

Health Evaluation of R&D and Transformation Functional Platform

Ocena sprawności platformy R&D i transformacji funkcjonalnej

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Abstract

In order to improve the operational performance of R&D and transformation functional platform, the health situation of R&D and transformation functional platform must be evaluated. First, the evaluation index system of R&D and transformation functional platform health was established based on influencing factors of platform health. Then, four regional R&D and transformation functional platforms, including Shanghai Lingang Intelligent Manufacturing Research Institute (SHIMRI), Ningbo Intelligent Manufacturing Research Institute (NBIMRI), Harbin University of Technology Intelligent Research Institute (HEBIMRI) and Suzhou Intelligent Manufacturing Research Institute (SZIMRI) are selected for empirical analysis with the help of factor analysis method and two factor theory based evaluation model. Finally, according to the empirical results, policy recommendations for optimize platform's operation and improve platform's health are proposed.

Key words: R&D and transformation functional platform, health evaluation, two-factor model

Streszczenie

W celu poprawy wydajności operacyjnej platformy R&D (Research and Development, Badania i Rozwój) i transformacji funkcjonalnej należy dokonać jej oceny sprawności. Najpierw ustalono system oceny indeksu funkcjonalności platformy, który oparto na czynniki wpływające na jej funkcjonowanie. Następnie cztery regionalne platformy funkcjonalne R&D i transformacji, w tym Shanghai Lingang Intelligent Manufacturing Research Institute (SHIMRI), Ningbo Intelligent Manufacturing Research Institute (NBIMRI), Inteligentny Instytut Badawczy Uniwersytetu Harbina (HEBIMRI) i Suzhou Intelligent Manufacturing Research Institute (SZIMRI) zostały wybrane do analizy empirycznej, w której wykorzystano metodę analizy czynnikowej i modelu oceny opartego na teorii dwuskładnikowej. Wreszcie, zgodnie z wynikami empirycznymi, zaproponowano zalecenia dotyczące polityki optymalizacji działania platformy i poprawy jej funkcjonalności.

Słowa kluczowe: platforma R&D i transformacji funkcjonalnej, ocena sprawności, teoria dwuskładnikowa

1. Introduction

R&D and transformation functional platform is a powerful complement to the high-tech industrial cluster. It effectively integrates the resources of each link and each entity in high-tech industry value chain, and promotes the cooperation of high-tech industry more conveniently, effectively and safely, finally to achieve high-tech industrial chain innovation and meet the common needs of industrial chain clusters. Therefore, setting up an effective high-tech industry functional platform operation mode is a deep-seated problem that needs to be solved urgently in the current harmonious construction of business ecosystem and the improvement of overall competitiveness in high-tech industry. It is also an important guide for the government to guide the cultivation of high-tech industries. At present, some countries and regions that regard high-tech industries as strategic pillar industries, including European Union, United States, Japan and South Korea, attach great importance to the construction and operation optimization of R&D and transformation functional platform. The major developed countries in Europe and the United States have made considerable research on R&D and transformation functional platform, including platforms' performance, the emergence of new formats and new models and so on. China's current research on high-tech industries is in its infancy, and the existing research on high-tech industries are very limited. Research on how to construct and optimize functional platform for high-tech industry R&D and transformation is even less. In the current stage of practice, functional platforms such as the intelligent network joint vehicle pilot demonstration zone and the biomedical innovation organization already been established in some area of China, but most platforms are only a kind of *semi-finished products*, and the *fragmentation phenomenon* is prominent. There are many problems in the development of platform, such as the effectiveness needs to be improved, the operation and management mechanism needs to be optimized, and the performance appraisal and evaluation mechanism is not perfect, etc. In addition, the imperfect financial investment mode and support methods are also bottlenecks encountered in the construction and development of platforms. Based on this, the research proposes an effective method to evaluate R&D and transformation functional platform health, which can not only improve the operational efficiency of platform, promote the competitiveness and sustainable development of the industry, but also contribute to *China's Made in China 2025* strategy and improve the competitiveness of *Made in China* in the international market. The importance of R&D and transformation of functional platform is becoming increasingly prominent, but most current research focuses on the construction of platforms and the formulation of government-re-

lated policies (Chesbrough, 2003; Xia, 2006; Antonova, 2011; Yu, 2017; Rohrbeck, 2010; West & Gallacher, 2006). Existing research has paid little attention to how to measure platform's health status and how to design and optimize platform's operation system according to health evaluation results and the characteristics of high-tech industries. The only relevant studies are as follows. Mueller (2006) proposed from the perspective of resource-based view that the key to R&D and transformation of functional platforms performance lies in the integration of resources within the platforms and the resources sharing among members. Sun & Wang (2010) used the system idea to construct the basic framework of R&D and transformation functional platform, analyzed its health improvement path, and proposed that the establishment of an efficient organizational guarantee mechanism, collaborative integration mechanism, and innovation incentive mechanism are the key to improvement platform performance. Chen (2012) proposed that the health status of R&D and transformation functional platform is affected by their resource conditions, openness, trust level, normative nature of contract governance, and the perfection degree of policy environment.

The evaluation of R&D and transformation functional platform health and the optimization of platform operation based on the evaluation results are the foundation and guarantee for platform sustainable development. It has great help to enhance platform ecosystem efficiency and upgrade its core competitiveness. However, the ecosystem of high-tech industry is complicated, and R&D and transformation functional platform health is not only related to the innovation subject, public service system, public technology support system, innovation environment layer and other organizations, but also subject to many constraints and constraints, such as the cooperation and sharing of all parties in its operation process. Based on the existing literature, field research and expert interviews, first, the influencing factors of R&D and transformation functional platform health been analyzed, and a high-tech industry R&D and transformation functional platform health evaluation index system been established; Then a two-stage factor analysis-two-factor model is constructed and an empirical study on platform health was carried out. Finally, based on empirical results, the corresponding optimization strategies for platform operation are proposed. This research is arranged as follows. In second section, analyzing influencing factors of R&D and transformation functional platforms health and establish the evaluation index system. In third section, evaluation method selection and evaluation model construction. In fourth section, data acquisition and processing. In fifth section, R&D and transformation functional platform health evaluation results analysis and platform operation optimization strategy proposed.

2. Evaluation index system construction

2.1. Analysis of factors affecting platform health

R&D and transformation functional platform is an important carrier for high-tech industry innovation, and also an important strategic resource for high-tech industry development. Its health is often affected by many factors. In the past, the typical classification of the factors affecting R&D and transformation functional platform health was from the perspective of platform structure and R&D level, and the platform health was divided into platform structure perfection level and R&D and transformation level. From the perspective of platform construction process and development trend, it is considered that *perfection level of platform structure* is the key factor affecting platform health. In practice, China began to explore the construction conception and development elements of R&D platform as early as the 1990s, and clearly stated in National Medium- and Long-Term Science and Technology Development Plan (2006-2020) that platform should integrate all kinds of innovative resources in the high-tech industry chain with enterprises as the main body and industry-university combination as the basis. Western scholars also pointed out that besides the perfection of platform structure, the national policy system is an implicit factor affecting platform health. Considering the characteristics of R&D and transformation functional platform and the multi-faceted nature of the environment, this study divides the influencing factors of R&D and transformation functional platform health into two categories: internal health influencing factors and external health influencing factors.

Internal factors affecting the health of R&D and transformation functional platform. First, the status of platform construction. For example, platform openness, it not only restricts the participation of members, but also restricts the members' use of innovative resources and services within platform, which will inevitably affect platform attractiveness ultimately. Another example is the quality of core scientific researchers, which directly determines the value of their cooperative R&D partner development system, scientific and technological achievements transfer system and knowledge sharing system. Second, the platform resource structure, including the reputation of platform members and their heterogeneity, the number of R&D and technical service organizations. The higher reputation and the more characteristic resources the main body in industrial chain have, the more beneficial it is to improve the efficiency of resource sharing platform and promote platform innovation. Similarly, the more R&D and technical service organizations (include organizations of scientific and technological achievements transformation, technology transactions, professional technical consultation, productivity promotion, and various engineering technology research

centers, key laboratories, etc.), the more resources the platform has, the more conducive to platform's health improvement. Third, the governance mechanism of platform. Including revenue distribution mechanism, cost sharing mechanism, and the internal coordination mechanism. During the operation, platform needs to select appropriate contract governance mechanisms to guide all members' behavior and reduce cooperation risk. For example, duo to R&D and transformation functional platform have a short development time, the resource sharing and service capabilities of some platforms are in a weak position. But the level of platforms technological innovation can be effectively improved through multi-agent collaboration, so the game among members will affect platforms survival quality and operational efficiency. However, the revenue distribution mechanism and cost sharing mechanism can directly determine the game behavior among members. Fourth, the R&D and transformation capabilities of platform. The number of patents, the number of patents transformed, the number of patents transformed to meet the market demand, and whether a certain number of basic common technologies and achievements can be used in many ways will not only affect the degree of platform resources waste, but also affect the completion of platform's initial strategic objectives. Fifth, the promotion of platform to the overall industry competitiveness. For example, the market share of leading products and the output value of new products, they are both the direct reflection of customers' acceptance of products and the indirect reflection of platform innovation and transformation results. Higher product market penetration is a strong proof of platform system innovation ability and potential.

External factors affecting the health of R&D and transformation functional platform. First, the policy system for platform development. R&D and transformation functional platform is an organizational system highly regulated by government and an important starting point for government to develop high-tech industries. The government's support policies and early strategic planning have an important impact on the development and operation of the platform. Second, government's R&D support. The investment on R&D is not only combined with the project, but also have a character of forward-looking and strategic, that is, focusing not only on the existing market prospects, but also on supporting R&D of future industries, common technologies and core technologies. The amount and the way of capital investment determine the platform development model at this stage, and also determine the strategy for its future development. Third, relevant laws and regulations. For example, the perfection of the taxation system, platform promotes R&D cooperation and technology transactions among members through its partner development system, knowledge sharing system and technology achievement transfer system,

as the result, all various taxes and fees will inevitably affect the platform's operation. In particular, China is a country with a turnover tax as the main source of taxation. Every statutory transaction between different entities must pay depreciation tax or business tax according to law, especially the business tax paid for R&D service outsourcing and technology transactions. Enterprise usually cannot make deductions, nor can it be included in the annual depreciation of enterprise intangible assets, but must be included in the cost of the current year. These taxes and fees generated in the transaction link, especially the non-deductible tax represented by the business tax will hinder the deepening of labor division between enterprises, which is not conducive to the platform's operational performance improvement. Fourth, the innovation environment of platform. The inaccessible inflow of social financial capital and the active participation of talents who understand the market, good at research and coordination, will increase platforms develop enthusiasm. Furthermore, platform will not rely too much on government's input, and the use efficiency of funds already invested by government will be greatly enhanced.

2.2. Establishment of evaluation index system

According to the analysis of influencing factors, a comprehensive evaluation index system for R&D and transformation functional platform health is constructed. Considering the importance of platform's internal and external coordination mechanism, this research will take it as the underlying index. After evaluating it separately, the evaluation results will be integrated into comprehensive index system.

(1) Construction of comprehensive evaluation index system

According to classification of the main influencing factors of R&D and transformation functional platform health, the first-level indicators in R&D and transformation functional platform health evaluation index system can be divided into two categories: internal health index and external health index. It is further subdivided into 5 second-level indicators and 19 third-level indicators, as shown in Table 1. Among them, the internal coordination mechanism and external coordination mechanism are determined according to the evaluation results of lower evaluation index.

(2) Construction of lower level index system

Considering that internal and external coordination is the key link of platform's healthy operation, whether the coordination mechanism is perfect is directly related to platform's sustainable development. Therefore, the platform coordination indicators are further refined, which contains 9 specific evaluation indicators, as shown in table 2. In the specific evaluation process, incorporated platform collaborative

evaluation results into the upper evaluation index system as platform internal collaborative common factor and platform external collaborative common factor.

3. Evaluation method selection and model construction

3.1. Evaluation method selection

According to the influencing factors analysis, the evaluation index of R&D and transformation functional platform health can be divided into two categories: internal health index and external health index. In this paper, the two-factor evaluation model is used to evaluate R&D and transformation functional platform health. In addition, in view of the fact that internal and external coordination has a particularly prominent impact on platform health, this paper uses the factor analysis method to summarize internal and external synergistic factors and put them into the two-factor evaluation model to evaluate platform health.

Different from the general comprehensive evaluation method, the two-factor method gradually clusters the factors in the platform health evaluation and finally forms two sets of evaluation factors, which highly summarizes all the factors involved in the evaluation. It is beneficial to grasp the health factors of each evaluation set as a whole, and can effectively guide the R&D and transformation of functional platform health operation practices. The two-factor method considers all factors comprehensively final and has strong comprehensiveness, especially, has a strong representative parameter. It can effectively solve the defect of results produced by methods such as *comprehensive index evaluation method*.

In this paper, factor analysis is used to deal with the relationship between lower indicators (i.e., platform synergy factors) and upper indicators (other impact indicators of R&D and transformation functional platform). The basic idea of factor analysis is to classify the observed variables. From the related dependencies within the research variables, several related variables are classified into the same class. Each type of variable becomes a factor with less several factors reflect most information in the original data. Through factor analysis, the information of lower level indicators is brought into e analysis framework of upper level indicators, so that the health of R&D and transformation functional platform is comprehensively evaluated by two factors.

3.2 Comprehensive evaluation model construction

The evaluation results of internal and external collaborative obtained by factor analysis are put into upper index system, which can evaluate R&D and transformation functional platform health comprehensively.

Table 1. R&D and transformation functional platform health evaluation index system

First-level indicators	Second-level indicators	Third-level indicators and description		
Internal health	Basic conditions	Reputation of platform members and their heterogeneity	Reputation of platform members and uniqueness of their resources	
		Platform openness	Platform restrictions on the use of resources by its members and restrictions on the provision of services to members	
		Quality of core scientific researchers	The capabilities, innovative resources, cooperative experience and reputation of scientific researchers in the field of technology R&D	
		Number of R&D and technical service institutions	Number of R&D and technical service institutions, the more institutions platform have, the more resources the platform has, and the better healthy development of platform.	
		Platform's ability to provide services	Various services provided by platform to main body	
	Governance mechanism	Income distribution mechanism	How platform revenue is distributed among members	
		Cost sharing mechanism	How platform costs are Share among Members	
		Platform internal coordination mechanism	Common factors of platform internal collaboration	
	Platform output	Number of authorized invention patents	The number of patents granted by platform for domestic and foreign invention in the previous year, including the number of software copyright registrations	
		Total industrial conversion value of technological achievements	Platform technology market transaction contract amount	
		Market share of leading products	The proportion of dominant products in domestic market in previous year	
		Output value of new products	The ratio of the output value of new products to the total output value of products in the industrial ecosystem in the previous year	
	External health	Government support policy	Policy system of platform development	The quantity and strength of government policies
			Total R&D investment	Total R&D funds invested by government
Strategic planning			National strategic planning which have a clear goals, timetables and technical routes, and already form a certain consensus	
Laws and regulations		Law and regulation system	Whether laws and regulations are perfect	
		Tax system	Whether the tax system is tilted to support platform development	
		Intellectual property protection system	Whether the intellectual property system sufficient to ensure the full flow of resources inside and outside the platform	
		External coordination mechanism of platform	Common factors of platform external collaboration	

Table 2. Evaluation index system of platform collaboration mechanism

Ordinal	Specific indicators	Indicator description
1	Trust level among platform members	Trust level between platform entities
2	Information Sharing among platform members	Whether there is deep information sharing among platform members
3	Service level among platform members	Whether platform members willing provide services to each other
4	Communication status among platform members	Whether platform members maintain a positive communication
5	Cooperative time of scientific researchers	Total time for scientific research staff cooperation
6	Cultivation and incentive mechanism of scientific research talents	Whether have a perfect training and incentive mechanism for scientific researchers?
7	Risk investment	Whether has a sound risk investment mechanism?
8	Financing system	Whether has a perfect financing mechanism?
9	Innovation and entrepreneurship culture	Whether have a strong innovation and entrepreneurial culture environment?

(1) Evaluation parameter composition

The platform internal and external health evaluation factors are as follows:

Platform internal health evaluation factors set: {Reputation of platform members and their heterogeneity; Platform openness; Quality of core scientific researchers; Number of R&D and technical service institutions; Platform's ability to provide services; The relationship between platform subjects; The status quo of platform subject collaboration; Income distribution mechanism; Cost sharing mechanism; Number of authorized invention patents; Total value of industrial transformation of technological achievements; Market share of leading products; Output value of new products}.

Platform external health evaluation factors set: {Policy system of platform system development; Total R&D investment; Financial environment of platform; strategic planning; Law and regulation system; Tax system; Innovation environment of platform; Intellectual property protection system}.

(2) Determination of parameter score matrix

If i represent different R&D and transformation functional platform, x_{ij} represent platform's internal health assessment factors, α_j represent the internal health index weight, then the internal health evaluation results are:

$$N_i = \sum \alpha_j^* x_{ij}, i = 1, 2, 3, 4$$

If y_{ij} represent platform's external health assessment factors, β_j represent the external health index weights, then the external health evaluation results are:

$$O_i = \sum \beta_j^* y_{ij}, i = 1, 2, 3, 4$$

4. Data acquisition and processing

4.1. Selection of empirical R&D and transformation functional platform

After the release of *Made in China 2025*, R&D and transformation functional platform has received unprecedented attention as an important pillar of high-tech field. At present, R&D and transformation functional platform in various regions cover many high-tech fields such as biomedicine, brain-like chips, material genomes, etc. Their operational goals are to form strong industrial influence and regional radiation through common technology R&D and transformation, and to help China's economic transformation and upgrading. In order to make the analysis comparable, this study mainly select four platforms in the field of intelligent manufacturing (Table 3) for empirical analysis, and analyzes the development status of R&D and transformation functional platforms in China.

4.2. Data sources and processing of upper indicators

The three-level indicator data in the upper indicators of evaluation index system mainly comes from *China's economic and social big data research platform*, *China national intellectual property office*, *Shanghai science and technology innovation center*, *Ningbo science and technology center*, *Suzhou science and technology center*, *Technology information center of Harbin University*, and the results of experts scoring with five special scales. In the evaluation system, the reverse indicators in the upper raw data are processed positively, and all the upper raw data are standardized by using the method of 0 mean and 1 variance. The processed upper index scores are shown in Table 4.

4.3. Lower level indicator data acquisition

By using KMO and Bartlett spherical test, the KMO value between the indicators of platform synergy mechanism is calculated to be 0.697, which is suitable for factor analysis. And the significance level of Bartlett's spherical test is less than 0.05, indicating that there is a significant difference between the indicators. It is suitable to analyze and deal with the platform synergy health index by using dimensionality reduction technology.

According to the criterion root of correlation coefficient matrix is greater than 1, the factor variable is extracted, and four factor variables with cumulative contribution rate of more than 80% are obtained. Using the method of maximum variance rotation, the formed factor interpretation matrix is rotated to determine the information in the evaluation index represented by the four factors. The rotation factor interpretation matrix is shown in Table 5.

According to the rotation factor interpretation matrix, it can be seen that the first factor is highly correlated with three evaluation indicators: resource sharing among platform members, service level among platform members, and communication status among platform members. Therefore, the first principal factor mainly reflects the influence of relationship among platform members. The second factor is mainly positively correlated with the trust level among innovation subjects and innovation entrepreneurship culture. It shows that the second factor mainly reflects the social innovation environment inside and outside the platform. The third factor is mainly related to the two evaluation indicators of venture capital and financing system, reflecting the financial environment of platform. The fourth factor is mainly related to the indicator of full-time equivalent of researcher's cooperation, indicating that this factor reflects the impact of platform's main body synergy mechanism. Further, the first and fourth factor belong to the third-level indicator of platform internal health status in the upper evaluation index system, and the second and third factors are the third-level indicators of platform external health status in

Table 3. Basic situation of empirical R&D and transformation functional platform

Ordinal	Platform	Establishment time	Location	Key areas of R&D and transformation
1	SHIMRI	12-18-2015	Shanghai	Intelligent sensing and internet of Things, intelligent and special robots, intelligent control and maintenance
2	NBIMRI	4-17-2018	Ningbo	Intelligent molding equipment, intelligent molds, intelligent molding technology, molding manufacturing big data
3	HEBIMRI	5-5-2018	Harbin	Machine perception and pattern recognition, natural language processing, robotics and intelligent systems in the field of artificial intelligence
4	SZIMRI	5-8-2018	Suzhou	Ultra-precise intelligent manufacturing and inspection, intelligent control and industrial software, additive manufacturing and manufacturing Internet of Things

Table 4. Upper indicators evaluation score for R&D and transformation functional platforms health

Ordinal	Indicators	SHIMRI	NBIMRI	HEBIMRI	SZIMRI
1	Reputation of platform members and their heterogeneity	0.91263	0.74728	0.76874	0.72675
2	Platform openness	0.33161	-0.23696	0.21701	-0.19301
3	Quality of core scientific researchers	0.87071	0.70711	0.84142	0.71722
4	Number of R&D and technical service institutions	0.77159	0.61929	0.628935	0.70153
5	Platform's ability to provide services	0.55618	-0.28618	0.73905	0.23427
6	Income distribution mechanism	-0.10251	-0.23594	-0.26881	-0.23677
7	Cost sharing mechanism	-0.00618	-0.43427	-0.23905	-0.23905
8	Number of authorized invention patents	0.46567	0.67784	1.54279	0.65674
9	Total industrial conversion value of technological achievements	1.61721	0.21721	0.23443	0.92582
10	Market share of leading products	1.55028	0.25028	0.58969	0.15598
11	Output value of new products	0.94254	0.60592	0.20592	0.10088
12	Policy system of platform development	1.31154	0.93603	0.85297	0.81154
13	Total R&D investment	1.07349	0.90349	-0.80326	0.87831
14	strategic planning	0.96684	0.86521	0.92041	-0.02705
15	Law and regulation system	-0.09975	0.89705	0.73688	0.75339
16	Tax system	0.10435	0.11257	-0.74721	-0.14335
17	Intellectual property protection system	0.15441	0.35465	-0.58496	0.15441

Table 5. Rotation factor interpretation matrix

Specific indicators	Factor variable			
	1	2	3	4
Trust level among platform members	0.605	0.530	0.093	-0.225
Information sharing among platform members	0.762	0.427	-0.106	0.528
Service level among platform members	0.542	-0.300	0.373	-0.193
Communication status among platform members	0.525	-0.326	0.328	0.077
Cooperative time of scientific researchers	-0.218	-0.522	-0.132	0.372
Cultivation and incentive mechanism of scientific research talents	-0.684	0.238	0.397	0.105
Risk investment	-0.435	0.244	0.716	0.389
Financing system	0.454	0.227	0.714	-0.366
Innovation and entrepreneurship culture	0.274	0.677	-0.112	0.466

the upper evaluation index system. The upper level indicator was eventually expanded to 21. After standardization, the above four synergistic factors of each platform scored as shown in Table 6.

4.4. Acquisition of evaluation index weight

In order to objectively and reasonably reflect the importance of each evaluation index to platform health, this paper uses a combination of questionnaire survey and entropy weight method to obtain evaluation index weight. Firstly, according to the principle of two-factor method, platform health status evaluation questionnaire was designed. The scale is divided into

five levels, and the weight of evaluation index is determined by expert scoring. Questionnaires survey was conducted among R&D and transformation functional platform personnel, relevant government department managers, and experts of scientific research institutions. A total of 135 questionnaires were distributed and a total of 112 valid questionnaires were collected, with a total recovery rate of 83%. The weights of evaluation parameters (w_j) are determined according to Delphi method and analytic hierarchy process. Secondly, considering that entropy weight method is a method to determine the objective weight according to index variability magnitude, this paper further uses it to calculate the

Table 6. Platform synergy factor indicator score

Indicators	SHIMRI	NBIMRI	HEBIMRI	SZIMRI
Relations among platform members	0.90110	-0.01937	0.38546	0.30301
Current situation of platform members collaboration	0.72631	0.08338	0.59424	0.72134
Innovation Environment of platform	1.44788	0.53978	-0.3208	1.22724
Financial environment of platform	0.23173	0.28197	-0.16959	1.06457

Table 7. Weight of R&D and transformation functional platform health evaluation index

Ordinal	Indicators	Primary weight (w_1)	Secondary weight (w_2)	Comprehensive weight (w_3)
1	Reputation of platform members and their heterogeneity	0.0712	0.0091	0.0654
2	Platform openness	0.0407	0.1715	0.0178
3	Quality of core scientific researchers	0.0686	0.2623	0.0831
4	Number of R&D and technical service institutions	0.0661	0.0032	0.0527
5	Platform's ability to provide services	0.0367	0.0065	0.0087
6	Income distribution mechanism	0.0611	0.0082	0.0404
7	Cost sharing mechanism	0.0614	0.0086	0.0443
8	Relations among platform members	0.0314	0.0749	0.2062
9	Current situation of platform members collaboration	0.0309	0.0829	0.0803
10	Number of authorized invention patents	0.0563	0.1576	0.0580
11	Total industrial conversion value of technological achievements	0.0657	0.0154	0.1407
12	Market share of leading products	0.0596	0.0256	0.0369
13	Output value of new products	0.0876	0.0857	0.0357
14	Policy system of platform development	0.0677	0.0315	0.0232
15	Total R&D investment	0.0396	0.1279	0.1036
16	Strategic planning	0.0716	0.1453	0.0289
17	Law and regulation system	0.0714	0.0932	0.0212
18	Tax system	0.0596	0.0865	0.0380
19	Intellectual property protection system	0.0536	0.0837	0.0911
20	Innovation environment of platform	0.0456	0.0704	0.0848
21	Financial environment of platform	0.0736	0.0579	0.0710

Table 8. R&D and transformation functional platform health evaluation results

Platform	Internal health status		External health status	
	order	score	order	score
SHIMRI	1	0.2298	1	0.1901
SZIMRI	2	0.1501	2	0.1142
HEBIMRI	3	0.1183	4	-0.4092
NBIMRI	4	-0.4982	3	0.1049

weight of each index (w_2). Finally, a weighted normalization process is performed on w_1 with w_2 as a weight and obtain a comprehensive weighting result (w_3), as shown in Table 7.

5. R&D and transformation functional platform health evaluation results analysis

Through the specific evaluation of R&D and transformation functional platforms health, it can be seen that each R&D and transformation functional platform presents different health characteristics.

5.1. Analysis of overall health evaluation results R&D and transformation functional platforms

(1) Internal health status

As shown in Table 8, the internal health evaluation results of the four R&D and transformation functional platforms are as follows: SHIMRI has the

highest level of internal health, followed by SZIMRI, HEBIMRI and NBIMRI. Due to different dimensions, the evaluation indicators are standardized in order to make the indexes comparable. Therefore, the average health score of each indicator is 0 points. A score higher than 0 indicates that platforms health is higher than the average level. The higher the score, the healthier of platforms. According to the score, the internal health level of SHIMRI, SZIMRI and HEBIMRI is better, while there are many internal health problems in NBIMRI.

(2) External health status

As shown in Table 8, the highest external health scores were scored by SHIMRI, followed by SZIMRI and NBIMRI. These three platforms external health scores are positive, indicating that their external health is good. While the external health score of HEBIMRI is negative, indicating that there are many external health problems in the platform.

(3) Comprehensive health status of R&D and transformation functional platforms

The four platforms can be roughly divided into two categories according to their internal and external health conditions. HEBIMRI and NBIMRI belong to the same category. The internal health status of HEBIMRI is higher than the average, but its external health status is at a low level. On the contrary, NBIMRI has a higher external health than the average level, while the internal health is at a lower level. SHIMRI and SZIMRI belong to the other category. The internal and external health conditions of these two platforms are at a good level, but in-depth analysis found that the internal and external health is still different. The external health status of SHIMRI is better than its internal health; SZIMRI, on the other hand, has a relatively high internal health level. In general, from the health scores, although the four platforms have higher-than-average internal or external health level, the overall scores of internal or external health are low, indicating that the health maintenance work of the four platforms needs to be strengthened from both internal and external aspects.

5.2. Analysis of main influencing factors of R&D and transformation functional platforms health

(1) HEBIMRI

HEBIMRI was established on May 5, 2018, but Harbin University of Technology began the research of artificial intelligence as early as the 1950s, which almost at the same time as the research of artificial intelligence started in the world. Due to the long-term internal integration, HEBIMRI internal health is higher than the average level, but the external health is low. Further analysis found that the sub-health of HEBIMRI mainly comes from the total investment of R&D funds, tax system, intellectual property protection system, etc. The influencing factors scores are shown in Table 9.

Table 9. Main influencing factors of HEBIMRI external health

Platform	Main influencing factors of external health	Score
HEBIMRI	Total R&D investment	-0.0832
	Tax system	-0.0284
	Intellectual property protection system	-0.0533

Since its establishment, HEBIMRI has actively integrated the academic resources and superior scientific research forces at home and abroad, but it still faces many problems. First, the government has limited capital investment and no systematic planning. As a platform based on colleges and universities, its funding source is very single, mainly come from the application and commitment of national projects, and the limited national projects funds cannot be used for infrastructure construction, which resulting in poor capital efficiency and make HEBIMRI has no enthu-

siasm to do more expansion work. Second, the transaction cost caused by platform specialization is too high. The increasingly widening and deepening of specialized labor division has led to the increase of transaction subjects, the expansion of transaction objects and the complexity of transaction types. In the face of increasing and very strange counterparties, it not only causes changes in cooperative relations, but also changes in contractual arrangements. The evolution of labor division will also lead to a substantial increase in taxes and fees, and the original tax system is not suitable, which requires redesigning the system or innovating the original rules. Third, the intellectual property protection system has weak protection capabilities. Once the technology developed by platform is transformed into service or product, it is easy to be modified and imitated, or even transcendental imitation. All these will lead to a significant reduction in profits, but the cost is not shared.

(2) NBIMRI

NBIMRI plans to builds a platform for innovation and entrepreneurship of intelligent manufacturing technology. In the next five years, it will adopt *one hospital, two centers, three directions, four bases and N demonstration factories* as the strategic goal and become the new engine for the development of Ningbo *Smart industry*. Since establishment, NBIMRI has received strong support from government departments, including funding and optimization of other systems in the external ecosystem, therefore, its external health is above average. However, its internal health is low at this stage. Further analysis shows that internal health is mainly affected by factors such as platform openness, platform service capability, revenue distribution mechanism and cost sharing mechanism. The influencing factors scores are shown in Table 10.

Table 10. Main influencing factors of NBIMRI internal health

Platform	Main influencing factors of internal health	Score
NBIMRI	Platform openness	-0.0042
	Platform's ability to provide services	-0.0025
	Income distribution mechanism	-0.0095
	Cost sharing mechanism	-0.0192

According to the report provided by Pulse Data Research Institute, R&D and transformation of functional platforms is a new thing in itself. Among the dozens of R&D and transformation functional platforms in China, more than 70% platforms have open shortages. NBIMRI is a platform for applied technology research and development, innovation and entrepreneurship and conditional service. It has a short set-up time, and there is a serious shortage of talents who understand the market, manage, and coordinate. At the same time, its own characteristics

tics and function orientation have not been fully integrated. There are not many channels and methods for platform development and management of innovative talents, and the ability of open public service is relatively weak. The second major internal operation problem of NBIMRI is the income distribution mechanism and the cost sharing mechanism. NBIMRI has many internal entities, including R&D center, technology transfer center, management transfer center, consultation center and other subordinate organizations. There are no clear rules and regulations on what kind of mechanism to invest R&D funds, allocate operating costs and distribute income, which leads to insufficient internal cohesion at this stage, and health needs to be focused on.

(3) Other platforms

Although SHIMRI and SZIMRI have a better overall health situation, the unhealth status of specific individual indicators cannot be ignored.

SHIMRI has been established for three years. With the help of Shanghai Science and Technology Innovation Center, the operation effect has been recognized by the industry. However, the following problems still exist in the current stage. First, the innovation mechanism is not perfect enough. SHIMRI has insufficient innovation resources, which results in the weak innovation ability of the existing innovators. At the same time, due to the fact that the development of Shanghai's science and technology finance is not active enough, the exit mechanism of Shanghai's technology finance is not perfect, and the openness of innovation cooperation needs to be improved, all these have limited the overall innovation level of SHIMRI. Second, there are also problems of income distribution and cost sharing. In addition to the large number of subjects, the revenue and cost mechanism is not perfect. At the same time, because in the initial stage and the technical team must running as a whole, the platform needs to integrate the research and development of the whole industry chain to promote the transformation of scientific and technological achievements. Therefore, how to create a more favorable environment for the cultivation of technology brokers, make them driven by interests rather than system or government, realize the cross-regional flow of technology brokers and reduce the cost of matching, is also an urgent matter.

Although SZIMRI is above average in terms of openness, income distribution and cost sharing, its health is not outstanding enough. Another factor that is critical to its health impact is the poor strategic planning, which is lower than the average level. Firstly, the government and the platform itself have no prominent positioning focus, which directly leads to the lack of advantages in market share of products developed and converted. At the same time, due to the lack of clear positioning, the social capital investment cannot be attractive enough, and the existing government investment has certain blindness in this

respect, which has brought certain obstacles to the rapid development of SZIMRI.

6. Suggestions and Recommendations

In order to improve R&D and transformation functional platform health, the following suggestions are put forward.

(1) Increase platform openness and build open network

Platform openness directly affects platform's attractiveness. The higher the degree of openness, the higher the level of resource sharing within the platform. For R&D and transformation functional platforms, realizing resource sharing and accelerating the flow and diffusion of innovation resources are the best ways to rapidly promote the generation and development of innovation and achieve rational allocation of resources. Under the current state of innovation, building an innovation network can greatly accelerate the flow and diffusion of innovation, and at the same time enable participants in the network to use network resources, which can save costs and maximize resource use. Innovative networks can accelerate the flow of resources, but in the face of the dynamic evolutionary game of resource sharing within the platform, a reasonable governance mechanism should be designed in the process of innovation network. Such as the punishment mechanism, set strict protection rules for platform resource sharing, prevent accidental disclosure of related resources in resource sharing system, and strengthen the punishment for members' possible malicious infringement shared resource behavior, which can effectively reduce the risk cost of members participating in sharing and enhance members' sharing willingness. Another example, bundling the income distribution with the shared resources provided by the members can also increase the enthusiasm of members to disclose knowledge and share resources.

(2) Adhere to market-oriented operation and build a sound operation mechanism

Clarify the mission and objectives of functional platform, learn from the experience of world-class R&D institutions, establish a market-oriented and professional operation mechanism, innovate and breakthrough in organizational structure and institutional mechanism, introduce an enterprise management model, coordinate and mobilize the strengths of all parties in society to ensure good operational efficiency. The transformation of scientific and technological achievements and the cultivation of upstream and downstream enterprises of the platform should be incorporated into the assessment system, and the distribution of income and the sharing of costs should be based on the results of research and development and transformation. Guiding and encouraging the two-way flow of talents among universities,

scientific research institutes and functional platforms, establishing an evaluation orientation based on the main criteria of ability, performance and contribution, adopting annual salary system, agreement salary system and project salary, and designing a reasonable income distribution mechanism for innovative teams and individuals, all these can improve platforms ability of gathering and attracting high-level innovative talents. For example, US Big Data R&D platform cooperates with universities to promote the innovation of the performance evaluation mechanism for researchers engaged in the transformation. The platform will directly allocate part of cooperation project funds to the University as the research funds. In the distribution of income that promotes the transformation of scientific and technological achievements, universities and platforms are divided into 8:2. Then, the university will allocate 80% of its revenue to innovative teams and individuals, which greatly improves platform overall innovation efficiency.

(3) Pay equal attention to science and technology and system, and the government should guide them reasonably.

Since the platform aims to integrate R&D and innovation resources of the whole industry chain and serve the innovation main body, the original policies and systems are mostly divided by departments, and there are many incompatibilities. Therefore, in order to promote the construction and development of R&D and transformation functional platforms, technological innovation and institutional innovation must be driven by two-wheel drive. Learning from the experience of world-class R&D institutions, and comprehensively applying breakthrough policy measures in terms of talents, results transformation, fiscal and taxation. Strengthen policy guidance and comprehensive support for functional platform construction, optimize operational mechanisms, attract top talents, and enhance core capabilities. Platform development needs to gather internal and external forces, therefore government support is very important. At different stages of platform construction, the government should assume different roles, such as planners, organizers, investors, leaders and liaisons. Government should formulate targeted policies, provide strong scientific research input, encourage society active participation, and guide the platform to develop steadily.

(4) Optimize financial support methods and build a diversified fund-raising mechanism

Government should sign a support agreement with platform in the form of contract, clarified the main objectives, and built a research funding mechanism and management model based on operational performance. Establish a periodic performance appraisal system, give full autonomy to the platform to construct and operate. The performance appraisal is di-

rectly linked with financial allocation, so as to determine the follow-up support and the independent use of funds. At the same time, we should build a diversified fund-raising mechanism to guide platforms to cooperate with resources of all parties, attract social funds to invest together, and realize benign interaction and sustainable development. We should give full play to the guiding role of financial investment funds, encourage and support platforms to set up investment funds through multiple financing means and channels, carry out market-oriented and specialized operations, and provide entrepreneurship incubation and technology investment and financing services in accordance with industrial characteristics.

(5) Pay attention to platform's internal and external coordination, strengthen the transparency of platform operation

The trust among members will have a positive impact on platform health. Platform should try to ensure the operating procedures are open and transparent, which is not only conducive to promoting the overall trust level, but also can further expand platform's service object. Therefore, in order to promote trust and understanding among members, the accuracy and completeness of the information submitted by platform and its members should be reviewed regularly, the normal communication and exchange mechanism among members and platforms should be established, and the high-level meeting mechanism of members should be established. At the same time, according to the different forms of cooperation among members, different interest distribution and cost risk sharing schemes should be developed to ensure members fulfill their commitments. In order to prevent resources waste and the real resources can be implemented in practice, it is necessary to strengthen platform prior and in-process control. The previous assessment is more focused on post-event control, resulting in problems that have not been dealt with in a timely manner and causing hysteresis. Therefore, it is necessary to combine the pre-contractual constraints with the post-evaluation in development process.

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