A Coupling Coordination Degree Research of Civil-Military Industrial Integration in Regional Economic Development Based on Industrial Cluster Perspective--Taking Aerospace Manufacturing of Shaanxi as an Example

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Abstract

Based on the principle of coupled cooperation, the article identifies indicators from the perspective of industrial clusters, uses the principal component analysis to extract the effective coupling indicators of military-and-civilian integration industry and regional economic development and builds a model for the coupling coordination between the two. Taking the aerospace manufacturing industry in Shaanxi Province as an example, the article finds that the coupling degree between the aerospace manufacturing industry in Shaanxi Province and the regional economy has been increasing year by year, gradually shifting from disordered development to orderly evolution. Finally, based on empirical conclusions, relevant recommendations are given.

Keywords: coupling coordination degree, military and civilian integration industry, regional economy, industrial clusters

1. Introduction

The military-civilian integration industry involves many industries such as aviation, spaceflight, shipbuilding, and weapons. It is an important part of China's national economy and plays a decisive role in the development of regional economy. The in-depth advancement of civil-military integration has allowed traditional industrial cities to accelerate their own economic transformation while advancing national defense construction.

Shaanxi Province is a major national defense science and technology province. The national defense industry spans six industries including aviation, aerospace, weapons, electronics, shipbuilding, and nuclear. Among them, the strength of aerospace and equipment manufacturing is particularly prominent (Zhang, 2012). Relying on Xi'an Yanliang National Aviation High-Tech Industrial Base, Xi'an National Civil Aviation Industrial Base and other state-level industrial bases and other types of research institutes, Shaanxi Province has built a number of large-scale and potential enterprise clusters. The province owns 17.80% of the country's output value of aerospace manufacturing enterprises. In 2015, Shaanxi's aerospace and equipment manufacturing industry's total profit, which greatly promoted the regional economic development.

In recent years, Chinese academia has focused its research on the development if military-civilian integration industries and regional economics in policy formulation, correlation analysis, and simple analysis of coupling coordination. Zhang, Liu, Ma, and Wu (2011) proposed the combination of national defense construction and regional economic construction from the perspective of top-level design. Zhang and Li (2011) used the measurement method to verify the relationship between aerospace manufacturing in Shaanxi Province and local economic development, later, a coupling degree model between military and civilian integration industries and regional economic development (Zhang & Ai, 2016). However, due to limitations in its scale, R&D, and production cycle, the military and civilian integration industry generally adopts a cluster-type development. From the perspective of industrial clusters, there are few articles on the study of military-civilian integration industries and regional economic development, while the main focus is on competitiveness research and related countermeasrues. Hu and Li (2014) used grey relational analysis to analyze the factors that enhance the competitiveness of military-civil integration industries. Zhang and Chang (2016) proposed solutions to the

development of military-civilian integration industries from the perspective of industrial clusters. Based on this, this article based on the perspective of clustering, taking the aerospace manufacturing industry in Shaanxi Province as an example, analyzes the coupling interaction between the military-and-civilian integration industry and the regional economy by constructing a multi-field coupling coordination model.

2. The Construction of Multi-Index System

Coupling is the normal correlation between each industry's interdependence and mutual promotion (Xiong & Li, 2010). Coupling of multiple fields in physics is a related research to solve the problems of superposition and mutual influence of temperature field, stress field and humidity field. In this paper, it mainly refers to the mutual coupling between military-and-civilian integration industrial clusters and regional economy under the influence of multiple indicators.

2.1 Selection of Indicators

Based on the principles of quantification, objectivity, prominence, and availability, and summarizing the previous literature, this paper selects 9 indicators of the aerospace manufacturing subsystem and 11 indicators of the regional economic subsystem from the perspective of the industrial cluster (Jiang & Jia, 2013). The indicators are shown in Table 1.

2.2 Principal Component Analysis of Regional Economic Indicators

2.2.1 Data Processing

The KMO Bartlett sphere test was performed on the data using the software SPSS 19.0. The results are shown in Table 2.

KMO=0.626, greater than 0.5, in the Bartlett sphere test, Sig.=0, less than 0.05, so the sample data can be used for factor analysis.

Principal component analysis was performed on the sample data, and a total of 2 principal components were extracted, as show in Table 3. Among them, the first principal component characteristic root is 10.4, the variance contribution rate is 94.543%, the second one is 0.450, the variance contribution rate is 4.092%, and the former two factors cumulative variance contribution rate is 98.635%.

Table 1. The coupling index system of aerospace manufacturing industry and regional economy in Shaanxi province

Coupling System	Indicator Type	Index Name	Unit of Measurement
Aerospace Manufacturing Subsystem	Cluster Density	The Proportion of Enterprises in the country	%
		The Proportion of main business income to the country	%
		The Proportion of total profits in the country	%
	Industrial Scale	Main business income	Billion yuan
		Total Profit	Billion yuan
	Creativity	R&D Personnel Equivalent to Full-time	Per person per year
		R&D internal expenditure	Ten thousand yuan
		New Product Sales Revenue	Ten thousand yuan
		Patent Applications	Pieces
Regional Economic Subsystem	Economic Development	GDP	Billion yuan
		The Actual amount of foreign direct investment	One hundred million US dollars
		Urban and Rural Residents Savings Deposit	Billion yuan
		Public finance income	Billion yuan
		Average wages of employees in urban units	yuan
		Per capita net income of rural households	yuan
		New investment in fixed assets	Billion yuan
	Economic environment	Average number of students enrolled in school per 100,000 population	person
		Patent authorization number	piece
		Total freight volume	10,000 tons
		Highway mileage	kilometers

Table 2. KMO and Bartlett's test results

Sample a sufficient Kaiser-Meyer-Olkin metric		.626
Bartlett's sphericity tese	Approximate Chi-square	345.321
	df	55
	Sig.	.000

Table 3. Total variance explained

Component	Initial feature value			Squared extraction			Rotation squared		
	Total	% of variance	Accumulation %	Total	% of variance	Accumulation %	Total	% of variance	accumulation %
1	10.400	94.543	94.543	10.400	94.543	94.543	6.212	56.475	56.475
2	.450	4.092	98.635	.450	4.092	98.635	4.638	42.160	98.635
3	.103	.938	99.573						
4	.019	.174	99.748						
5	.015	.137	99.885						
6	.006	.059	99.944						
7	.004	.035	99.979						
8	.001	.011	99.990						
9	.001	.009	99.998						
10	.000	.001	100.000						
11	1.323E-5	.000	100.000						

xtraction method: Principal component analysis.

1.2.2 The Determination and Influence of Regional Economic Indicator Fields

Observe the factor loading matrix and find that the data in each column of the initial composition matrix is not significantly different. Therefore, the factorial maximum method is used to orthogonally rotate the factor axis, and the rotated load matrix is shown in Table 4.

The essence of factor analysis is to classify the original variance according to the level of relevance, so that the same group of variables has a high correlation (Zhang & Ge, 2016). As can be seen from Table 4, public factor 1 has a comparative effect on GDP, the Actual amount of FDI, new investment in fixed assets, urban and rural residents savings deposit, public finance income, average wages of employees in urban units, per capita net income of rural households, and patent authorization number. These indicators reflect the level of regional economic development and are called economic fields. The public factor 2 has a large load on total freight volume, highway mileage and the average number of students enrolled in school per 100,000 population. These indicators reflect the necessary supporting environment in the region, and are called environment fields. The specific situation is shown in Table 5.

Table 4. Rotated factor loading matrix

	Component	
	1	2
GDP	.762	.644
The Actual amount of FDI	.840	.536
New investment in fixed assets	.891	.441
Urban and Rural Residents Savings Deposit	.763	.640
Public finance income	.769	.625
Average wages of employees in urban units	.743	.668
Per capita net income of rural households	.844	.535
Average number of students enrolled in school per 100,000 population	.572	.817
Patent authorization number	.901	.415
Total freight volume	.641	.744
Highway mileage	.380	.903

Extraction method :main ingredient.

Rotary method : Orthogonal rotation method standardized with Kaiser.

a. Rotation converges after 3 iterstions.

Table 5. Regional economic index field

Common Factors	1	2
Explained Indicators	GDP the Actual amount of FDI new investment in fixed assets urban and rural residents savings deposit public finance income average wages of employees in urban units per capita net income of rural households patent authorization number	total freight volume highway mileage the average number of students enrolled in school per 100,000 population
Index Name	economic fields	environment fields
Variance Contribution Rate(%)	94.543	4.092

From a narrow perspective, regional economic development refers to the increase of social wealth in a region. The economic field expresses the concept of narrow regional economic growth. Judging from the classification index of economic fields, 8 indicators such as GDP, new investment in fixed assets and public finance income have reached 94.543% of the regional economy, which is the main factor affecting regional economic development. Regional economic development is not only reflected in direct economic indicators, indirect environmental indicators also reflect the development of regional economies. Total freight volume, highway mileage and the average number of students enrolled in school per 100,000 population account for 4.092% of the regional economy, which also reflects the development of regional economy.

2.3 Principal Component Analysis of Aerospace Manufacturing Indicators

2.3.1 Aerospace Manufacturing Index Field Selection

The sample data for aerospace manufacturing has a KMO 0F 0.673, Bartlett's sphericity test approximates chi-squared=120.430, Sig .=0, and can be used as a factor analysis. With reference to the above method, factor analysis is performed on aerospace manufacturing sample data. Three common factors were extracted and the factor axis was orthogonally rotated using the maximum variance method. The index field of the aerospace manufacturing industry was determined based on the rotated load matrix. The results are shown in Table 6.

Table 6. Aerospace manufacturing index field

Common Factors	1	2	3
Explained Indicators	Main business income R&D internal expenditure The Proportion of Enterprises in the country The Proportion of main business income to the country	New Product Sales Revenue Patent Applications R&D Personnel Equivalent to Full-time	The Proportion of total profits in the country Total Profit
Index Name	Scale Field	Technical Field	Benefit Field
Variance Contribution rate(%)	70.634	16.369	5.375

Public factor 1 has a greater load on main business income, R&D internal expenditure, the proportion of enterprises in the country and the proportion of main business income to the country. These indicators reflect the scale of the industry and are defined as scale fields. Factor 2 has a greater load on new product sales revenue, patent applications and R&D personnel equivalent to full-time. These indicators reflect the technical level and are defined as technical fields. Factor 3 reflects the benefits of the industry and is defined as the benefit field.

2.3.2 The Impact of Indicator Fields on Industrial Development

(1) The impact of scale field on industrial development. The aerospace manufacturing industry has high requirements in terms of scale, technology, and funds. The development of the industry often requires the cooperation of a number of production and R&D units. The clustering of aerospace manufacturing in a certain region can better exert the economies of scale of the industry and improve the joint research and development

capabilities of the industry. The indicators such as the main business income, the proportion of the number of companies in the country, and the proportion of the main business income in the country reflect the position of the aerospace manufacturing industry in Shaanxi Province. With the further development of China's aerospace manufacturing industry, the "big boss" status of aviation industry in Shaanxi Province will surely be further strengthened, which will help the growth of the industry and promote the development of the regional economy.

(2) The impact of technical field impact on industrial development. Technology is the core of sustainable industrial development and maintaining competitiveness. The new product sales revenue, the number of patent applications, and R&D personnel equivalent to full-time reflect the investment and harvest of Shaanxi Province in the technical improvement of aerospace manufacturing industry, and are the key indicators for the sustainable development of the industry.

(3) The impact of benefit field impact on industrial development. At present, China's economic development is in a period of transition from extensive to intensive. In the process of continuous optimization and upgrading of industrial structure, backward industries must be eliminated. Profit indicators such as total profits reflect market demand and are an important manifestation of the sustainable development of the industry.

3. Coupling Coordination Model Construction

The coupling coordinating view holds that the system follows the evolution from disorder to order. The key to this evolution is the synergy between the various parameters within the system. Coupling is a measure of this synergy. The coupling degree of military-civilian integration industry and regional economy refers to the degree of mutual influence of each element in these two subsystems, revealing the level of synergy between the two, which can be measured by constructing the coupling coordination degree model of the two.

3.1 Data Standardization Processing and Determination of Indicator Weights

In order to avoid distortion of the model results due to different data dimension, attributes, etc., the indicators are first standardized by the average and range method. $u_i (i=1 or 2)$ respectively represent the regional economy and the military-civilian integration industry subsystem. u_{ij} is the j-th indicator in the i-th system, which is obtained after standardization of the original index. The specific formula is as follows:

$$u_i = \sum_{j=1}^{n} w_{ij} u_{ij}, \sum_{j=1}^{n} w_{ij} = 1 (i=1,2)$$

$$u_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})}$$

The indicators selected in this paper are all positive indicators, and the value of u_{ij} is between [0,1] .

The weight w of each indicator is determined by the entropy weighting method. Using the entropy is actually calculated using the information value coefficient of the indicator. The calculation process is as follows:

(1) Calculate the proportion of the m-th data value in the j-th indicator of the i-th system after standardization:

$$y_{mj} = \frac{u_{ij}}{\sum_{m=1}^{n} u_{ij}}, 0 \le y_{mj} \le 1$$

Get the weight matrix:

$$Y = \{y_{mj}\}_{m \times n}$$

(2) Calculate the information entropy value of the j-th indicator:

$$e_j = -K \sum_{m=1}^{n} y_{mj} \ln y_{mj}, K = \frac{1}{\ln m}$$

The information utility value d_j of an indicator depends on the difference between the information entropy e_j and 1 of the indicator, $d_j = 1 - e_j$. The value directly affects the weight of the indicator. The larger d_j is, the larger the weight of the indicator. The weight of the j-th indicator is:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}$$

The weights of the indicators calculated according to the above method are shown in Table 7.

Table 7. The weight of each indicator in the coupled coordination model

Coupling System	Indicator Name	Index Weight
Aerospace Manufacturing Subsystem	The Proportion of Enterprises in the country	0.1118
	The Proportion of main business income to the country	0.1203
	The Proportion of total profits in the country	0.1105
	Main business income	0.1093
	Total Profit	0.1143
	R&D Personnel Equivalent to Full-time	0.1115
	R&D internal expenditure	0.1021
	New Product Sales Revenue	0.1180
	Patent Applications	0.1022
Regional Economic Subsystem	GDP	0.0922
	The Actual amount of foreign direct investment	0.0896
	Urban and Rural Residents Savings Deposit	0.0918
	Public finance income	0.0899
	Average wages of employees in urban units	0.0929
	Per capita net income of rural households	0.0884
	New investment in fixed assets	0.0852
	Average number of students enrolled in school per 100,000 population	0.0992
	Patent authorization number	0.0803
	Total freight volume	0.0912
	Highway mileage	0.0993

3.2 Construction of Coupling Coordination Model

Let α_i, β_i be the weights of the i-th indicator of regional economy and military-civilian integration industry respectively. U and W are the comprehensive contributions of regional economy and military-civilian integration industry.

$$U = \partial_i \times U_i, W = \beta_i \times W_i,$$

If U>W, it indicates that the orderly development of regional economy is faster than industrial development, and the economy is in a state of industrial lag; if W>U, it means that the industrial development is faster than the regional economic development and the economy is in the state of industrial transcendence; if W=U, then development level of the two systems is equivalent, and the economy is in an industrial synergy state.

In physics, if the variables $u_i(i=1,2,\ldots,m)$, $u_j(j=1,2,\ldots,n)$ represent system parameters, respectively, the coupling coordination model of multiple system is:

$$C_n = n\left[(u_1 \bullet u_2 .. u_n)\prod (u_i + u_j)\right]^{1/n}$$

This paper has two systems of regional economy and military-civilian integration industry. This paper takes aerospace manufacturing industry as an example, that is, n=2. Therefore, the coupling coordination degree model of this paper is:

$$C = 2\left[(U \bullet W)\prod (U + W)\right]^{1/2}$$

The coupling degree evaluation value C is between 0 and 1. The closer C is to 1, the greater the coupling between aerospace manufacturing and regional economy, and the two systems achieve benign coupling. Conversely, C tends to 0 indicates that the coupling degree of the two systems is smaller, and the two systems are in an imbalance state.

The calculation formula of the coupling coordination degree D is:

$$D = \sqrt{C \times T}, T = aU + bW$$

Where a and b are undetermined coefficients.

Generally speaking, the evaluation criteria for the coupling degree of military-civilian integration industry and regional economy are shown in Table 8.

Table 8. Evaluation table of coupling and coordination degree between military-civilian integration industry and regional economy

Coordination	Coordination level	Coordination	Coordination level
0-0.09	Extreme Imbalance	0.50-0.59	Reluctant coordination
0.10-0.19	Serious Imbalance	0.60-0.69	Primary coordination
0.20-0.29	Moderate Imbalance	0.70-0.79	Intermediate coordination
0.30-0.39	Mild Imbalance	0.80-0.89	Good coordination
0.40-0.49	On the verge of Imbalance	0.90-1.00	Quality coordination

4. An Empirical Study on the Coupling Relationship between Aerospace Manufacturing Industry and Regional Economy in Shaanxi Province

4.1 Outcome of Practice

According to relevant research (Ge, 2016), in the process of coupling and coordinating between military-civilian integration industry and regional economy, the development of military-civilian integration industry will certainly promote the development of regional economy. The sustainable development of regional economy is the result of the interaction of various factors, and the development of military-civilian integration industry is one of the reasons.

Therefore, the regional economy and the military-civilian integration industry are assigned 0.4 and 0.6 respectively. The relevant data is brought into the coupling coordination degree model to obtain the evolution table of the coupling coordination degree between the aerospace manufacturing industry and the regional economy in Shaanxi Province from 2004 to 2015, as shown in Table 9.

Table 9. Evolution table of coupling coordination degree between aerospace manufacturing industry and regional economy in Shaanxi province

Year	U	W	C	T	D	Coordination level
2004	0.0003	0.2110	0.0171	0.1267	0.0466	Extreme Imbalance
2005	0.0427	0.1836	0.1860	0.1272	0.1538	Serious Imbalance
2006	0.1388	0.3071	0.3092	0.2398	0.2723	Moderate Imbalance
2007	0.1989	0.4024	0.3648	0.3210	0.3422	Mild Imbalance
2008	0.2971	0.3387	0.3978	0.3220	0.3579	Mild Imbalance
2009	0.3937	0.3478	0.4244	0.3581	0.3899	Mild Imbalance
2010	0.4661	0.5212	0.4960	0.4991	0.4976	On the verge of imbalance
2011	0.5932	0.6106	0.5485	0.6037	0.5754	Reluctant Coordination
2012	0.7089	0.6695	0.5868	0.6853	0.6341	Primary Coordination
2013	0.8169	0.7289	0.6206	0.7641	0.6886	Primary Coordination
2014	0.9020	0.7497	0.6398	0.8106	0.7202	Intermediate coordination
2015	0.9861	0.6995	0.6397	0.8142	0.7217	Intermediate coordination

4.2 Empirical Conclusion

Through the analysis of the coupling and coordination degree between the aerospace manufacturing industry in the military-civilian integration and the regional economy in Shaanxi Province from 2004 to 2015, it is concluded that the coupling degree of the aerospace manufacturing industry in Shaanxi Province and the regional economy is gradually changed from a disordered state to an orderly state. The coupling coordination between the two has been strengthened year by year.
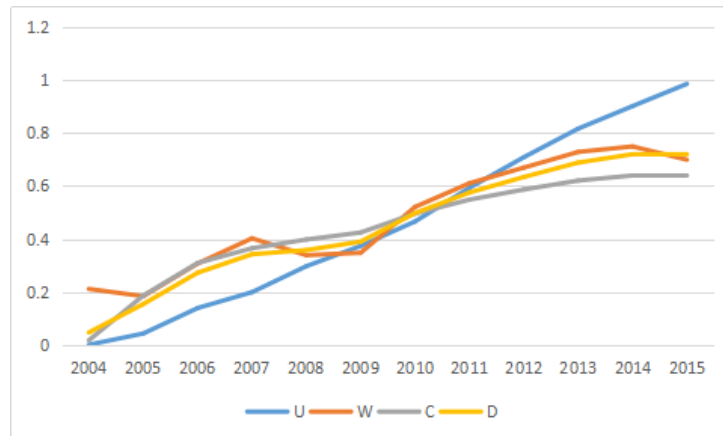
Figure 1. Evolution of coupling coordination degree between aerospace manufacturing industry and regional economy

Observing the weights of various indicators, in the regional economic subsystem, the GDP, urban and rural residents savings deposit, average wages of employees in urban units, average number of students enrolled in school per 100,000 population, total freight volume and highway mileage are more than 0.09, which has played an important role in promoting regional economic development. In the aerospace manufacturing subsystem, the proportion of main business income to the country, total profit and new product sales revenue account for a large weight. The four indicators have a significant effect on promoting industrial development. All the indicators work together to promote the coupling development of aerospace manufacturing and regional economy.

Before 2009, the comprehensive contribution of the regional economy was less than the comprehensive contribution of the aerospace manufacturing industry, and it was in the economic lag phase. Since 2010, the comprehensive contribution of regional economy has gradually increased, turning into industrial lag, indicating that there is a good interaction between the two.

Before 2010, Shaanxi's aerospace manufacturing and regional economy were in a disorderly development stage. Since 2010, it has been transferred to an orderly stage, and the degree of coupling coordination has interaction and correlation between regional economy and aerospace manufacturing industry is getting deeper and deeper.

5. Related Recommendations

The development of regional economy and military-civilian integration industry is in an orderly coupling state, and the degree of correlation between the two is deeper and deeper. Economic and environment fields in the regional economy and scale, innovation and efficiency in the military-civilian integration industry have a deep impact on the development of the two systems. Combined with the empirical conclusions of this paper, the following coupling strategies are proposed:

(1) Enterprises should appropriately expand their business scope and increase their business income. Whether from the principal component analysis of the indicator system or the weight calculation of the coupling coordination degree, the impact of the scale of the aerospace manufacturing industry on the industrial development and regional economy can be seen. The aerospace industry belongs to the high-tech industry and can provide leaps and bounds growth for the regional economy. Therefore, the company can expand its business scope and expands its scale to enable it to develop with the regional economy.

(2) Enterprises continue to increase their talents and technology investment to improve their innovation capabilities. Technological innovation is another important factor affecting the growth of the industry, and technological innovation affects the efficiency of the enterprise by affecting the market competitiveness of the enterprise's products. Enterprises will promote the development of regional economy by increasing the input of talents and technology to achieve effective output.

(3) Local governments should promote the integration of military and civilian industries into industrial parks and achieve cluster development. Industrial clusters can realize the sharing of technology, talents and resources. The development of military-civilian integration industry requires the cooperation of many enterprises in many fields. By building a military-civilian integration industrial base to promote industrial cluster development, local governments can help reduce costs and transaction costs, promote joint innovation of relevant enterprises, and

promote further coupling between military-civilian integration industrial and regional economies.

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