quantitative research methods that target the whole dimension. There are foreign articles based on AHP-SWOT studies on strategy and urban construction, etc. [2],[3],[4].

To analyze the internal and external environment and the strengths and weaknesses of the Northeast economy, this paper uses a combination of Analytic Hierarchy Process (AHP) and SWOT analysis to carry out quantitative calculations using a hierarchical analysis model, and ultimately propose targeted policy recommendations and explore the potential more accurately for high-quality economic development in the Northeast.

2 AHP-SWOT analysis research methodology and data preparation

2.1 Research Methodology

The article uses AHP-SWOT analysis to provide recommendations on the construction of an economic development strategy of scale in the Northeast. The main steps are as follows:

2.1.1 Through analysis of the macro-environment, international capital flows and regional instability factors, as well as literature search and data review of the current economic development of the Northeast region and supported by authoritative data such as the National Bureau of Statistics, the internal and external influencing factors affecting the development of the scale economy in the Northeast region are collected and a SWOT analysis matrix is formed. And through the relevant data obtained from the survey, the actual strength of each factor in the SWOT analysis matrix is calculated.

2.1.2 Based on the SWOT analysis matrix, the model was divided into four levels according to the A method: goal level, criteria level 1, criteria level 2 and alternative choices. The goal level is the objective and motivation of the study, and all the levels under it will have different degrees of influence on the target level. criteria level 1 is the strengths (S), weaknesses (W), opportunities (O) and threats (T) contained in the internal and external environment, criteria level 2 is the specific elements of the previous layer, and the alternative choices layer is the combination of the criteria layers as shown in Fig. 1.

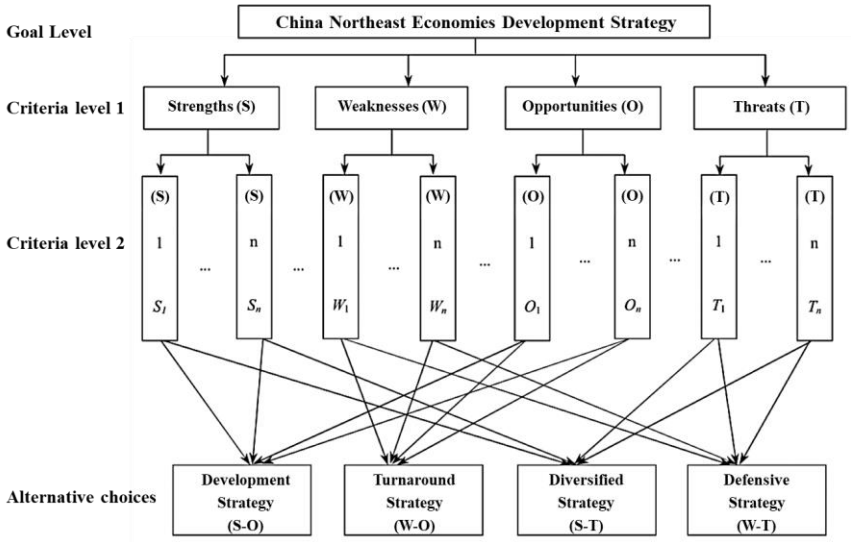

Fig. 1. Model of AHP-SWOT

2.1.3 The next step is to make comparison matrix of AHP-SWOT and make pair wise comparisons between each criterion. Results of the comparison (for each factors pair) were described in term of integer values from 1 to 9, which are shown in Table 1.

Table 1. Scale for comparison

Scale	Degree of preference
1	Equal importance
3	Moderate importance of one factor over another
5	Strong or essential importance
7	Very strong importance
9	Extreme importance
1/2, 1/3…	If the criterion in the column is preferred to the criteria in the row, then the inverse of the rating is given

2.1.4 This step is to normalize the matrix by totaling the numbers in each column. Each entry in the column is then divided by the column sum to yield its normalized score.

2.1.5 This step is the consistency analysis. The purpose for doing this is to make sure that the original preference ratings were consistent, so we need 3 steps to arrive at the consistency ratio:

1) Calculate the consistency measure; 2) Calculate the consistency index (CI); 3) Calculate the consistency ratio (CI/RI where RI is a random index).

2.1.6 Determine the strategic positioning of development. Based on the above calculation results, construct a strategic quadrilateral for the development of the economy of scale in the Northeast region, calculate the center coordinates of the strategic quadrilateral, judge the strategic positioning accordingly and formulate the development strategy.

2.2 Data preparation

The data for this study came from a questionnaire survey, 1,372 questionnaires were returned in the end, with 1,274 valid questionnaires and an effective rate of 92.9%, and the statistics of the questionnaires are shown in Table 2.

Table 2. Descriptive statistics of questionnaire survey

Respondents	questionnaires	valid questionnaires	effective rate %
Teachers and students at universities	352	331	94.0
Employees of automobile industry	580	522	90.0
Cadres and employees of finance	240	239	99.6
Teachers and academics in economics	60	60	100
Employees of Finance and Planning Museum	140	122	87.1
Total	1,372	1,274	92.9

3 Materials

3.1 Strengths (S) Analysis

3.1.1 Geographical advantages (S1): The Northeast is close to Russia, South Korea, North Korea and Japan, is taking on increasingly important roles in foreign trade and economic cooperation and has great potential for development. Japan and South Korea are important sources of imported capital and advanced technology, as well as important markets for Northeast China's exports; Russia has become an important export destination.

3.1.2 Northeast industrial base (S2): Modern industrial clusters have been formed in the Northeast, including the automotive and locomotive cluster in Changchun, the chemical industry cluster in Jilin, the special machine tool and steel industry cluster in Shenyang, etc. These clusters with strong industrial bases have created a strong pulling effect on the economy.

3.1.3 Northeast Systematic Infrastructure (S3): The cities in the northeast are better laid out and more functional. With the investment of China's revitalization strategy, old industrial bases in Northeast China, metro, light rail and interprovincial intercity rail transport have all been rapidly developed, and energy supply is relatively abundant compared to southern regions.

3.1.4 The northeast is rich in natural resources (S4): The Northeast has two forest ecosystems, including the Xing'an Mountain and Changbai Mountain areas, and rich marine resources in the Bohai Bay area. The Northeast is an important grain silo in China, and rich plant and animal resources provide good resource support for the economic development of the Northeast.

3.2 Weaknesses (W) Analysis

3.2.1 Serious talent loss (W1): Northeast has a strong foundation of educational resources. But in the past decade, due to the relative backwardness of economic development in Northeast China and the lack of attractiveness of talent policies, Northeast China has experienced a serious talent loss, especially in the past five years, when the talent inflow to Northeast China was the lowest in the country, statistically averaging 3.61% according to the statistics on the source of students and employment destinations of universities across China between 2016-2021.

3.2.2 The imbalance in the share of industries (W2): According to the analysis of the industrial structure of the Northeast, there is an imbalance in the proportion of heavy industries (63%) and light industries (37%).The lack of sufficient new and high-tech industries has led to a small value of industries with more development potential and a weak pull on the economy, which will drag down the existing advantages of the Northeast if this disadvantage continues.

3.2.3 Irrational energy structure for industrial development (W3): From the perspective of sustainable regional development, some of the important resources needed for industrial development in the Northeast are lacking. Coal production has been declining steadily for 10 years and at least 10 mines are facing closure due to lack of economic benefits. It is therefore urgent for the Northeast to rapidly restructure its energy structure, adopt a green and sustainable development approach and increase the share of new energy sources such as wind power.

3.2.4 Insufficient innovation (W4): The lack of healthy competition, low efficiency and conservation exist in the Northeast under the relative backwardness of the system and the ageing population, which affects the efficiency of innovation and reform.

3.3 Opportunity (O) Analysis

3.3.1 Industrial restructuring (O1): Some industries in the Northeast are facing restructuring based on,eg. the automobile industry, especially the NEV industrial chain.

3.3.2 China's financial policy environment (O2): China's financial market is gradually opening to the outside world. A good financial market environment will stimulate and drive industrial upgrading and investment, with annual profits of up to US$9 billion predicted for the banking and securities sector by 2030.

3.3.3 High financial stability in China (O3): In response to the coronavirus, the People's Bank of China stabilized the financial market through initiatives such as a 300 billion RMB as special loan, granting loan extensions and other preferential policies for loans to small, medium and micro enterprises and private enterprises to help enterprises maintain stable cash flows and reduce financing costs for the real economy [5]. From February to March 2020, the peak of the coronavirus, the domestic RMB traded at a depreciation of 0.7 percent, while the emerging market currency index fell by 10 percent in the same period, and the RMB exchange rate performed relatively steadily in the global foreign exchange market.

3.3.4 Big data and cloud computing in China (O4): The development of big data and cloud computing has provided stronger technical support for data collection and analysis, enabling

more accurate and timely processing of statistics on economic sectors, promoting the development of internet finance in China, and creating more value.

3.4 Threats (T) Analysis

3.4.1 Regional competition (T1): Industrial structure similarity coefficient can be used to measure the similarity of industrial structure, comparing the industrial structure of two regions, the construction of similarity coefficient can effectively respond to the degree of similarity of industrial structure between regions indicators. The similarity of the industrial structure of the three provinces has been measured, with a similarity coefficient from 0.935 to 0.995, which shows that the industrial structure convergence is too high.

3.4.2 The threat of energy price increases and energy conservation and emission reduction policies (T2) Heavy industries in the northeast are energy-dependent, and the impact of energy price fluctuations on the economic development of the northeast is highlighted. With high logistics costs, rising energy prices hinder the sustainable development of the northeast.

3.4.3 Impact of international exchange rate movements on exports (T3): The spread of the global sovereign debt crisis has increased debt risk in emerging markets. The depreciation of the euro and the US dollar can directly alleviate their sovereign debt crisis, stimulate exports, and reduce imports by devaluing the crisis countries' currencies. It is unfavorable for the Northeast's agricultural and light industrial exports, leading to an increase foreign trade and economic risks.

3.4.4 Core technology is monopolized (T4): Due to the international monopoly of core technologies in the automobile, machinery and electronics industries, resulting in no breakthrough in core technologies in machinery, automobile manufacturing and components in the Northeast, core components rely on CKD imports and bear up to 10 times higher costs.

4 Method and Discussion

4.1 Results of Normalization and Consistency analysis

Based on the questionnaire statistics, the SWOT strategy assessment matrix A, the strengths assessment matrix S, the weaknesses assessment matrix W, the opportunities assessment matrix O, and the threats assessment matrix T have been determined.

Use the evaluation matrix to calculate the weights of each factor on the target level, using the A matrix as an example, and proceed as the following equation (1) to (10):

1) Normalizing each column of the vector of A: $\widetilde{W_{ij}} = a_{ij} / \sum_{i=1}^{n} a_{ij}$ (1)

2) Summation by rows for $\widetilde{W_{ij}}$: $\widetilde{W_i} = \sum_{j=1}^{n} \widetilde{W_{ij}}$ (2)

3) Normalizing to get approximate characteristic roots $\widetilde{W_{ij}}$: $W_i = \widetilde{W_i} = \sum_{i=1}^{n} W_i, W = (W_1, W_2, W_3, \cdots W_n)^T$ (3)

4) Calculating λ as Maximum characteristic root approximation, $\lambda = \frac{1}{n} \sum_{i=1}^{n} \frac{(AW)_i}{W_i}$ (4)

5) Calculating the consistency index (CI), $\mathrm{CI} = \frac{\lambda - n}{n-1}$ (5)

6) Calculating the random index (RI), RI=0.90 (6)

7) Calculating the consistency ratio (CR), $\mathrm{CR} = {CI}/{RI}$ (7)

if $\mathrm{CR} \leq 0.1$, the CR of the matrix A is within the allowed range, then the feature vectors of matrix A can be used as weight vectors.

After the Consistency analysis, all results of matrix A, S, W, O, T are $\mathrm{CR} \leq 0.1$, see Table 2.

Table 2. Results of Normalization and Consistency analysis

Matrix	λ	W_1	W_2	W_3	W_4	CI	RI	CR
A	4.25	0.13	0.47	0.12	0.29	0.08	0.90	0.09
S	4.07	0.52	0.21	0.21	0.05	0.02	0.90	0.03
W	4.04	0.52	0.20	0.20	0.08	0.01	0.90	0.02
O	4.12	0.09	0.54	0.28	0.09	0.04	0.90	0.04
T	4.19	0.44	0.34	0.14	0.08	0.06	0.90	0.07

The consistency analysis for the choices level (denoted here by level B) continues in the same way as in 4.1. Use level A to indicate a single level, the ranking of goal from factors $A_1, A_2, \cdots, A_m$ is $a_1, a_2, \cdots, a_m$,

The ranking of factors from level B to level A are: $\sum_{j=1}^{m} a_j b_{ij}$ (8)

$$B_1: a_1 b_{11} + a_2 b_{12} + \cdots + a_m b_{1m}$$

$$B_2: a_1 b_{21} + a_2 b_{12} + \cdots + a_m b_{2m}$$

$$\cdots \quad (9)$$

$$B_{n-1}: a_1 b_{n1} + a_2 b_{n2} + \cdots + a_m b_{(n-1)m}$$

$$B_n: a_1 b_{n1} + a_2 b_{n2} + \cdots + a_m b_{nm}$$

The total consistency analysis is CR, and all CR must fulfill $\mathrm{CR} \leq 0.1$, $\mathrm{CR} = \frac{\sum_{j=1}^{m} CI(j) a_j}{\sum_{j=1}^{m} RI(j) a_j}$ (10)

4.2 SWOT quadrilateral strategic choices

After the calculation the total ranking table at decision level are as Table 3.

Table 3. Total ranking table at decision level

SWOT	Group weight	SWOT elements	CR	Weight in group	Weighted	Total weight
S	0.13	S1	0.03	0.52	0.07	0.13
		S2		0.21	0.03	
		S3		0.21	0.03	
		S4		0.05	0.01	
W	0.47	W1	0.02	0.52	0.24	0.47
		W2		0.20	0.09	
		W3		0.20	0.09	
		W4		0.08	0.04	

O	0.12	O1	0.04	0.09	0.01	0.12
		O2		0.54	0.06	
		O3		0.28	0.03	
		O4		0.09	0.01	
T	0.29	T1	0.07	0.44	0.12	0.29
		T2		0.34	0.10	
		T3		0.14	0.04	
		T4		0.08	0.02	

After using AHP to determine the total weight of each group of SWOT influencing elements for strategic choice, the premise of strategic choice is available, by constructing a SWOT quadrilateral, the sovereign weight of each strategic element is marked on the corresponding axes and connected in sequence to form a SWOT quadrilateral, as shown in Fig 2.

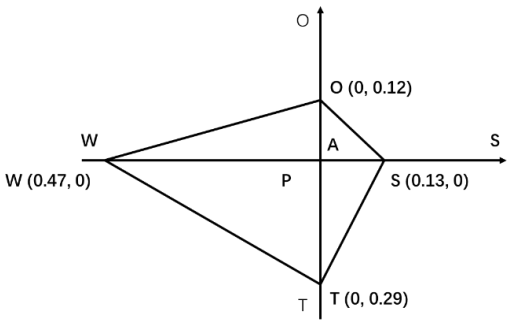

Fig. 2. SWOT Quadrilateral

Based on Fig 2, calculate the area of the triangle in each quadrant:

$$S_{\Delta SAO} = \frac{0.13 \times 0.12}{2} = 0.0078, S_{\Delta WAO} = \frac{0.47 \times 0.12}{2} = 0.0282$$

$$S_{\Delta WAT} = \frac{0.47 \times 0.29}{2} = 0.0682, S_{\Delta SAT} = \frac{0.13 \times 0.29}{2} = 0.0189$$

The triangular area is ordered as $S_{\Delta WAT} > S_{\Delta WAO} > S_{\Delta SAT} \Delta > S_{\Delta SAO}$. Therefore, the choice of economic development strategy for the Northeast is: WT (known as Defensive Strategy) > WO (known as Turnaround Strategy) > ST (known as Diversified Strategy) > SO (known as Development Strategy).

5 Conclusion

After the AHP-SWOT Analysis using this method to process the questionnaire data and internal validate for SWOT, we can get more objective conclusion than normal SWOT Analysis. And AHP-SWOT as the underlying algorithmic tool will make the process of strategic analysis more efficient.

In summary, the defensive strategy (WT) is recommended as the primary strategy. Combined with the single level ranking analyzed by AHP-SWOT, the following constructive countermeasures are highlighted and recommended:

1) Develop an attractive talent policy to attract scarce talent and leaders to fill the huge talent gap (W1).
2) Preventing the effects of regional competitive instability and building a healthy chain of economies of scale (T1).
3) Promote energy conservation and emission reduction policies, develop a long-term energy plan for the Northeast region, and focus on rectifying highly polluting and inefficient industries (T2 and W3).
4) Adjust and formulate industrial structure development strategies in the Northeast to avoid duplication of investment in industries with too high a similarity coefficient (W2).
5) Strengthen the financial regulatory system to prevent high-risk foreign trade financing and eliminate the effects of volatility in international financial markets (T3).

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