



Evaluation Model of Coordination Degree Between Regional Economic Development and Financial Service Trade in Liaoning Province Based on EWM Algorithm

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Abstract. To measure regional financial service trade and the collaborative relationship between the regional economic development, this paper make full use of synergetics, the entropy weight method and analytic hierarchy process to construct evaluation system, scientific selection of economic structure, economy, the internationalization level index and running environment index, based on the algorithm of EWM in-depth discussion of the system of financial service trade and economic development in Liaoning province cooperative relationship, it provides theoretical support for the next step of Liaoning province's high-quality development. The results show that the regional economic system and financial service trade system of Liaoning province show an alternating m-shape development trend. The synergistic index of regional economic system and regional financial service trade system fluctuates and the synergistic effect of the two subsystems is generally low.

Keywords: Synergetic · Analytic Hierarchy Process · Trade In Financial Services

1 Introduction

Under the international macro-background of economic globalization, political multi-polarization, and knowledge economy, service trade shows an unprecedented rapid development. Therefore, service trade has become an important component of regional economic development. Financial service trade plays a vital role in service trade and regional economic growth because of its unique position in the industrial base-financial industry. With the development of financial services trade, China's financial investment environment has been improved by promoting specialization, improving resource allocation efficiency, and obtaining dynamic comparative benefits, which has promoted the rapid development of the economy and injected new impetus into regional economic development. The research on the synergistic relationship between financial service trade and economic development system in Liaoning Province is helpful for Liaoning Province to achieve successful regional development under new historical opportunities.

X. Wang, J. Yu and J. Li—Equally contributed to this works.

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D. Qiu et al. (Eds.): ICBEM 2022, AHIS 5, pp. 1325–1337, 2023.

https://doi.org/10.2991/978-94-6463-030-5_132

For a long time, the synergy between regional financial services trade and regional economic development has attracted wide attention in the economic field, and there are not a few studies in this area. Domestic and foreign experts have analyzed the relationship between the two using economics, regression analysis, and regional development theory. For example, Zhang Xueyi [7], based on the microeconomic perspective, believed that it is necessary to promote the linkage of regional financial services aggregation and regional economic development, must play the network effect of regional financial services aggregation. Sun Lixiang [4] analyzed the relationship between the construction of the capital economic circle and the trade-in financial services and concluded that establishing a financial back-office service area has a significant driving effect and demonstration effect on economic growth and social development of the capital economic circle. Lu Liang [3] believed that constructing an integrated financial service system is an important part of accelerating regional development and a successful experience in promoting rapid economic development. Yang Hongai [6] tested the path of financial service trade with the help of multiple regression, and provided targeted policy recommendations for the development of Shanghai's financial service trade; based on regional development theory and comparative advantage theory, Liu Weijie [2] used index method to analyze the comparative advantage of service trade in Beijing-Tianjin-Hebei region, and then analyzed the realistic conditions of the coordinated development of service trade in Beijing-Tianjin-Hebei region. Fernandes, D. [1] focused on the relationship between financial service trade and economic development in the financial crisis era.

The existing literature mainly focuses on the influence of regional financial trade on regional economic development and its influence path. The research on some characteristics is insufficient, manifested as the unilateral influence of regional financial trade on regional financial development, and only stays in the qualitative analysis rather than quantitative analysis of the two subsystems. However, financial service trade and economic development systems are complementary and mutually reinforcing. The existing literature fails to clarify the synergistic relationship between the two. This paper makes full use of synergetic, entropy method and analytic hierarchy process to construct an evaluation system, studies the mutual influence and mutual promotion relationship between regional financial trade and the two subsystems of regional economic development, and reveals the future development trend and evolution law of the composite system composed of the two systems. Taking Liaoning Province as an example, this paper collects and analyzes the cross-sectional data of the region for ten years, and probes into the synergistic relationship between Liaoning's financial service trade and economic development system, to better grasp the development status of Liaoning Province and further promote the high-quality development of China's economy.

2 Synergetic

Synergetic believes that the sequence and structure of the system when reaching the critical region are determined by the coordination effect and coordination degree between the various elements of the system. Only the coordinated development between the various components or subsystems of the system can ensure the benign operation of the

system. Synergy refers to the harmony between systems or between the elements of the system in the process of development and evolution. The greater the synergy between the system elements, the more it can achieve the overall effect of '1 + 1 > 2'. Therefore, this paper uses the coupling coordination degree to analyze the coordination status of each subsystem and the whole system in the financial service trade industry system. By selecting the coordination metric index, the coordination of the metric industry system, objectively accurately reflect the evolution of the development mechanism of regional economic system. Grasping the development trend as a whole has important practical significance for optimizing the industrial development environment and formulating industrial policies.

3 Construction of Regional Financial Service Trade and Regional Economic Synergy Model

3.1 Model Order Parameter Construction

The synergy degree model of financial service trade and regional economy comprises two subsystems: financial service trade competitiveness and regional economic development. Based on synergetic theory, this paper studies the mutual influence and mutual promotion between the two subsystems and reveals the future development trend and evolution law of the composite system composed of the two systems. The order parameter is a parameter variable that determines the system's macroscopic behavior and characterizes the system's order degree. It determines the final structure and order degree of the system. [5] In this paper, a total of six order parameters are selected. The selection of order parameters for regional economic development can judge the type and development direction of the regional economy through economic structure. Economic aggregate can judge the overall development level of the regional economy, and economic quality can judge the development potential of the regional economy. Therefore, the order parameter is selected as economic structure, economic aggregate, and economic quality. The order parameters of financial service trade competitiveness can be divided into two categories. One is the reality index, which explains the results of financial service trade competitiveness. The other is the analytical index, which explains the reasons for financial service trade competitiveness. [8] After comprehensive consideration, this paper finally selects the efficiency level index, internationalization level index, and operation environment index as the order parameters of the competitiveness of financial service trade. The specific order parameters and evaluation indexes are shown in Table 1.

3.2 Determination of Index Weight

In this paper, the coupling weight of the entropy method and the analytic hierarchy process is used to determine the weight of each data. The entropy method uses the amount of information carried by the data itself (the entropy principle in physics) to determine the weight. If the data itself carries more information, the uncertainty is small, and the entropy value is small. Conversely, if the data itself carries less information, so uncertainty, entropy is large. Small entropy means that small uncertainty represents the

Table 1. Statistical table of the order parameter.

The Index System of Financial Service Trade Competitiveness and Regional Economic Development				Positive indicators
Subsystem	Order parameter	Evaluating indicator	Code	
Regional economic development	Economic structure	Proportion of primary industry output (%)	X ₁	Positive correlation
		The proportion of secondary industry output value (%)	X ₂	Positive correlation
		Proportion of tertiary industry output value (%)	X ₃	Positive correlation
	Total supply and demand	Total GDP (billion yuan)	X ₄	Positive correlation
		Regional fiscal revenue (billion yuan)	X ₅	Positive correlation
		Total import and export trade (billions)	X ₆	Positive correlation
	Economy quality	CPI index (last year = 100)	X ₇	Positive correlation
		Per capita disposable income of urban residents (yuan)	X ₈	Positive correlation
		Per capita disposable income of rural residents (yuan)	X ₉	Positive correlation
Competitiveness of trade-in financial services	Efficiency level index	Commercial bank assets profit margin (%)	Y ₁	Positive correlation
		Non-performing loan ratio of financial institutions (%)	Y ₂	Negative correlation

(continued)

Table 1. (continued)

The Index System of Financial Service Trade Competitiveness and Regional Economic Development				Positive indicators
Subsystem	Order parameter	Evaluating indicator	Code	
		Net assets profit margin of local state-owned enterprises (%)	Y ₃	Positive correlation
	Internationalization level indicators	The proportion of total import and export in GDP (%)	Y ₄	Positive correlation
		Total import and export volume of foreign trade services (million yuan)	Y ₅	Positive correlation
		Actual Utilization of Foreign Investment by Regions (CNY 100 Million)	Y ₆	Positive correlation
	Operating environment indicators	M2 growth rate (%)	Y ₇	Positive correlation
		Total Retail Sales of Social Consumer Goods (CNY 100 Million)	Y ₈	Positive correlation
		Stock market index	Y ₉	Positive correlation

data set, and the corresponding weight is high. On the contrary, the corresponding weight is low. Since the units of each data in the Table 1 are not uniform, the original data are first standardized. The formula is as follows:

3.3 Calculation Formula of Positive Index

$$X'_{ij} = \frac{X_{ij} - \min\{X_{1j}, \dots, X_{nj}\}}{\max\{X_{1j}, \dots, X_{nj}\} - \min\{X_{1j}, \dots, X_{nj}\}} \quad (1)$$

Calculation formula of negative index:

$$X'_{ij} = \frac{\max\{X_{1j}, \dots, X_{nj}\} - X_{ij}}{\max\{X_{1j}, \dots, X_{nj}\} - \min\{X_{1j}, \dots, X_{nj}\}} \quad (2)$$

$$E_j = -\frac{1}{\ln n} \sum_{i=1}^N p_{ij} \cdot \ln p_{ij} \tag{3}$$

$$p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^n x'_{ij}} \tag{4}$$

$$w_j = \frac{1 - E_j}{m - \sum_{j=1}^m E_j} \tag{5}$$

$$z_i = \sum_{j=1}^m w_j \cdot x'_{ij} \tag{6}$$

Z_i is the comprehensive score of the first sample. At the same time, this paper also selects for coupling analysis. Because the AHP algorithm is more common, it is not described here. The order parameter weight obtained by the EWM entropy method formula is Q_1 , the order parameter weight obtained by the AHP analytic hierarchy process in Q_2 , and the coupling weight of the order parameter of this model is Q_a . Through the coupling calculation of the above AHP and EWM methods, the coupling weights of the order parameters of regional economic development and financial service trade competitiveness are obtained.

$$Q_a = \frac{Q_1 + Q_2}{2} \tag{7}$$

Subsystem synergy model

Set the subsystem $S_j (j \in [1, 2])$, S_1 is the subsystem of regional economic development, S_2 is the subsystem of regional financial service trade, then the regional economic development and regional financial service trade as a composite system $S \{S_1, S_2\}$. The order parameter is $E_j = (E_{j1}, E_{j2}, \dots, E_{jn})$, where $\beta_{ji} \leq E_{ji} \leq \alpha_{ji}, n \geq 1, i = 1, 2, n, \alpha_{ji}, \beta_{ji}$ are the critical values of E_{ji} when the system is stable. Assuming $(E_{j1}, E_{j2}, \dots, E_{jl})$ as a positive index, its value is positively correlated with the degree of order; $(E_{jl+1}, E_{jl+2}, \dots, E_{jn})$ is the reverse index, and its value is negatively correlated with the degree of system order. Then the system order degree $u_j(E_{ji})$ of the order parameter component E_{ji} of the subsystem S_j is:

$$u_j(e_{ji}) = \begin{cases} \frac{E_{ji} - \beta_{ji}}{\alpha_{ji} - \beta_{ji}}, & i \in [1, l] \\ \frac{\alpha_{ji} - E_{ji}}{\alpha_{ji} - \beta_{ji}}, & i \in [l + 1, n] \end{cases} \tag{8}$$

In this paper, the linear weighting method is used to ‘integrate’ each order parameter component, to determine the order degree of the order parameter variable system $u_j(e_j)$: w_j is the weight of each index, which has been calculated in Sect. 3.2.

$$u_j(e_j) = \sum_{j=1}^n w_j u_j(e_{ji}), w_j \geq 0, \sum_{j=1}^n w_j = 1 \tag{9}$$

Synergy model of the composite system

The coordination degree of the composite system composed of regional economic development and financial service trade competitiveness reflects the coordination degree between subsystems. This paper uses the coupling coordination degree model to calculate the coordination degree of the composite system. Assuming that $U_{1(t)}$ is the orderly contribution of the regional economic development subsystem at t time, $U_{2(t)}$ is the orderly contribution of the regional financial service trade competitiveness subsystem at t time, $U_{(t)} \in [-1, 1]$, we can get:

$$U_{(t)} = sig(\cdot) \sqrt{|U_{1(t)} - U_{1(t-1)}| \cdot |U_{2(t)} - U_{2(t-1)}|} \quad (10)$$

$$sig(\cdot) = \begin{cases} 1, & U_{1(t)} - U_{1(t-1)} \geq 0, U_{2(t)} - U_{2(t-1)} \geq 0 \\ -1, & miscellaneous \end{cases} \quad (11)$$

When $U_{(t)}$ tends to 1, it shows that the regional economy and regional financial services trade competitiveness have great synergy, and the coordinated development level of the two is high. The closer $U_{(t)}$ is to -1 , the more fragile the system structure is. The relationship between the two is unstable, and the two subsystems are in a state of disorderly development.

4 Synergy Evaluation of Regional Economic Development and Regional Financial Services Trade

4.1 Research Area

As the representative of the old industrial base of the three northeastern provinces, Liaoning Province has 14 prefecture-level cities (two of which are sub-provincial cities) with a total area of 148,600 square kilometers. In 2020, the population of Liaoning Province is about 42.42 million, and the cumulative GDP is about 2511.11 billion yuan, an increase of 0.8% compared with 2019. With the comprehensive revitalization of Liaoning province, comprehensively promote the deepening reform, optimize the business environment, promote regional financial services trade and regional economic coordinated development plays an important role in realizing the high-quality development of Liaoning province. At the same time, the economic development of the three northeast provinces also has certain representativeness and reference significance.

4.2 Data Source

The data source of the order parameter index of the regional financial service trade and regional economic development system in Liaoning Province is the 'Liaoning Statistical Yearbook' and 'China Financial Yearbook' from 2010 to 2019, as well as the statistical bulletin of national economic and social development in the corresponding years. For some missing data, the SPSS software is used for multiple interpolations to determine the data. Due to the different observation units of each subsystem's order parameter index data, the measured values of each index are quite different and cannot be directly calculated. Therefore, the original data should be standardized, that is, dimensionless. The specific index data are shown in Table 2 (X7 and Y9 are exponential indicators).

Table 2. Liaoning Province regional logistics and regional economic system order parameter index data.

Index	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
X1/%	10.60	10.40	10.50	10.30	10.00	10.20	9.00	8.80	8.60	8.70
X2/%	51.70	51.80	49.80	47.90	45.10	41.30	38.60	38.40	38.50	38.30
X3/%	37.70	37.80	39.70	41.80	44.90	48.50	52.40	52.80	52.90	53.00
X4/10 ⁸ RMB	13896.30	16354.90	17848.60	19208.80	20025.70	20210.30	20392.50	21693.00	23510.50	24909.50
X5/10 ⁸ RMB	2004.80	2643.20	3105.40	3343.80	3192.80	2127.40	2200.50	2392.80	2616.10	2652.40
X6/10 ⁸ RMB	5461.36	6199.02	6561.77	7028.22	7019.94	6033.95	5744.93	6720.79	7563.82	7273.47
X7	103.00	105.20	102.80	102.40	101.70	101.40	101.60	101.40	102.50	102.40
X8/RMB	17712.60	20466.80	23222.70	25578.20	29081.70	31125.70	32876.10	34993.40	37341.90	39777.20
X9/RMB	6908.00	8296.50	9383.70	10522.70	11191.50	12056.90	12880.70	13746.80	14656.30	16108.30
Y1/%	1.10	1.38	1.38	1.35	1.34	1.21	1.09	1.01	1.00	0.97
Y2/%	2.43	1.77	1.56	1.49	1.64	1.94	1.91	1.85	1.97	1.98
Y3/%	6.20	6.20	3.70	3.70	2.40	-1.00	1.00	6.20	1.00	3.70
Y4/%	39.30	37.90	36.76	36.59	35.05	29.86	28.17	30.98	32.17	29.20
Y5/10 ⁸ RMB	5461.36	6199.02	6561.77	7028.22	7019.94	6034.45	5744.93	6720.79	7563.82	7273.47
Y6/10 ⁸ RMB	1404.78	1567.65	1690.64	1785.96	1689.26	325.62	199.13	360.65	323.63	229.62
Y7/%	19.70	13.60	13.80	13.60	12.20	13.30	11.30	8.10	8.10	8.70
Y8/10 ⁸ RMB	4956.05	5710.48	6439.90	7186.68	7899.46	8364.83	8597.08	8696.43	9112.75	9670.60
Y9	3049.00	2895.04	2418.45	2430.69	2416.53	3861.65	3207.60	3694.70	3574.71	3781.12

4.3 Determine the Index Weight

Based on the standardization of the evaluation index data of the coordinated development of regional economy and financial service trade in Liaoning Province, the proportion, entropy, and difference coefficient of each index are calculated by using entropy method (EWM) Formulas (1)–(6), and the final entropy method index weight is obtained. And then through the analytic hierarchy process (AHP) to build a set of multi-level evaluation index systems, adopt a combination of subjective and objective ways, to fully reflect the weight of each order parameter index, regional economic development, and regional financial services trade order parameter judgment matrix, respectively as shown in Table 3 and Table 4, using the analytic hierarchy process formula to calculate the characteristic vector and weight value of each index, consistency test results are passed. Finally, we use the mean method formula (7) to calculate the coupling weight; the linear diagram of EWM weight, AHP weight and coupling weight is shown in Fig. 1. As can be seen

Table 3. Judgement matrix of the regional economic development order parameter.

	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	1	2	2	3	3	5	6	2	1
X2	1/2	1	1	3/2	3/2	5/2	3	1	1/2
X3	1/2	1	1	3/2	3/2	5/2	3	1	1/2
X4	1/3	2/3	2/3	1	1	5/3	2	2/3	1/3
X5	1/3	2/3	2/3	1	1	5/3	2	2/3	1/3
X6	1/5	2/5	2/5	3/5	3/5	1	6/5	2/5	1/5
X7	1/6	1/3	1/3	1/2	1/2	5/6	1	1/3	1/6
X8	1/2	1	1	3/5	3/2	5/2	3	1	1/2
X9	1	2	2	3	3	5	6	2	1

Table 4. Judgment matrix of regional financial services trade order parameter.

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9
Y1	1	4	2	5	6	1	3	4	5
Y2	1/4	1	1/2	5/4	3/2	1/4	3/4	1	5/4
Y3	1/2	2	1	5/2	3	1/2	3/2	2	5/2
Y4	1/5	4/5	2/5	1	6/5	1/5	3/5	4/5	1
Y5	1/6	2/3	1/3	5/6	1	1/6	1/2	2/3	5/6
Y6	1	4	2	5	6	1	3	4	5
Y7	1/3	4/3	2/3	5/3	2	1/3	1	4/3	5/3
Y8	1/4	1	1/2	5/4	3/2	1/4	3/4	1	5/4
Y9	1/5	4/5	2/5	1	6/5	1/5	3/5	4/5	1

from the figure, the fluctuation of EWM weight is larger, and the influence on coupling weight is larger, while the fluctuation of AHP weight is smaller, and the influence on coupling weight is smaller.

4.4 System Order Degree and Synergy Degree Analysis

Formulas (8) and (9) are used to calculate the order degree of the regional economy and financial service trade subsystem, respectively; on this basis, the synergy degree of the composite system of the regional economy and financial service trade is calculated by using Formulas (10) and (11). The changes of order degree and synergy degree of the regional economy and regional financial services in Liaoning Province are shown in Fig. 2.

4.4.1 Subsystem Order Degree Analysis

It can be seen from Fig. 2 that the order degree of the regional economic subsystem in Liaoning Province is generally on the rise, and the order degree of the financial service trade subsystem is generally on the decline. The degree of order of the regional economic

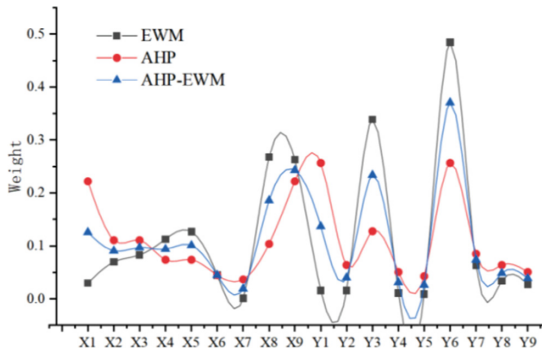


Fig. 1. Linear graph of EWM weight, AHP weight, and coupling weight.

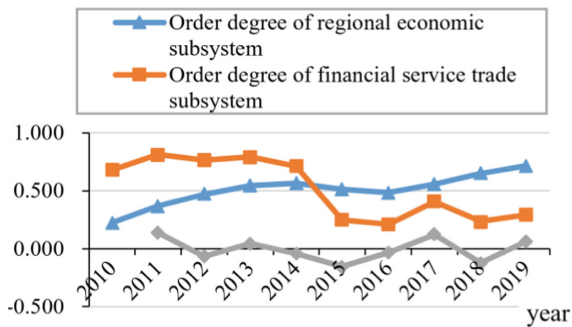


Fig. 2. Changes in the degree of order and synergy between regional economy and regional financial services in Liaoning Province.

subsystem increased from 0.224 in 2010 to 0.719 in 2019, and the degree of order of the regional financial service trade subsystem decreased from 0.681 in 2010 to 0.294 in 2019. The lowest value of the degree of order of the regional financial service trade subsystem in 2016 was 0.210, and the peak value of the degree of order of the regional economic subsystem in 2019 was 0.719, indicating that the contribution of the regional economic subsystem to the composite system increased, while the contribution of the financial service trade subsystem to the composite system decreased. By comparing the order degree of the two subsystems of the regional economy and financial service trade, it can be seen that from 2010 to 2014, the order degree of the financial service trade subsystem is significantly higher than that of the regional economic subsystem, indicating that the financial service trade in Liaoning Province is ahead of the regional economy and has a supporting and promoting effect on the regional economy. From 2015 to 2019, the order degree of the regional economic subsystem is significantly higher than that of the financial service trade subsystem, and the order degree of the regional economic subsystem grows rapidly, while the order degree of the regional financial trade system fluctuates within a certain range, indicating that the regional economy of Liaoning Province is ahead of the financial service trade, which has certain support and boosts effect on the financial service trade.

4.4.2 Synergy Analysis of Composite System

It can be seen from Fig. 3 that the regional economic system and the financial service trade system in Liaoning Province show an M-type development trend of alternating increase and decrease, and are generally in a low-level synergy state. From 2010 to 2011, the order degree of the regional economic subsystem and the financial service trade subsystem increased rapidly. The order degree of the regional economic subsystem was much higher than that of the regional financial service trade subsystem, and its development was ahead of the financial service trade system. At this time, the synergy degree of the composite system was positive, that is, the two subsystems had synergistic effects. In 2012 and 2013, the order degree of the regional economic subsystem showed an increasing trend. However, because the order degree of the financial service trade subsystem decreased first and then increased, the composite system was negative first and then positive, indicating that the synergy effect of the two systems was enhanced. From 2014 to 2016, the order degree of the regional economic system showed a slow downward trend, and the financial service trade system showed a slow-fast-slow downward trend. At this time, the synergy degree of the composite system was negative, and the two subsystems were in a state of imbalance, and the synergy effect was weak. The synergy degree of the composite system from 2017 to 2019 is mainly affected by the fluctuation of financial service trade, and the synergy effect changes from strong to weak and then to strong.

4.4.3 Policies and Suggestions

Combined with the '14th Five-Year' new development pattern of Liaoning Province, promote the comprehensive green transformation of economic and social development, promote the construction of the 'five points and one line' coastal economic belt, and comprehensively expand the opening to the outside world. In recent years, in the overall

downturn of regional financial service trade, it is recommended to expand the capital scale of financial service institutions, pay attention to the cultivation of high-quality financial talents, strengthen the informatization construction of technology on the financial service industry, improve the domestic and foreign demand for financial service trade, and optimize the opportunities to support the related industries of the financial service industry, to make it more orderly, complementary and continuously develop in a good direction with the regional economy.

5 Conclusions

From 2010 to 2019, the orderliness of the regional economic subsystem of Liaoning Province is on the rise, and the orderliness of the financial service trade subsystem is on the decline. After 2014, the lack of attention to financial services trade in the region and the lack of growth capacity have had a certain negative impact on the region's economic development. By 2019, the financial service trade index has shown positive growth, and the synergy of the two subsystems has turned from negative to positive.

This paper conducts a qualitative analysis of regional financial trade and regional economic development in Liaoning Province based on the collaborative analysis method, EWM and AHP. The results can better quantify Liaoning Province and verify the robustness of the model. The calculation results positively guide the next step of economic structure optimization and financial service trade policy formulation in Liaoning Province.

Acknowledgments. The workload of each author is equivalent.

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