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Dynamic Measurement and Strategic Choice of the Shaanxi Light Industry Transformation and Upgrading Level

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Abstract: *Although the Shaanxi light industry industry has been developed for many years and its comprehensive strength has significantly improved,it is now facing new challenges and dilemmas in terms of transformation and upgrading due to changes in domestic and foreign environments.This paper constructs an index system to measure the level of transformation and upgrading of Shaanxi's light industry.The system is based on an analysis of the industry's current situation and includes five dimensions: capacity, subjects, dynamics, conception and environment.Using statistical data from 2011 to 2020, we measured the level of transformation and upgrading of Shaanxi light industry in a dynamic manner using the entropy value method and fuzzy comprehensive evaluation method.We also analyzed the strengths and weaknesses of its transformation and upgrading.The results indicate that Shaanxi light industry has advantages in transformation and upgrading in the dimensions of environment and motivation.However there are shortcomings in the areas of ability, concept and subjects.This paper proposes strategic choices to promote the transformation and upgrading of Shaanxi light industry.*

Keywords: *Shaanxi light industry; Transformation and upgrading; Entropy value method; Fuzzy comprehensive evaluation method; Level measurement*

1. Introduction

Light industry is one of the important traditional industries in Shaanxi Province, and its industrial chain covers a broad range of fields including textiles, clothing, food and beverages. In recent years, Shaanxi's light industry has made significant progress, and its comprehensive strength has been significantly improved, which not only provides a large number of jobs, but also continuously meets the growing demand for high-quality light industry products. With the changes in the domestic and international market environment, Shaanxi's light industry is also facing severe challenges and transformation and upgrading dilemmas. Data show that in the 20 years from 2000 to 2020, the share of the total output value of Shaanxi's light industry in the total industrial output value has been declining year by year, and by the end of 2020, the ratio of the total output value of Shaanxi's light and heavy industries will be reduced from 1:2.3 in 2000 to 1:4. At present, the total number of light industry manufacturing is 7,145, accounting for only about 2.79% of the country's total.R&D expenditure in light manufacturing accounts for only 3.06% of total manufacturing expenditure, much lower than the average for the eastern region. It can be seen that the transformation and upgrading of Shaanxi's light industry is imminent.

Scientific and technological innovation is a crucial internal driving force for promoting the transformation and development of the industry.The subjects of innovation are the backbone of the development of light industry.While the innovation environment and capacity is an important condition for the development of light industry, which provides a strong support for the transformation and upgrading of light industry and high-quality development [1]. This paper combines the existing research results, on the basis of constructing the index system for measuring the level of transformation and upgrading of Shaanxi light industry, adopts the entropy value method and the fuzzy comprehensive evaluation method to measure the dynamic level of transformation and upgrading of Shaanxi light industry, analyzes the dilemma of transformation and upgrading in depth, and puts forward the strategic choice of the transformation and upgrading of Shaanxi light industry accordingly, which is of strategic significance for accelerating the high-quality development of Shaanxi light industry.

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2. Review of relevant literature

It is generally believed that industrial transformation and upgrading is mainly to promote technological progress through the transformation of the development mode and the optimization of industrial structure, to comprehensively improve the technical efficiency, scale efficiency and factor allocation efficiency, and then to achieve a change in the state of the low end of the industrial value chain, so as to achieve the sustainable development of the industrial value chain[2]. Or it is the process of transitioning from traditional development methods to new methods with the strategic goal of enhancing the industry's core competitiveness and sustainable development capabilities.[3] .The research results indicate that various factors impact the transformation and upgrading of the light industry.These factors include innovation capacity, R&D intensity, technological progress, innovation environment, quality of talent, and the integration of production and financing[4,5,6].

Overall, the evaluation systems developed by previous studies, particularly for the light industry, are not comprehensive enough, lack operability, and fail to fully capture the essence of "transformation and upgrading of light industry".Based on existing literature, this paper focus on Shaanxi light industry and constructs an evaluation system with five dimensions.The system is based on the concepts of industrial transformation,upgrading,and high-quality development.The study applies the entropy method and fuzzy comprehensive evaluation method to analyze the level of transformation and upgrading of Shaanxi light industry from 2011 to 2020.The study also examines the development dynamics of industrial transformation and upgrading and proposes targeted proposals for the transformation and upgrading of the Shaanxi light industry. It also analyzes the development dynamics of industrial transformation and upgrading, and puts forward the strategic choices for the transformation and upgrading of Shaanxi light industry in a targeted way.

3. Shaanxi light industry transformation and upgrading level indicator system and measurement model construction

3.1. Selection of assessment indicators

The selection of indicators for transformation and upgrading of light industry is based on scientific, feasibility and pertinence principles combined with key indicators that have an impact.This paper presents the Shaanxi light industry transformation and upgrading indicator evaluation system,which consists of five dimensions:transformation and upgrading capacity, subjects, motivation, concept and environment.The measurement points for each dimension are explained below.

(1) Transformation and upgrading capacity is an important prerequisite, and this paper measures the transformation and upgrading capacity based on economic results and basic scale. Specifically, the total assets and total profits of light industry enterprises above the scale of Shaanxi are used to measure the economic results of light industry; the number of light industry enterprises above the scale of Shaanxi and the average number of employees are used to measure the basic scale of light industry. The base scale reflects the number of light industry enterprises in the province,indicating the basic status quo and changes in the scale of Shaanxi's light industry or the total amount of human resources in the light industry. This also embodies the transformation and upgrading base level or competitiveness of Shaanxi's light industry.

(2) Transformation and upgrading of the subject is the endogenous power, and this paper measures the transformation and upgrading of enterprise through science and technology research and development,as well as the application of enterprise R&D talent resources. Specifically, it adopts the ratio of R&D personnel and researchers to R&D personnel in R&D organisations in each region of Shaanxi Province to measure enterprise R&D talent resources; and it adopts the number of patent applications in Shaanxi Province and the number of industrial enterprises above the scale with R&D activities to measure enterprise science and technology R&D and application. Enterprise R&D resources talent resources help enterprises to improve their innovation ability, reflecting the competitiveness of Shaanxi light industry enterprises in the market.

(3) Transformation and upgrading dynamics is a key factor, and this paper measures transformation and upgrading dynamics with the central macro-arrangement of scientific research projects in Shaanxi Province and the support of R&D in each region. Specifically, it adopts the investment funds for R&D topics in universities in Shaanxi Province and the number of R&D topics in universities to measure the central macro-arrangement of scientific research projects; and it adopts the number of contracts for

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foreign technology introduction in Shaanxi Province and the amount of contracts to measure the level of foreign technology introduction in Shaanxi Province.

(4) Transformation and upgrading concept is the driving force, and this paper measures the concept of transformation and upgrading through Shaanxi Province Science and Technology Activity Week and R&D support in each region. Specifically, it adopts the number of times and the number of participants in the theme of science and technology popularization in Shaanxi Province to reflect the implementation of the Science and Technology Activity Week; and examines the government's R&D support for science and technology with the intensity of R&D investment in Shaanxi Province and the government implementation of R&D in industrial enterprises above the scale.

(5) Transformation and upgrading environment is an external condition, and this paper measures the transformation and upgrading environment through Shaanxi Province science and technology education training and economic benefits. Specifically, the number of science and technology museums and the area of science and technology museum exhibition halls in Shaanxi Province are used to measure science and technology education and training; the contribution rate of total assets of industrial enterprises over the size of Shaanxi Province and the turnover times of current assets of industrial enterprises above the size of Shaanxi Province are used to measure the main economic benefits. The five measurement dimensions and measurement indicators are shown in Table 1.

Table 1: Indicator System for Transformation and Upgrading of Light Industry.

Level 1 indicators	Level 2 indicators	Tertiary indicators
Transformation and upgrading capacity	Economic results	B1C1 Total assets of light industry enterprises above designated size(Ten thousand dollars)
		B1C2 Total profit of light industry enterprises above designated size(Ten thousand dollars)
	Base scale	B1C3 Number of light industry enterprises above scale(Pieces)
		B1C4 Average number of workers employed by light industry enterprises above designated size(Person)
Transformation and upgrading of subjects	R&D and application of enterprise science and technology	B2C1 Number of patent applications(Items)
		B2C2 Number of industrial enterprises above scale with R&D activities(Pieces)
	Corporate R&D talent resources	B2C3 R&D staff of regional R&D organizations(Person)
		B2C4 Researchers as a percentage of R&D personnel(%)
Transformation and upgrading dynamics	Centralized macro arrangements scientific research projects	B3C1 Input(Pieces)
		B3C2 Number of R&D topics in higher educatio(Pieces)
	Overseas technology introduction contracts	B3C3 Number of foreign technology introduction contracts(Items)
		B3C4 Contract amount(Billions of dollars)
Transformation and upgrading concept	Science and technology activities week	B4C1 Number of science topics(Freq)
		B4C2 Number of participants(Ten thousand person)
	R&D support	B4C3 R&D investment intensity(%)
		B4C4 R&D government implementation funding for industrial enterprises above scale(Ten thousand dollars)
Transformation and upgrading environment	Science and technology education training	B5C1 Number of science and technology centers(Pieces)
		B5C2 Science and technology museum exhibition hall area(Ten thousand square meters)
	Economic benefit	B5C3 Contribution ratio of total assets of industrial enterprises above designated size(%)
		B5C4 Turnover of current assets of industrial enterprises above designated size(Times/Year)

3.2. Determination of indicator weights

The entropy value is frequently used in information entropy theory to quantify the amount of information provided by the assessment indicator data. The specific calculation process of entropy value method is calculated as follows:

Evaluate m assessment indicators in n years and establish the original panel data matrix $X=(x_{ij})m\times n$.

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The calculation results can be influenced by indicator units and orders of magnitude. To eliminate this influence, it is necessary to standardize the original panel data.

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \tag{1}$$

The entropy e_j of each indicator is then calculated.

$$e_j = -k\sum_{i=1}^{n} P_{ij} \ln P_{ij} \tag{2}$$

Then calculate the information entropy redundancy of the ith metric.

$$d_j = 1 - e_j \tag{3}$$

Finalize the weights of the assessment indicators to obtain a weight matrix $W=(w_j)_{m\times n}$.

$$\omega_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{4}$$

3.3. Transformation and upgrading level measurement model construction

The entropy calculation above is first applied to establish the weight set $W=(w_i)$.Then calculate the corresponding weight values for each indicator data in the factor set $X=(xi)$. Finally, the degree of affiliation y_{ij} is calculated for each factor.

$$y_{ij}(t_k) = \frac{x_{ij}(t_k) - x_{ij}(t_k)}{\max[x_j(t_1)] - \min[x_j(t_1)]} \tag{5}$$

Where, $x_{ij}(t_k)$ and $s_{ij}(t_k)$ represent the original and standardized values of the jth indicator in the year, respectively, and $max[x_j(t_1)]$ and $min[x_j(t_1)]$ represent the maximum and minimum values of the jth indicator, respectively.

Finally, the score for fuzzy comprehensive evaluation is calculated as Z. The score of a particular assessment indicator is equal to the degree of affiliation multiplied by the weight multiplied by 100, and the sum of the scores of all indicators is the total score.

$$Z=W\times Y\times 100 \tag{6}$$

4. Shaanxi light industry transformation and upgrading level measurement

4.1. Indicator weight measurement

Table 2: Weights of Indicators of Shaanxi Light Industry Transformation and Upgrading Assessment Index System.

Indicators	Entropy e_j	Redundancy d_j	Indicator weights w_j	Level 1 indicators weights
B1C1	0.9219	0.0781	0.0313	0.1467
B1C2	0.9163	0.0837	0.0336	
B1C3	0.8752	0.1248	0.0501	
B1C4	0.9210	0.0790	0.0317	
B2C1	0.8838	0.1162	0.0466	0.2060
B2C2	0.8641	0.1359	0.0545	
B2C3	0.9394	0.0606	0.0243	
B2C4	0.7993	0.2007	0.0806	
B3C1	0.7888	0.2112	0.0848	0.2435
B3C2	0.8568	0.1432	0.0575	
B3C3	0.8822	0.1178	0.0473	
B3C4	0.8658	0.1342	0.0539	
B4C1	0.8442	0.1558	0.0625	0.1847
B4C2	0.8636	0.1364	0.0547	
B4C3	0.8980	0.1020	0.0410	
B4C4	0.9339	0.0661	0.0265	
B5C1	0.8065	0.1935	0.0777	0.2190
B5C2	0.8278	0.1722	0.0691	
B5C3	0.8836	0.1164	0.0467	
B5C4	0.9366	0.0634	0.0255	

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In this paper, the key indicators about the transformation and upgrading of Shaanxi light industry in "Shaanxi Statistical Yearbook" and "China Science and Technology Statistical Yearbook" are selected.The data covers a dynamic 10-year period from 2011 to 2021.

According to the index system of transformation and upgrading level constructed in the previous section, m = 20 and n = 10 in the evaluation matrix $X=(x_{ij})_{m\times n}$. The raw data are standardized according to formula (1), and Stata and Excel are used to process the raw data. The entropy value e_j , redundancy d_j , and weight value w_j of each indicator are calculated sequentially according to formula (2) (3) (4), and the results are shown in Table 2.

By measuring the weight value of each indicator in the evaluation index system of transformation and upgrading of light industry in Shaanxi Province during the period of 2011-2020, it indicates that the transformation and upgrading dynamics represent the most critical dimension of Shaanxi light industry transformation and upgrading. Additionally, the level of transformation and upgrading is most significantly influenced by the amout of input funding.

4.2. Calculation of indicator affiliation

The affiliation of each indicator in each year is calculated using equation (5), resulting in a one-factor evaluation matrix $Y=(y_{ij})_{m\times n}$.The matrix has dimensions m = 20 and n = 10, and the results are presented in Table 3.

Table 3: Indicator Affiliation.

Year	2011	2012	2013	2014	2016	2017	2018	2019	2020
B1C1	0.000	0.201	0.822	0.429	0.705	0.834	0.913	0.970	1.000
B1C2	0.000	0.187	0.666	0.913	0.485	0.472	0.447	0.515	0.447
B1C3	0.000	0.085	0.138	0.361	0.675	0.845	0.944	1.000	0.963
B1C4	0.218	0.496	0.000	0.623	0.843	0.942	0.815	1.000	0.385
B2C1	0.000	0.099	0.265	0.274	0.347	0.448	0.536	0.779	1.000
B2C2	0.000	0.041	0.148	0.266	1.000	0.517	0.466	0.560	0.700
B2C3	0.000	0.419	0.750	1.000	0.855	0.835	0.452	0.631	0.837
B2C4	0.471	0.529	0.471	0.353	0.000	0.000	0.294	0.235	1.000
B3C1	0.000	0.006	0.135	0.224	0.146	0.191	0.518	0.929	1.000
B3C2	0.000	0.070	0.126	0.229	0.388	0.479	0.630	0.793	1.000
B3C3	0.000	0.199	0.281	0.309	0.305	0.543	0.536	0.943	1.000
B3C4	0.000	0.086	0.311	0.155	0.308	0.501	0.584	0.704	1.000
B4C1	0.129	0.000	0.000	0.357	1.000	0.454	0.551	0.654	0.321
B4C2	0.000	0.099	0.099	0.936	1.000	0.220	0.946	0.630	0.726
B4C3	0.000	0.093	0.372	0.279	0.488	0.372	0.535	0.651	1.000
B4C4	0.000	0.308	0.548	0.702	0.945	0.940	0.881	0.755	0.586
B5C1	0.067	0.000	0.000	0.067	0.467	0.600	0.667	0.933	1.000
B5C2	0.000	0.100	0.109	0.118	0.300	0.364	0.727	0.909	1.000
B5C3	1.000	0.909	0.680	0.643	0.129	0.396	0.469	0.212	0.000
B5C4	0.393	0.475	0.721	1.000	0.656	0.672	0.557	0.443	0.000

5. Analysis of the results of Shaanxi light industry transformation and upgrading level measurement

5.1. Overall analysis of transformation and upgrading level

The overall score for transformation and upgrading is obtained by summing the scores of the five dimensions using formula(6).The ranking from 2011 to 2020 determined based on the overall score of transformation and upgrading in each year. Table 4 shows the specific results.

The data indicates the dynamic evolution of the level of transformation and upgrading of Shaanxi light industry in the five dimensions: capacity, subjects, dynamics, concept and environment over a 10-year period. The data indicates that in 2002, the Shaanxi light industry had the highest overall ranking for transformation and upgrading level, while in 2011, it had the lowest overall ranking. The level of transformation and upgrading in Shaanxi light industry has shown clear upward trend. The overall score for transformation and upgrading has increased significantly since 2019, rising from 11.485 in 2011 to 70.913 in 2020.

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Table 4: Measurement of the Level of Transformation and Upgrading of Shaanxi's Light Industry.

Year	Transformation and upgrading capacity score	Transformation and upgrading subject score	Transformation and upgrading dynamics score	Transformation and upgrading concept score	Transformation and upgrading environment score	Overall Transformation and Upgrading Score	Comprehensive Ranking
2011	0.691	3.792	0	0.809	6.192	11.485	10
2012	3.259	5.976	1.857	1.741	6.147	18.979	9
2013	5.506	7.659	4.875	3.52	5.767	27.327	8
2014	8.194	8.006	5.514	10.359	6.883	38.956	7
2015	9.974	5.483	6.378	9.699	9.289	40.822	6
2016	9.891	9.154	6.564	16.234	7.968	49.81	4
2017	11.42	6.944	9.644	8.065	10.734	46.806	5
2018	11.674	8.513	13.695	13.149	13.815	60.846	3
2019	12.949	10.117	20.69	12.207	15.649	71.613	2
2020	10.681	18.577	24.346	11.631	14.678	79.913	1
Aver-age score	8.424	8.422	9.356	8.741	9.712	44.656	

5.2. Analysis of Transformation and Upgrading Capacity

Since 2011, Shaanxi's light industry has undergone significant transformation and upgrading, as evidenced by improvements in the four key indicators: total assets, total profit, number of enterprises and average number of enterprises, and average number of employees of light industry enterprises above designated size. Figure 1 displays the specific data.

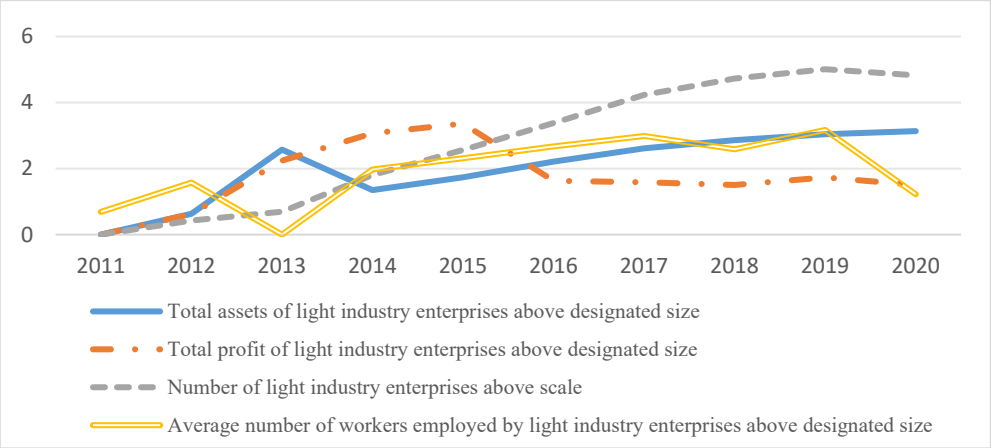

Figure 1: Shaanxi Province Light Industry Transformation and Upgrading Ability Score in 2011-2020.

Among them, the total assets of light industry enterprises above designated size and the number of enterprises have shown the most significant improvement. From an objective standpoint, the total assets of large-scale light industry enterprises have increased from 102.131 billion yuan in 2011 to 356.482 billion yuan in 2020. Additionally, the number of large-scale light industry enterprises has increased from 1,166 in 2011 to 2,296 in 2020. The transformation and upgrading capacity of the light industry in Shaanxi Province is significantly influenced by the total assets and number of enterprises. These factors are crucial indicators that require attention.

5.3. Analysis of Transformation and Upgrading Subjects

Since 2011, the score of subjects of Shaanxi light industry transformation and upgrading subjects has consistently increased. The four key indicators, namely, the number of patent applications, the number of industrial enterprises above scale with R&D activities, the R&D personnel of R&D organizations in each region and the proportion of researchers to R&D personnel, have all shown significantly improvement. Figure 2 provides specific data.

The score of the indicator of the number of patent applications has shown the most consistent growth over the 10-year period and has the highest growth rate. This suggests that the number of patent applications has a greater impact on the level of transformation and upgrading of subjects. The proportion of researchers in R&D personnel shows the smallest growth in the index score. The trend is characterized by a decline followed by a rise. The score value gradually declined before 2015 and

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gradually increased after 2015. The score value gradually declined from before 2015, and gradually increased after 2015.

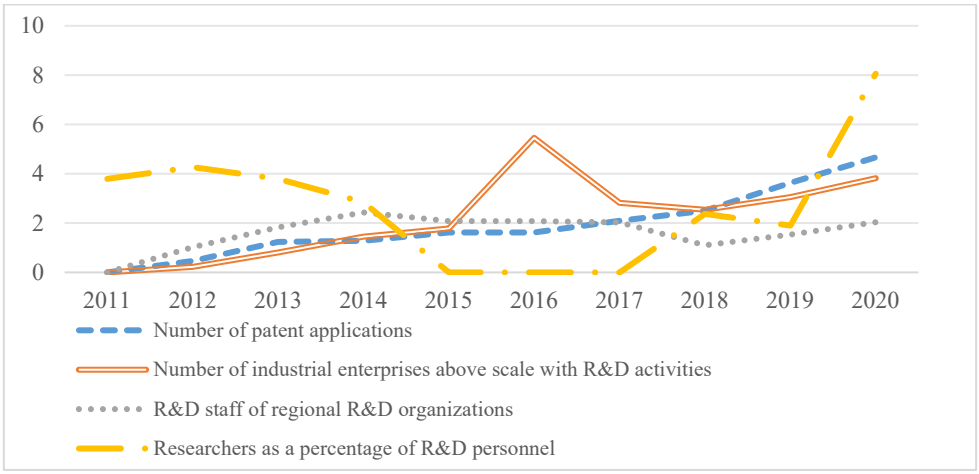

Figure 2: Shaanxi Province Light Industry Transformation and Upgrading Subjects Score in 2011-2020.

5.4. Analysis of Transformation and Upgrading Dynamics

Since 2011, the transformation and upgrading dynamics of Shaanxi light industry has gradually increased. The four key indicators, namely, the investment funds for R&D topics in universities in Shaanxi Province, the number of R&D topics in universities, the number of foreign technology introduction contracts and the contract amount, have all shown significant improvement. Figure 3 displays specific data.

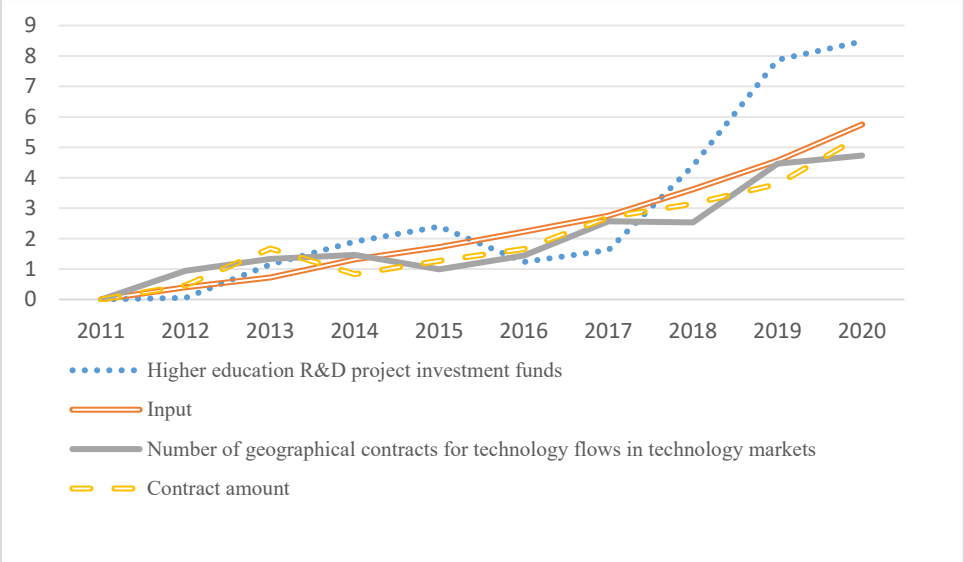

Figure 3: Shaanxi Province Light Industry Transformation and Upgrading dynamics Score in 2011-2020.

The number of university R&D topics and the contract amount of the two index scores have grown more steadily from 2011 to 2020. The index score of the number of foreign technology introduction contracts grew slowly from 2011 to 2014, but has grown more rapidly since 2016. The input funding index score began to decline after 2015, rebounded in 2016, and has grown steadily since then steady growth.

5.5. Analysis of Transformation and Upgrading Concept

Since 2011, the concept of transformation and upgrading of Shaanxi light industry has not been evident. The trend of the four indicators, namely, the number of science topics, the number of

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participants, the intensity of R&D investment, and the government's implementation of R&D funding for large-scale industrial enterprises, has been unstable. Figure 4 displays specific data.

The score for R&D governmental implementation funding for industrial enterprises initially increases and then decreases, with 2015 as the turning point. The score value gradually increased before 2015 and declined after 2015. The indicator score for the number of participants and science topics are the most unstable, with frequently rises and declines. In contrast, the R&D funding intensity indicator score has a stable trend of increasing changes compared to the other three indicators, with the highest rate of improvement. Specifically, the R&D funding intensity indicator score increased from 0.000 in 2011 to 4.096 in 2020.

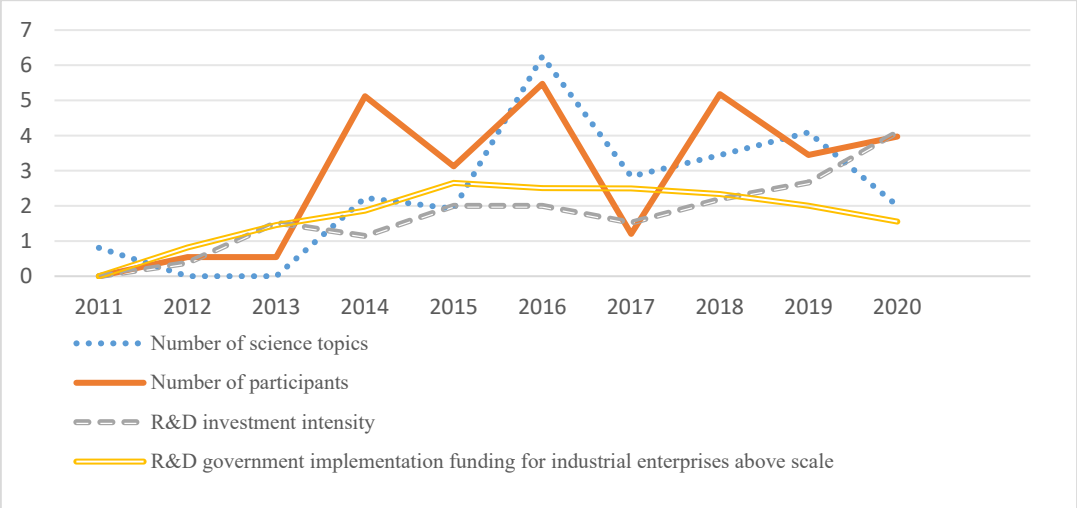

Figure 4: Shaanxi Province Light Industry Transformation and Upgrading Concept Score in 2011-2020.

5.6. Analysis of Transformation and Upgrading Environment

Since 2011, the environment for the transformation and upgrading of Shaanxi's light industry has been unstable. The scores of the indicators for the contribution rate of total assets of industrial enterprises above a large scale have generally been in a downward trend. However, the scores of the indicators for the number of science and technology museums and the area of science and technology museums' exhibition halls have generally been on an upward trend. Please refer to Figure 5 for specific data.

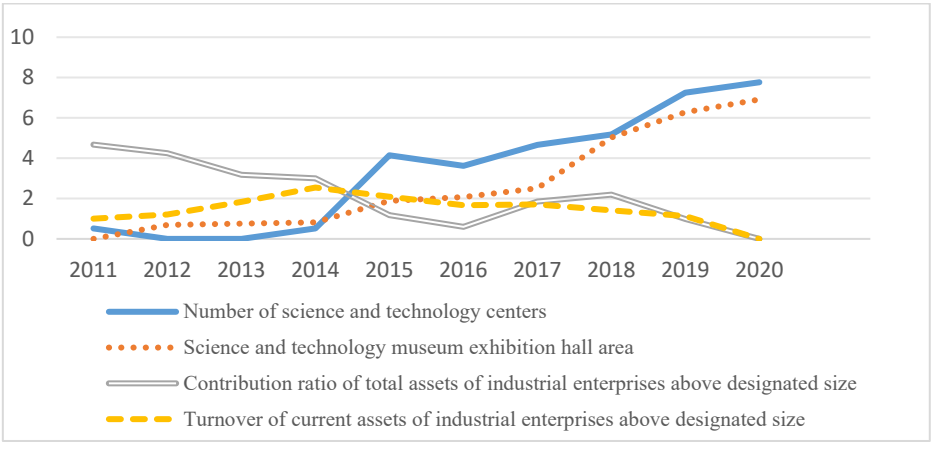

Figure 5: Shaanxi Province Light Industry Transformation and Upgrading environment Score in 2011-2020.

The analysis of the aforementioned dimensions reveals that the total profit of large-scale light industrial enterprises above scale, the proportion of researchers in R&D personnel, the input funding allocated to R&D topics in universities, the number of science topics, and the area of science and technology museum exhibition halls remain unchanged.

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The level of transformation and upgrading in Shaanxi light industry is influenced by several dimensions,ranked in order of importance as follow:,transformation and upgrading environment, transformation and upgrading dynamics, transformation and upgrading concepts, transformation and upgrading main body and transformation and upgrading capacity.Notably,the transformation and upgrading environment has the strongest impact,while the transformation and upgrading capacity has the weakest.It is important to measure these dimensions dynamically.

6. Strategic choices for the transformation and upgrading of Shaanxi's light industry

(1) Increase investment in scientific and technological research and development of light industry to enhance the industrial chain.

To improve the transformation and upgrading capacity of Shaanxi's light industry, it is necessary to increase investment in scientific and technological research and development. This can be achieved by establishing and improving scientific research platforms, encouraging enterprises to conduct independent research and development, and promoting advanced manufacturing and automated production technologies. Additionally, efforts should be made to improve product quality and efficiency while reducing production costs. To achieve this, light industry enterprises should be encouraged to strengthen their research and development investment, and the number of enterprises with research and development activities should be increased. Other necessary efforts include technological improvement and equipment upgrading, the development of high-value-added products, talent training, internationalization, and industry chain construction.

(2) Promote scientific and technological innovation in light industry enterprises and actively encourage school-enterprise cooperation.

Actively carry out independent innovation and improve the level of scientific and technological innovation; improve the use of patents and strengthen the cultivation and publicity of intellectual property rights awareness; raise the awareness of enterprise employees on the protection and application of intellectual property rights and increase the number of patents. Strengthen cooperation and synergy among regional research and development organizations, promote resource sharing, make full use of the R&D advantages of each organization, and improve the technological level and innovation ability of the light industry. Attract more high-end light industry scientific and technological talents form the light industry to participate in the scientific and technological innovation of the light industry, so as to promote the transformation, upgrading and high-quality development of Shaanxi light industry.

(3) The government is stepping up its policy of promoting light industry industry and broadening the scope of cooperation.

The central macro arrangement of scientific research projects should strongly support for the transformation and upgrading of Shaanxi light industry power. This can be achieved through various financial support and policy encouragement, which will aid in the transformation and upgrading of Shaanxi light industry. Increase funding support for scientific and technological innovation, allocate a higher proportion of funds to support the scientific and technological research and development in enterprises and universities, and facilitate the transformation and application of scientific and technological achievements. At the same time, attention should also be given to the industrialization and commercialisation of scientific and technological advancements. This will transform scientific and technological achievements into a driving force for industrial development, thereby enhancing the overall competitiveness of Shaanxi light industry industry.

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