Research on Efficiency of Sci-tech Input-output of Enterprises from Two-stage Perspective: Based on the Data of Seven Pillar Industries in Shaanxi Province

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Abstract: The industry categories are numerous in Shaanxi province, their characteristics on sci-tech input-output are different from each other. Based on two-stage sci-tech input-output model, this paper studies the data of seven pillar industries in Shaanxi province from 2005 to 2014 in method of series network DEA. The result shows that there are differences between stages and industries, reveals that it is unreasonable to the scale and structure of sci-tech input-output. The seven pillar industries are divided into four categories judging by the features of two-stage efficiencies, and makes suggestions accordingly.
Keywords: sci-tech input-output, series network DEA, efficiency, pillar industries

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1. INTRODUCTION

Computer and other electronic equipment, energy and chemical industry, equipment manufacturing industry, manufacture of medicines industry, foods industry, textile wearing apparel industry and non-ferrous metallurgy industry have been called seven pillar industries promoting the economic development of Shaanxi Province after 2003 [1].Their main indicators have been absorbed by national statistical system. Data shows that the eight pillar industries' average share of the province's total industrial output value of 97.56%, in Shaanxi Province from 2005 to 2014,is crucial to the province's economy. In order to speed up the implementation of innovation-driven development strategy, pillar industries in Shaanxi Province should improve the efficiency of the use of science and technology investment, rather than increasing investment in science and technology, so that limited technology investment can maximize the effectiveness to increase the industry's independent innovation capability and core competitiveness in Shaanxi Province.

Science and technology input and output system is a multi-input and multi-output system whose dimension is not exactly the same, because of the complexity of the system itself and index of imperfection, relevant scholars have not form a unified evaluation method. They use data envelopment analysis (DEA), econometric approach, stochastic frontier analysis and so on [2]. DEA is widely used because it can reflect the diversity of inputs and outputs to fulfill the principle of multiple optimization.

Since the study of the relative efficiency of science and technology investment in China from 1985 to 2003 by DEA [3], many scholars have made a lot of research on the efficiency of science and technology investment in China at all levels. The early stage of science and technology into the output process as an only input and output of the large system, ignoring the internal operation of the system; the current scholars begin to technology input and output process to refine and ashes, so two-stage sci-tech input-output model receive more attention. It has appeared a two-stage additive DEA model [4], a two-stage model with shared inputs [5] and a two-stage model with additional inputs [6]. Among them, Feng Feng, Zhang Leiyong [7] use the series network DEA of 29 provinces and cities in China's technology input and output data, giving the advice on efficiency of science and technology input and output recommendations. Peng Cheng, Zheng Changde [8] take advantage of the construction of two-stage system chain model, analyzing China's 29 categories of manufacturing technology input and output data. Feng Zhijun, Chen Wei [9] use the construction of resource-constrained two-stage DEA model, evaluating the R&D innovation and the overall efficiency of each sub-stage in 17 sub-sectors of high-tech industry in China.

Based on the research results of relevant scholars and two-stage sci-tech input-output model, this paper studies the data of pillar industries in Shaanxi province from 2005 to 2014 in method of series network DEA. We focus on the provincial industry level to analyze the causes of inefficiency, and propose recommendations for efficiency improvement.

2. RESEARCH DESIGN, MODEL ESTABLISHMENT AND SELECTION OF INDICATORS

2.1 Research methods

Data Envelopment Analysis (DEA) is a measure of the relative efficiency of multi-input, multi-output decision-making units (DMUs). It uses the envelopment model of input data and output data to evaluate the relative effectiveness and give recommendations for improvement [10].

Suppose there are n decision units to be evaluated, $DMU_i(i=1,2,\ldots,n)$, relying on m kinds of input elements, $x_{ij}(i=1,\ldots,n;j=1,\ldots,m)$, produce p kinds of output elements, $y_{ir}(i=1,\ldots,n;r=1,\ldots,p)$, $x_{ij}\geq0$, $y_{ir}\geq0$. Each DMU_i has a relative efficiency evaluation index h_i, as shown in equation (1):

$$h_i\left(\boldsymbol{u},\boldsymbol{v}\right)=\frac{\sum_{r=1}^{p}u_r y_{ir}}{\sum_{j=1}^{m}v_j x_{ij}} \tag{1}$$

u is the set of weights for output, v is the set of weight for input, u_r represents the weight coefficient of the r output, and v_j represents the weight coefficient of the j input. Taking the efficiency index of the $i_o(1\leq i_o\leq n)$ decision-making unit as the goal, the efficiency index of all the decision-making units is taken as the constraint, form the following model:

$$\begin{aligned}
&\max h_{i_o}\left(\boldsymbol{u},\boldsymbol{v}\right)=\frac{\sum_{r=1}^{p}u_r y_{i_o r}}{\sum_{j=1}^{m}v_j x_{i_o j}}\\
&s.t.\quad \frac{\sum_{r=1}^{p}u_r y_{i_o r}}{\sum_{j=1}^{m}v_j x_{i_o j}}\leq 1\\
&\qquad u_r, v_j \geq 0, i=1,\cdots,n; j=1,\cdots,m; r=1,\cdots,p
\end{aligned} \tag{2}$$

Equation (2) is CCR model, convert it into a dual form, as shown in equation (3):

$$\begin{aligned}
&\max \theta\\
&s.t.\quad \sum_{i=1}^{n}\lambda_i y_{ir}\geq y_{i_o r}\\
&\qquad \theta_{x_{i_o j}}-\sum_{i}^{n}\lambda_i x_{ij}\geq 0\\
&\qquad \lambda_i\geq 0, i=1,\cdots,n; j=1,\cdots,m; r=1,\cdots,p
\end{aligned} \tag{3}$$

Equation (3) is CCR model under the premise of constant scale pay. θ is the relative efficiency metrics of DMU, referred to as comprehensive efficiency. When θ = 1, DMU is valid; when θ <1, DMU is invalid. Further, $\sum_{i=1}^{n}\lambda_i=1$ are introduced in the CCR model, we can build the BCC model under the premise of the scale pay variable, whose efficiency is pure technical efficiency. Scale efficiency is the ratio of overall efficiency and pure technical efficiency. Then we calculate scale efficiency and measure slack variables.

$$
\begin{aligned}
&\min\left[\theta-\varepsilon(e^{T}s^{-}+e^{T}s^{+})\right]=V(\varepsilon)\\
&s.t.\quad \sum_{j=1}^{n}\lambda_j x_j+s^{-}=\theta x\\
&\qquad \sum_{j=1}^{n}\lambda_j y_j-s^{+}=y\\
&\qquad \lambda_j\geq 0(j=1,\cdots,n);s^{-}\geq 0,s^{+}\geq 0
\end{aligned}
\tag{4}
$$

In addition, ε is infinitesimal, s^- is the relaxation variable of the DMU input index, $s^+$is the slack variable of the output index of each DMU, θ is the pure technical efficiency, λ_j is the weight of the input and output variable. When θ=1, and s^-=0, s^+=0, the decision-making unit is DEA effective; When θ=1, and $s^-\neq$0, $s^+\neq$0, the decision-making unit is only weak DEA effective; when θ=1, the decision making unit is not valid for weak DEA.

2.2 The establishment of the model

The sci-tech input-output process of enterprise is divided into two stages of technology research & development and economic transformation [11], in the technology R&D stage, through the R&D resources investment from enterprise R & D department, R&D results come out; in the economic transformation stage, enterprises not only absorb the R&D results from technology R&D stage as their own inputs, but also absorb the technology applications, for the purpose that the enterprises need to make additional investment in R&D activities or transformation of technology R&D stage. The final output of the two-stage system is the production output. Based on this, the two-stage technology input-output model is shown in Fig. 1.

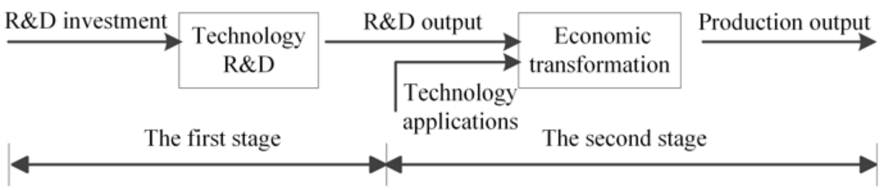

Fig. 1 the two-stage technology input-output model

2.3 Selection of indicators

In the above model, there are four types of indicators of R&D investment, R&D output, application of science and technology and production output. According to the actual situation, we form a measurable and practical index system.

2.3.1 Phase I (R&D phase) Input and output indicators

Expenditure on R&D projects(million) is a flow index, which can reflect the actual investment during the technical R&D stage. Full-time equivalent of R&D personnel (man-year) is the sum of the number of full-time staff, reflecting the technical development stage of staff input. Expenditure on R&D projects and Full-time equivalent of R&D personnel can reflect the scale and potential of technology research and development [12].

The number of patents application (item) is selected as the first indicator of the output of the R&D stage to reflect the true level of output of the enterprises during the R&D phase. In addition, the number of new product development projects (items) contains a wider range of outputs and is positively correlated with Full-time equivalent of R&D personnel [13], so it is the second indicator in this stage of output.

2.3.2 Phase II (Economic Transition Phase) Input and Output Indicators

The output indicators for the first phase are also the inputs for the second phase. New product development expenses (million) reflects the cost of new product design, model development, testing, experiment and other expenses, so it can represent the application of technology applications. Select the new product output value (million) as the first indicator in the second stage of the output, because it can reflect the situation of new product industrialization; select new product sales income(million) as the second indicator of the output, which can reflect the new product economic benefits.Two-stage technology input-output structure model shown in Fig. 2.

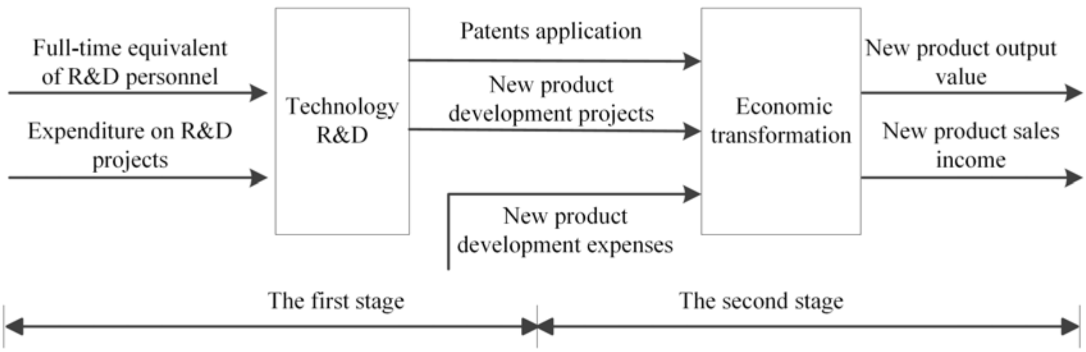

Fig. 2 Two-stage technology input-output structure model

3. ANALYSIS OF EMPIRICAL RESULTS

According to the relevant panel data of the seven pillar industries in 2005 and 2014, the efficiency evaluation and analysis are carried out by DEAP2.1 software based on the two-stage technology input-output model. Data are from the *Shaanxi Statistical Yearbook*(2006-2015). In the yearbook, there is no specific indicator data for the seven pillar industries. So this article use the data from *Shaanxi Statistical Yearbook* in 'The Situation of Industrial Enterprises above Designated Projects' and 'Developing, Producing and Sales of Industrial Enterprises above Designated', with the reference from in Table 1. Seven Pillar Industries in Shaanxi Province contain the following national economy industries.

Table 1. Seven Pillar Industries in Shaanxi Province contain the following national economy industries

<table>
<tr><th>Seven Pillar Industries</th><th>national economy industries</th><th>Seven Pillar Industries</th><th>national economy industries</th></tr>
<tr><td>Computer and other electronic equipment</td><td>Manufacture of computers, communication and other electronic equipment</td><td>Manufacture of medicines industry</td><td>Manufacture of medicines</td></tr>
<tr><td rowspan="8">Energy and chemical industry</td><td>Processing of petroleum, coking, processing nuclear fuel</td><td rowspan="4">Foods industry</td><td>Processing of food from agricultural products</td></tr>
<tr><td>Manufacture of chemical raw material and chemical products</td><td>Manufacture of foods</td></tr>
<tr><td>Production and supply of electric power and heat power</td><td>Manufacture of wine,beverages and refined tea</td></tr>
<tr><td>Mining supporting activities</td><td>Manufacture of tobacco</td></tr>
<tr><td>Manufacture of chemical fibers</td><td rowspan="4">Textile wearing apparel industry</td><td>Manufacture of textile</td></tr>
<tr><td>Manufacture of rubber and plastics</td><td rowspan="3">Manufacture of textile and clothing</td></tr>
<tr><td>Mining and washing of coal</td></tr>
<tr><td>Extraction of petroleum and natural gas</td></tr>
<tr><td rowspan="7">Equipment manufacturing industry</td><td>Manufacture of metal products</td><td rowspan="4">Non-ferrous metallurgy industry</td><td>Mining and processing of ferrous metal ores</td></tr>
<tr><td>Manufacture of general purpose machinery</td><td>Mining and processing of non-ferrous metal ores</td></tr>
<tr><td>Manufacture of special purpose machinery</td><td>Smelting and pressing of ferrous metals</td></tr>
<tr><td>Manufacture of railway, shipping, aerospace and other transport equipments</td><td>Smelting and pressing of non-ferrous metals</td></tr>
<tr><td>Manufacture of electrical machinery and equipment</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>Manufacture of measuring instrument and machinery</td></tr>
<tr><td>Automotive industry</td></tr>
</table>

For the reason that the two-stage process of technology input-output efficiency evaluation has a certain time lag from input to output, there is no uniform standard to determine the lag period. Therefore, this paper adopts the practice of setting the two-stage input-output lag 1 year [14], that is, the first phase of the input time period is from 2005 to 2012, the first phase of the output time & the second phase of the input time is from 2006 to 2013, the second phase of the output time is from 2007 to 2014.

Using the series network DEA method to measure the efficiency of input and output of science and technology, the output should be increased with the increase of input, which is called as equal amplitude expansion [15]. The Pearson correlation analysis is used to check whether the sample of the study meet this property (see Table 2, Table 3). It can be seen that each input-output indicator is positively correlated at a significant level of 0.01, so they can be used as input-output indicators in this study.

Table 2 Pearson correlation coefficient between the input and output indicators in the first stage

Indicators	Full-time equivalent of R&D personnel	Expenditure on R&D projects
Patents application	0.840**	0.918**
New product development projects	0.864**	0.929**

Table 3 Pearson correlation coefficient between the input and output indicators in the second stage

Indicators	Patents application	New product development projects	New product development expenses
New product output value	0.848**	0.891**	0.913**
New product sales income	0.822**	0.871**	0.892**

Note: ** indicates a significance level of 0.01.

3.1 Analysis of input-output results in the first stage (R&D stage)

As can be seen from Table 4, the seven industrial pillar industries in the technical R&D stage, none of the industries maintains an integrated efficiency value of 1 from 2006 to 2013. Computer and other electronic equipment, textile wearing apparel industry and foods industry good performance in most of the years, indicating that their technology research and development efficiency in most of the time achieve DEA effective and their R&D resources achieve the most excellent state. The overall efficiency of manufacture of medicines industry and energy and chemical industry show an upward and downward trend, 8-year average is

0.791 and 0.712, which is at the middle level. The average annual efficiency equipment manufacturing industry and non-ferrous metallurgy industry is only 0.515 and 0.412, indicating that their technology research and development efficiency is low.

Table 4 Comprehensive efficiency of seven pillar industries in Shaanxi Province of the first stage (R&D stage)

Pillar industries	2006	2007	2008	2009	2010	2011	2012	2013	Average value
Computer and other electronic equipment	0.49	1	1	1	0.611	1	1	1	0.888
Energy and chemical industry	0.325	1	0.422	0.598	0.949	0.682	0.826	0.893	0.712
Equipment manufacturing industry	0.35	0.425	0.43	0.641	0.598	0.475	0.737	0.465	0.515
Manufacture of medicines industry	1	0.922	1	0.472	0.4	0.847	1	0.686	0.791
Foods industry	1	1	1	0.633	0.45	0.782	1	1	0.858
Textile wearing apparel industry	1	1	1	1	1	1	0.516	0.517	0.879
Non-ferrous metallurgy industry	0.699	0.356	0.575	0.524	0.235	0.158	0.325	0.426	0.412
Average value	0.695	0.815	0.775	0.695	0.606	0.706	0.772	0.712	0.722

We can see from gross industrial output value and R&D resources configuration, The energy and chemical industry and equipment manufacturing industry are the core pillar industries in Shaanxi Province, but their comprehensive efficiency of the R&D stage is lower than the average level of the industries [16]. What's more, the energy and chemical industry's technology R&D efficiency is on the rise from 2011 to 2013, but the equipment manufacturing industry's technology R&D efficiency has been always low.

3.2 Analysis of input-output results in the second stage (economic transformation stage)

As can be seen from Table 5, the economic transformation efficiency values of non-ferrous metallurgical industry are 1 in the last eight years, which means DEA effective, showing a very stable situation, indicating an optimal state in the economic transformation phase of the allocation of resources. The average annual efficiency of the food industry is 0.763, which is second only to the non-ferrous metallurgical industry, but the annual comprehensive efficiency is fluctuating. The comprehensive efficiency of the textile wearing apparel industry is 0.510, and its comprehensive efficiency has been declining from 2007 to 2014. The combined efficiency of the manufacture of medicines industry and equipment manufacturing industries is hovering at low levels for most of the years. As to computer and other electronic equipment and energy and chemical industry, the overall efficiency of the average annual value is only 0.378 and 0.255, which is at a disadvantage.

Table 5 Comprehensive efficiency of seven pillar industries in Shaanxi Province of the second stage (economic transformation stage)

Pillar industries	2007	2008	2009	2010	2011	2012	2013	2014	Average value
Computer and other electronic equipment	0.927	0.38	0.138	0.159	0.403	0.232	0.13	0.654	0.378
Energy and chemical industry	0.846	0.277	0.049	0.157	0.305	0.122	0.198	0.085	0.255
Equipment manufacturing industry	1	0.307	0.166	0.334	0.332	0.33	0.252	0.377	0.387
Manufacture of medicines industry	0.579	0.787	0.263	0.372	0.527	0.347	0.235	0.445	0.444
Foods industry	1	0.273	0.278	1	0.664	1	1	0.889	0.763
Textile wearing apparel industry	1	1	0.416	0.206	0.442	0.462	0.318	0.236	0.51
Non-ferrous metallurgy industry	1	1	1	1	1	1	1	1	1
Average value	0.907	0.575	0.330	0.461	0.525	0.499	0.448	0.527	0.534

On the whole, the average efficiency value in R&D stage of the seven pillar industries is 0.722, which is higher than the average efficiency value, 0.534, in the economic transformation stage. The result means that the low efficiency of science and technology input and output of seven pillar industries is mainly due to the low efficiency of economic transformation. In order to further analyze the inter-industry efficiency differences, the two-dimensional distribution of the two-stage efficiency is shown in the horizontal and vertical axes for the R&D efficiency and economic conversion efficiency of the seven pillar industries (see Fig. 3).

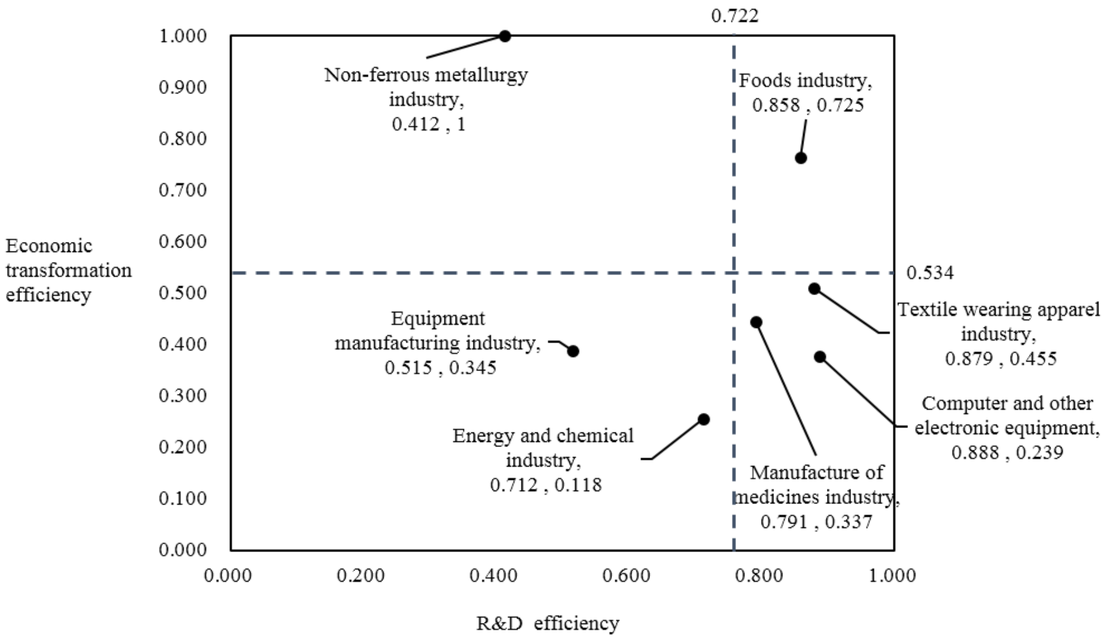

Fig. 3 The two-dimensional distribution in the two-stage efficiency of the seven pillar industries

We regard the average of the industry average level of each stage as a standard. In R&D stage, it is defined that [0,0.722] is called low-tech R&D efficiency and [0.722,1] is called high-tech R&D efficiency. In economic transformation stage, it is defined that [0,0.534) is called low- economic transformation efficiency and [0.534,1] is called high-economic transformation efficiency. So the seven pillar industries can be divided into four major types: high technology R&D efficiency and high economic efficiency, such as food industry, which is both excellent in technology R&D and economic transformation; high technology R&D efficiency and low economic efficiency, such as computer and other electronic equipment, manufacture of medicines industry and textile wearing apparel industry, which is excellent in technology R&D; low technology R&D efficiency and high economic efficiency, such as non-ferrous metallurgy industry, which is excellent in economic transformation; low technology R&D efficiency and low economic efficiency, such as equipment manufacturing industry and energy and chemical industry, which is both poor in technology R&D and economic transformation.

Overall, only food industry is both excellent in two stages of science and technology output industry among the seven pillars industries. Non-ferrous metallurgy industry, computer and other electronic equipment, manufacture of medicines industry and textile wearing apparel industry, are single excellent in two stages of science and technology output industry among the seven pillars industries. Equipment manufacturing industry and energy and chemical industry, are both poor in two stages of science and technology output industry among the seven pillars industries.

For high technology R&D efficiency and low economic efficiency, the ‘target stage’ of improving efficiency is the economic transformation stage. Similarly, as to high technology R&D efficiency and low economic efficiency, the focus should be in the technical development stage. For low technology R&D efficiency and low economic efficiency, the ‘target stage’ of improving efficiency is both.

3.3 Analysis of single cycle results of technology input and output

In order to understand further the factors that affect the efficiency of input and output of science and technology, we study the results of the single-cycle output of science and technology input and output of the seven pillars industries in 2013 and 2014.

It can be seen from Table 6, the comprehensive efficiency of computer and other electronic equipment and the food industry in Shaanxi Province in 2013 reached the efficiency of DEA, which indicated that the technological innovation of the two pillar industries were at a high level. While the other five pillar industries are manifested as DEA ineffective, including equipment manufacturing industry and non-ferrous metallurgy industry, their average annual efficiency is only 0.465 and 0.426, reflecting that the two pillar industries have a big improvement space.

Table 6 Efficiency in R&D stage of seven pillar industries in Shaanxi Province in 2013

Pillar industries	Comprehensive efficiency	Pure technical efficiency	Scale efficiency	Return to scale	Slack variable under variable return to scale			
					S_1^-	S_2^-	S_1^+	S_2^+
Computer and other electronic equipment	1.000	1.000	1.000	invariance	0.00	0.00	0.00	0.00
Energy and chemical industry	0.893	1.000	0.893	decline	0.00	0.00	0.00	0.00
Equipment manufacturing industry	0.465	1.000	0.465	decline	0.00	0.00	0.00	0.00
Manufacture of medicines industry	0.686	0.763	0.898	growing	197.95	4690.36	33.88	0.00
Foods industry	1.000	1.000	1.000	invariance	0.00	0.00	0.00	0.00
Textile wearing apparel industry	0.517	1.000	0.517	growing	0.00	0.00	0.00	0.00
Non-ferrous metallurgy industry	0.426	0.437	0.975	growing	1091.52	89341.04	0.00	119.45
Average value	0.712	0.886	0.821		184.21	13433.06	4.84	17.07

From the point of view of the pure technical efficiency and scale efficiency, the non-DEA effective decision-making units are caused by the inefficiency of pure technology or the inefficiency of pure scale efficiency. The main reason for the low efficiency of Manufacture of Medicines Industry and non-ferrous metallurgical industry is that their pure technical efficiency is too low, and the improvement rate is 23.70% and 56.30%. The scale efficiency also needs different degree of improvement, the adjustment rate is 10.20% and 2.50%. Both pillar industries are in the stage of increasing returns to scale, indicating that the investment is not enough to make the scale advantage. We should increase the corresponding resources investment, enhance the level of technology R&D to achieve economies of scale. For the energy and chemical industry, equipment manufacturing industry and Textile Wearing Apparel Industry, its pure technical efficiency has reached the DEA effective, indicating that the current input has reached a combination of the largest output, so it is the overall efficiency of the factors which restricts the scale of efficiency. Among them, the energy and chemical industry and equipment manufacturing industry, the scale of remuneration in a decreasing stage, therefore, it is possible to reduce the scale of R&D activities and improve the efficiency of scale. While Textile Wearing Apparel Industry is in an increasing stage, indicating that its use of R&D resources in the performance of good, but has not yet formed a scale advantage. So it is necessary to increase the scale of R&D activities further.

Table 7 Efficiency in economic transformation stage of seven pillar industries in Shaanxi Province in 2014

Pillar industries	Comprehensive efficiency	Pure technical efficiency	Scale efficiency	Return to scale	Slack variable under variable return to scale				
					S_1^-	S_2^-	S_3^-	S_1^+	S_2^+
Computer and other electronic equipment	0.654	0.677	0.966	decline	502.08	650.13	0.00	620442.02	796910.52
Energy and chemical industry	0.085	0.189	0.448	decline	366.69	0.00	221512.80	2291929.04	2071756.27
Equipment manufacturing industry	0.377	1.000	0.377	decline	0.00	0.00	0.00	0.00	0.00
Manufacture of medicines industry	0.445	0.491	0.907	growing	8.04	99.94	0.00	497184.36	499401.94
Foods industry	0.889	1.000	0.889	growing	0.00	0.00	0.00	0.00	0.00
Textile wearing apparel industry	0.236	1.000	0.236	growing	0.00	0.00	0.00	0.00	0.00
Non-ferrous metallurgy industry	1.000	1.000	1.000	invariance	0.00	0.00	0.00	0.00	0.00
Average value	0.527	0.765	0.689		125.26	107.15	31644.69	487079.35	481152.68

It can be seen from Table 7 that the comprehensive efficiency of the industrial transformation phase of the seven pillar industries in 2014 is low, and only non-ferrous metallurgy industry has achieved the comprehensive efficiency DEA. The pure technical efficiency of the equipment manufacturing industry, the food industry and the textile wearing apparel industry has been DEA effective, showing that the scale of inefficiency leads to low overall efficiency. Among them, the scale efficiency of the equipment manufacturing industry is in the diminishing stage, indicating that you can consider the appropriate reduction in the scale of its economic transformation activities to improve the scale of efficiency. And food industry and textile wearing apparel industry are in the incremental stage, so it is necessary for the two pillar industries to consider how to appropriately expand the scale of the activities in the economic transformation phase. The main reason for the low efficiency of computer and other electronic equipment and Manufacture of Medicines Industry is that their pure technical efficiency is too low and the improvement rate is 32.30% and 50.90% respectively, while the scale efficiency is improved to a modest rate of 3.40% and 9.30%. Energy and chemical industry's pure technical efficiency and scale efficiency are very low, which lead to an invalid comprehensive efficiency of DEA.

From the view of slack movement in variable return to scale, there is a certain degree of input redundancy and insufficient output among computer and other electronic equipment, energy and chemical industry and manufacture of medicines industry, as is shown in Table 8. Among them, the number of patent applications and the number of new product development projects in computer and other electronic equipment can increase by 58.86% and 70.13% respectively. The new products output value and new products sales income are insufficient, they can have an increase of 47.81% and 74.62% respectively. So as the manufacture of medicines industry. The number of patent applications and the number of new product development projects in energy and chemical industry can increase by 28.87% and 49.37% respectively. The new products output value and new products sales income are insufficient, they can have an increase of 472.07% and 428.35% respectively. Therefore, the energy and chemical industry should increase the efficiency of economic transformation, in order to make more new product output and new product sales revenue.

Table 8 The input-output adjustment table of non-DEA effective pillar industries

Pillar industries	input indicators			output indicators	
	Patents application	New product development projects	New product development expenses	New product output value	New product sales income
Computer and other electronic equipment	-58.86%	-70.13%		47.81%	74.62%
Energy and chemical industry	-28.87%		-49.37%	472.07%	428.35%
Manufacture of medicines industry	-4.16%	-39.66%		103.72%	110.20%

4. CONCLUSION

Based on two-stage sci-tech input-output model, this paper studies the data of seven pillar industries in Shaanxi province from 2005 to 2014 in method of series network DEA. The result shows that there are differences between stages and industries, reveals that it is unreasonable to the scale and structure of sci-tech input-output. The pillar industries are divided into four categories judging by the features of two-stage efficiencies: high technology R&D efficiency and high economic efficiency, such as food industry; high technology R&D efficiency and low economic efficiency, such as computer and other electronic equipment, manufacture of medicines industry and textile wearing apparel industry; low technology R&D efficiency and high economic efficiency, such as non-ferrous metallurgy industry; low technology R&D efficiency and low economic efficiency, such as equipment manufacturing industry and energy and chemical industry. As the core pillar industries in Shaanxi Province, equipment manufacturing industry and energy and chemical industry, are lower than the industry average in the efficiency of the two-stage average. According to the results of single cycle of science and technology input and output in 2013 and 2014, computer and other electronic equipment, energy and chemical industry and manufacture of medicines industry have a certain degree of investment redundancy and insufficient output.

As the scale and structure of science and technology input and output of the seven pillar industries are not reasonable, we should not pay attention to the quantity of science and technology investment blindly, so we can pay attention to the structure of science and technology investment and the optimal allocation of scientific and technological resources. Focus on the "target phase" efficiency improvement and the input redundancy and lack of output orientation to improve the efficiency of the entire technology input and output.

In short, this article evaluates and analyzes the efficiency of science and technology input and output of the seven pillar industries, which has an important theoretical and practical significance. We consider that the accuracy of the DEA method is susceptible to the selected indicators, so the follow-up study can be selected according to the more appropriate indicators model, other research methods can also be used.

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