Exploration of Combining Innovation Effect of Industry, University and Research Institute Based on Utility Theory

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Abstract. To explore the industry, university and research institute collaborative innovation mechanism from the perspective of utility theory, the main utility demand was evaluated through factor analysis method and analytic hierarchy process (AHP). In addition, the subjective and objective utility demands of each subject were analysed. Moreover, through system dynamics method, the relationship between innovation subject effectiveness and collaborative innovation mechanism effectiveness was verified. First of all, on the basis of collaborative innovation subject effectiveness and collaborative innovation interest, the preliminary screening of index was conducted by questionnaire survey. Secondly, the hierarchy model was established and the AHP was used to determine the subjective and objective utility demand of subjects and analyse the differences between objective and subjective utility demands. Finally, the method of system dynamics was introduced and the system dynamics model including the industry, university and research institute subject effectiveness sub-system, output subsystem, long-term effective subsystem and industry, university and research institute collaborative innovation mechanism subsystem were constructed based on the utility theory. The results demonstrated the relationship between the industry, university and research institute collaborative innovation subject effectiveness and collaborative innovation mechanism effectiveness. To sum up, the mechanism has quite high effectiveness so that it can be applied to various production fields.

1. Introduction

As a part of the national collaborative innovation system, the industry, university and research institute collaborative innovation is an important part of improving the core competitiveness of the country, which has been highly valued by governments, experts and scholars [1]. The industry, university and research institute collaborative innovation includes three subjects of enterprises, universities and research institutes. They belong to different systems and there are differences in social function orientation and organizational purposes. Although with the development of society, some changes have taken place in the social function of enterprises, universities and research institutes, enterprises need to bear certain social responsibilities, and universities and research institutes need to undertake the responsibility for social development, the essence of enterprises is still a profit-making organization [2]. As a member of our educational system, universities and scientific research institutes still take talent training and scientific research as the main task. Based on utility theory, this paper

explores the relationship between the subject effectiveness and collaborative innovation mechanism effectiveness. It is expected that this research can enrich the related theories of industry, university and research institute collaborative innovation, and provide a new theoretical basis for improving the effectiveness of the effectiveness of industry, university and research institute collaborative innovation mechanism.

2. Application steps of analytic hierarchy process

There are four main steps in the application of analytic hierarchy process (AHP).

Establish a hierarchical structure model. Construct the hierarchical structure model and determine the membership relationship between the indexes. The hierarchy includes the target layer, criterion layer and solution layer: there is only one element in the target layer, which is generally the goal or the best state of problems to be analysed [3]; the criterion layer is the intermediate links to achieve the goal; the solution layer includes a variety of measures and decision solutions selectable to achieve the goal, also known as the index layer.

Construct a judgment matrix. Hierarchical structure can reflect the relationship among elements, but the degree of importance of each criterion in the criterion layer is not always the same in the goal measurement of the problem to be analysed.

Do hierarchical single ranking and consistency check. Judge the characteristic vector that matrix A corresponds to the largest eigenvalue. After normalization, it is the ranking weight of the corresponding factors for the same layer to a certain factor of the last layer, and the process is called hierarchical single ranking.

Carry out hierarchical overall ranking and consistency check. The weights in the hierarchical overall ranking and consistency ranking need to synthesize the weights from the top to the bottom under the single criterion, so we need to calculate the index of consistency check to evaluate the consistency of the hierarchical overall ranking.

$$CI = \sum_{i=1}^{m} a_i CI_i \tag{1}$$

$$RI = \sum_{i=1}^{m} a_i RI_i \tag{2}$$

$$CR = CI / RI \tag{3}$$

3. Evaluation and analysis of the utility requirements of the collaborative innovation subject of industry, university and research institute

3.1. Determination of the utility requirements of each subject by analytic hierarchy process

Construct judgment matrix: This article, through the questionnaire, assesses the utility requirements of the collaborative innovation subject of industry, university and research institute. The research objects include senior positions / personnel and related experts and scholars in enterprises, universities and research institutes. 5 invalid questionnaires were excluded, and 41 valid questionnaires were collected, including 10 questionnaires of experts, 11 questionnaires of enterprises, 10 questionnaires of colleges and universities, and 10 questionnaires of institutes [4]. Each questionnaire is processed by the judgment matrix, and the subjective and objective utility requirements of each subject are calculated according to the result aggregation.

Do hierarchical single ranking and its consistency check: The consistency of each matrix is calculated by Yaahp software, and the consistency coefficient of each layer matrix of subjects is counted as table 1. When CR is less than or equal to 1, it is considered that the judgment matrix

conform to the satisfied consistency criteria. According to the data in the table, the maximum value of CR is 0.0909, less than 0.1, consistent with the consistency standard [5], so the results of hierarchical single ranking can be accepted.

Table 1. Hierarchical single ranking and consistency check.

CR	A	A1	A2	A3
Enterprise subjective utility	0.0000—0.0904	0.0000—0.0715	0.0292—0.0673	0.0000—0.0772
Enterprise objective utility	0.0000—0.0825	0.0000—0.0904	0.0295—0.0662	0.0000—0.0707
Subjective utility of colleges and universities	0.0000—0.0516	0.0029—0.0933	0.0066—0.0758	0.0000—0.0176
Objective utility of colleges and universities	0.0000—0.0516	0.0000—0.0909	0.0167—0.0703	0.0000—0.0825
Institute subjective utility	0.0000—0.0516	0.0077—0.0834	0.0071—0.0732	0.0000—0.0036
Institute objective utility	0.0000—0.0176	0.0183—0.0909	0.0000—0.0626	0.0000—0.0707

Carry out hierarchical overall ranking and consistency check. In order to evaluate the consistency test of the overall ranking, it is necessary to calculate the index of the consistency test. The overall ranking consistency of each questionnaire is calculated according to the consistency test formula of the hierarchical overall ranking, and the results are shown in Table 2. According to the data in the table, the maximum value of CR is 0.0734, less than 0.1, which satisfies the condition of consistency check, so the overall ranking results have good consistency.

Table 2. Hierarchical total ranking and consistency check.

	CR
Enterprise subjective utility	0.0060—0.0591
Enterprise objective utility	0.0227—0.0624
Subjective utility of colleges and universities	0.0101—0.0503
Objective utility of colleges and universities	0.0133—0.0679
Institute subjective utility	0.0198—0.0734
Institute objective utility	0.0082—0.0672

3.2. Analysis of conclusion

From the weight distribution of the first level indicators of the enterprise subjective and objective utility demand, in the collaborative innovation running process of industry, university and research institute, the subjective utility demand of enterprises for the economic interests is up to 0.5364, much higher than the degree of attention to cultivate knowledge and talents [6]. From Figure 1, we can see that, in the utility demand for the economic interests of the enterprise, the difference of subjective and objective utility is great. However, in knowledge and talent training, the subjective and objective utility demand has smaller gap, but the emphasis on knowledge and talents in the actual operation of the enterprise industry, university and research institute is less than its due importance in this regard.

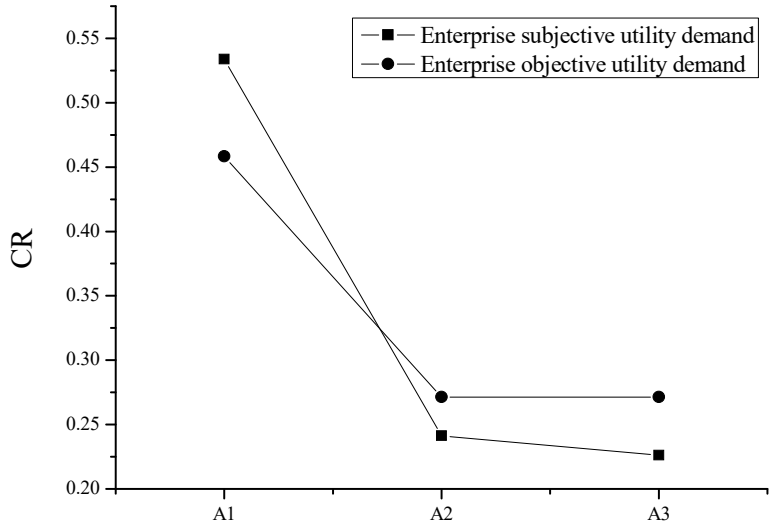

Figure 1. Enterprise subjective and objective utility demand.

It can be seen from Figure 2 that, the subjective utility demand of college for economic benefits is much higher than that of the objective utility demand, leading to relatively low emphasis on knowledge and talents cultivation. The results show that the colleges and universities, in the cooperative innovation, deviates from the aim of the organization in the decision or behavior to a certain extent. It places the economic interests rather than personnel training on the main position.

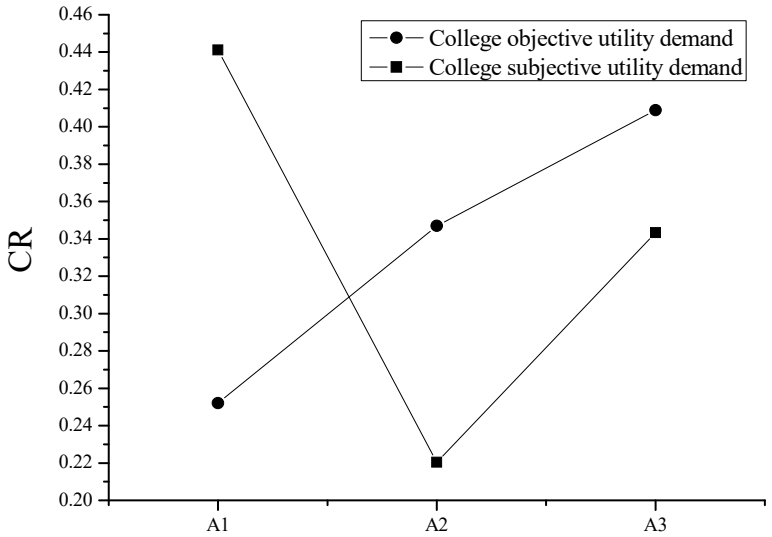

Figure 2. College subjective and objective utility demand.

From the data in the table and Figure 3, we can see that, in terms of economic interests, there is a great difference between the subjective and objective demands of scientific research institutes, and the subjective utility demand of scientific research institutes for personnel training and knowledge benefits is lower than the due importance based on organizational purposes.

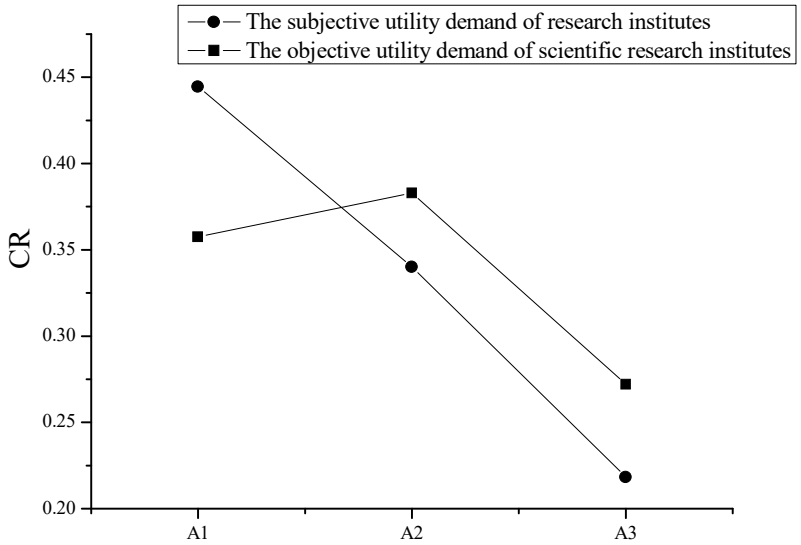

Figure 3. The subjective and objective utility demand of scientific research institutes.

4. Effectiveness of the collaborative innovation mechanism of industry, university and research institute under the perspective of utility theory

4.1. System dynamics model of the effectiveness of the collaborative innovation mechanism of industry, university and research institute based on the subject utility

According to the actual operation situation of the industry, university and research institute, the emergence of the output, the subject utility, the long-term effectiveness and the mechanism effectiveness in the collaborative innovation needs a process. Taking output as an example, knowledge output is most likely to occur in the early stage, and the realization of economic benefits is at a later stage. Therefore, smoothing function is used in the equation of state variables.

L1 collaborative innovation mechanism of industry, university and research institute effectiveness =INTEG (SMOOTH (LN) (collaborative innovation output + collaborative innovation mechanism long-lasting effectiveness + 5* enterprise utility subsystem +3* research institute utility subsystem + 3* university utility subsystem), 6), 0)

L2 collaborative innovation output = INTEG (SMOOTH (innovative talent output + knowledge output + economic output – collaborative innovation loss of industry, university and research institute, 6), 0)

L3 collaborative innovation mechanism long-term effectiveness = INTEG (SMOOTH (LN (3* principal matching), 6), 2)

L4 enterprise utility subsystem = INTEG (SMOOTH (enterprise actual perceived utility - difference of enterprise subjective and objective utility, 6), 0)

L5 utility subsystem in colleges and universities =INTEG (SMOOTH (perceived utility of colleges and universities = difference of subjective and objective utility in colleges and universities, 6), 0)

L6 utility subsystem of scientific research institutes =INTEG (SMOOTH (actual perceived utility of scientific research institutes - difference of subjective and objective utility of scientific research institutes, 6), 0)

4.2. Effectiveness evolution and simulation analysis of the collaborative innovation mechanism of the industry, university and research institute based on the subject utility

Model validation test system dynamics is the simulation of the reality. It mainly focuses on the rationality of the structure of the model, but does not pay much attention to the initial value. Therefore, the validity of the model is verified by theoretical tests. According to Wang Qifan's research, the

system structure determines the system behavior. As a result, the model structure test method can be used to verify the validity of the model, so as to verify the consistency between simulation results and related behavior rules. The validity test results of the system dynamics model are shown in Figures 4, 5, 6 and 7.

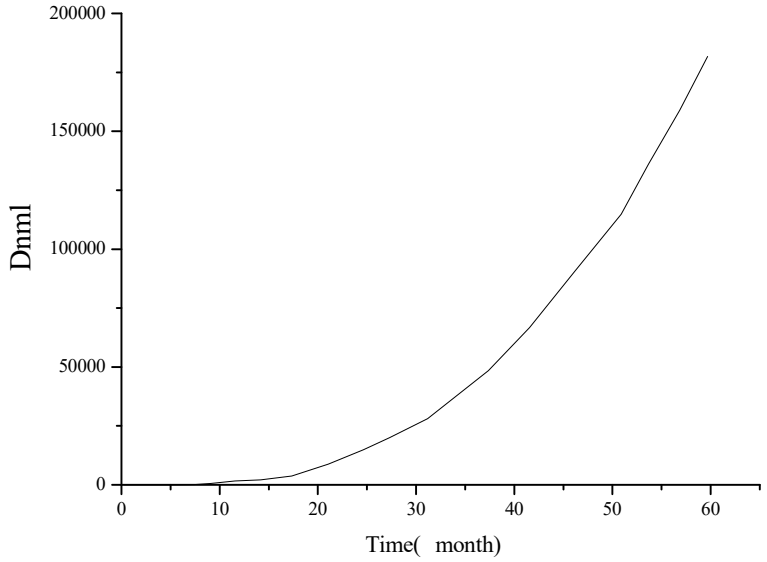

Figure 4. Enterprise utility subsystem.

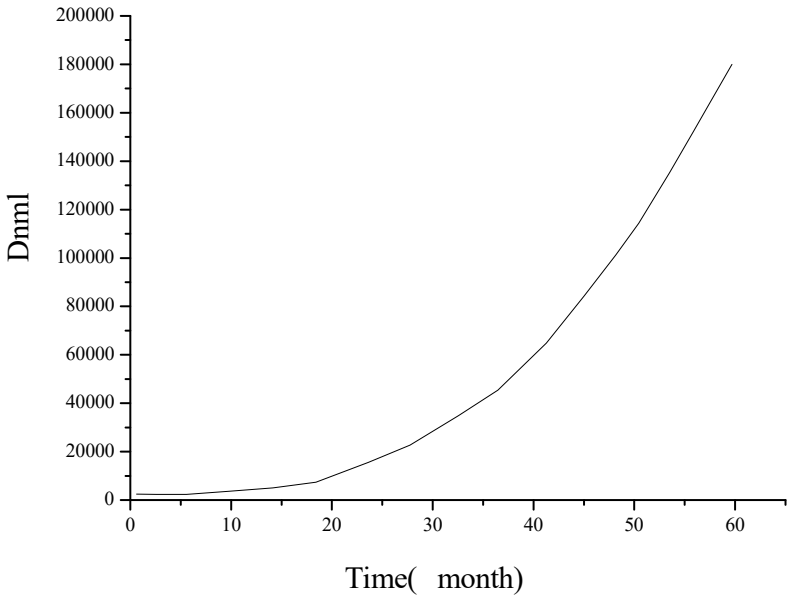

Figure 5. Utility subsystem in colleges and universities.

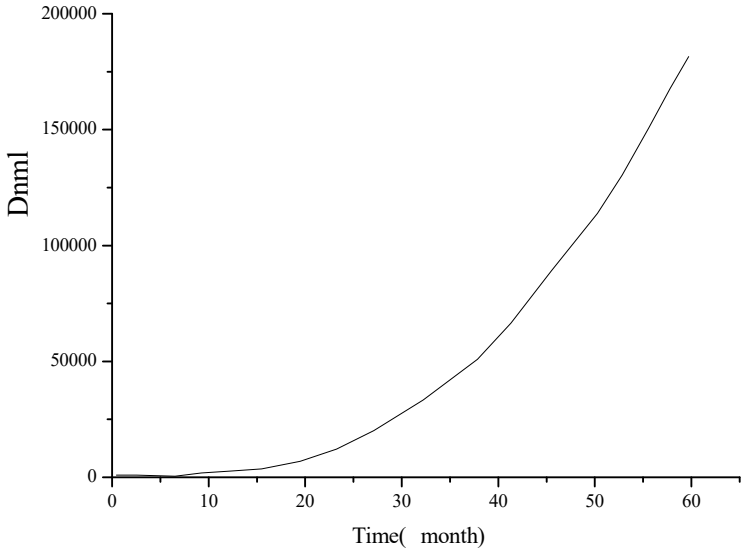

Figure 6. Utility subsystem of scientific research institutes.

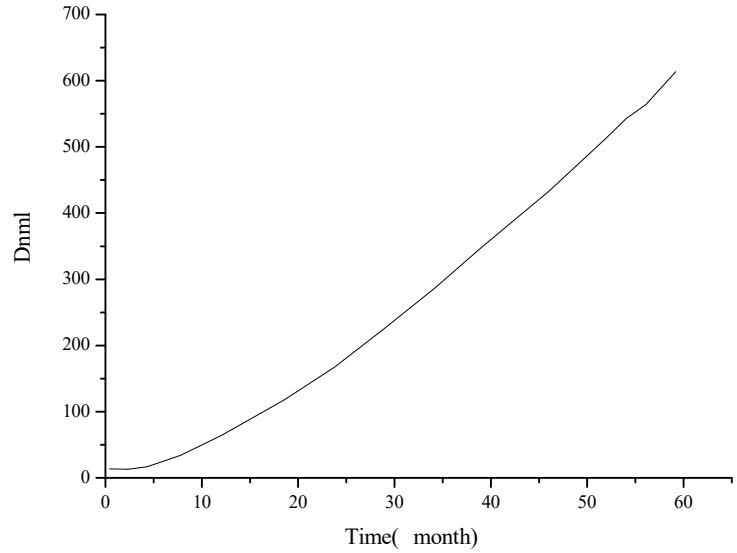

Figure 7. Effectiveness of the collaborative innovation mechanism of industry, university and research institute.

The results of the test show that the utility subsystem of the three subjects of enterprises, universities and scientific research institutes is basically zero in the early stage of collaborative innovation. At the beginning of collaborative innovation operation of industry, university and research institute, the main parties have different degrees of invested capital, equipment, human resources and knowledge resources. Due to the certain time for effective operation of collaborative innovation, the initial output is almost zero, so the actual perceived utility of each subject is zero. The late utility increases obviously, because over time, collaborative innovation output is increasing, and affected by collaborative innovation long-term effectiveness, collaborative efficiency and staff satisfaction is also rising. In consequence, collaborative innovation output increases more rapidly, leading to rapid growth in the subject utility. The model reflects the actual operation situation of collaborative innovation mechanism of industry, university and research institute, having a high degree of fitting with the reality.

5. Conclusion

This paper analyzes the characteristics of the effectiveness of the collaborative innovation mechanism of the industry, university and research institute. The purpose and function of collaborative innovation of industry, university and research institute are different, and subject internal management and incentive mechanism are different, which leads to different cognitions of collaborative innovation output of industry, university and research institute. Therefore, we must pay attention to the heterogeneity of the subjects in the collaborative innovation of industry, university and research institute, coordinate the objectives of all subjects and the overall objectives of collaborative innovation of industry, university and research institute, and take account of the subject utility and the overall effectiveness of the alliance, so as to avoid a zero sum game. Secondly, based on the utility theory, combined with the actual situation of collaborative innovation operation, we establish a system dynamics model and confirm the relationship between subjective and objective utility demand difference of collaborative innovation subjects and collaborative innovation mechanism effectiveness. The higher the coincidence between the subjective and objective utility demand of collaborative innovation of industry, university and research institute and the objective demand utility based on organizational purpose and mission is, the higher the effectiveness of the collaborative innovation mechanism of industry, university and research institute is. Finally, the rate of scientific and technological achievements, as an important link between knowledge output and economic benefits, its high efficiency means that more new knowledge and new technology are applied to the field of production. As a result, the collaborative innovation output is correspondingly increased, and the effectiveness of collaborative innovation mechanism is higher.

Acknowledgments

This article is funded by 2016 annual project of Humanities and Social Sciences in Jiangxi Universities (Project number: JJ162007) and the Science and technology research project of Jiangxi Provincial Education Department (Project number: 161537).

References

[1] Luan, G., Wang, H., Lv, H., Hu, N., Suo, Y., & Wang, X. (2016). Separation and purification of five flavone glucosides and one lignan from caragana korshinskii, kom. By the combination of hsccc and semi-preparative rplc. Chromatographia, 79(13-14), 823-831.

[2] Huang, S., Duan, S., Wang, J., Bao, S., Qiu, X., & Li, C., et al. (2016). Folic-acid-mediated functionalized gold nanocages for targeted delivery of anti-mir-181b in combination of gene therapy and photothermal therapy against hepatocellular carcinoma. Advanced Functional Materials, 26(15), 2532-2544.

[3] An, J., Zhang, D., Wu, J., Li, J., Teng, X., & Gao, X., et al. (2017). The acitretin and methotrexate combination therapy for psoriasis vulgaris achieves higher effectiveness and less liver fibrosis. Pharmacological Research, 121, 158-168.

[4] Song, M. L., Fisher, R., Wang, J. L., & Cui, L. B. (2016). Environmental performance evaluation with big data: theories and methods. Annals of Operations Research, 1-14.

[5] Tecco, N., Baudino, C., Girgenti, V., & Peano, C. (2016). Innovation strategies in a fruit growers association impacts assessment by using combined lca and s-lca methodologies. Science of the Total Environment, 568, 253.

[6] Kalapouti, K., Petridis, K., Malesios, C., & Dey, P. K. (2017). Measuring efficiency of innovation using combined data envelopment analysis and structural equation modeling: empirical study in eu regions. Annals of Operations Research (7), 1-24.