Evaluation of Multinational Corporation R&D Centers' Knowledge Spillover Effect Based on AHP and VIKOR Algorithm*

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ABSTRACT: Based on analysis the agglomeration of multinational corporation R&D centers, the attribute of knowledge and the way of knowledge spillover, we built the "knowledge fermentation" model and the knowledge multiplier mode. Then, we evaluated the efficiency of the agglomeration of multinational corporation R&D centers using the date of Beijing, Shanghai and Tianjin. The empirical research is a combination of AHP and VIKOR algorithm.
KEYWORD: Agglomeration of multinational corporation R&D centers; Knowledge spillover; Evaluation model; AHP and VIKOR algorithm

1 INTRODUCTION

Driven by the knowledge economy and the world economy globalization, the multinational companies recently focus on R&D rather than production and marketing area[1]. Multinational companies as the most important subject of R&D globalization, they have a pivotal position in the business of overseas R&D investment, international strategic technology alliances, international patent applications and international technology trade. The agglomeration of multinational corporation R&D centers and knowledge spillover have far-reaching impact on the economic, technological.

The willingness of export, host country's human resources and the accumulation of technical knowledge effect multinational companies' R&D expansion[2]. The host countries' market size, industrial technology and research capabilities impact the choice of overseas R&D location. Different R&D types should be corresponding to different types of host country. Multinational companies R&D can be divided into innovative R&D and adaptability R&D[3]. The absorption and utilization of regional FDI scale and market size play a key factor in the R&D institutions location of multinational companies in China. At the same the intensity of R&D resources and the level of intellectual property protection of multinational companies also affect the location of R&D institutions. Multinational companies R&D are focus on FDI, market size and human resources, particularly pay attention to our abundant and inexpensive human resources.

The study of multiplier effect on knowledge is still in primary stage. Pan Kailing explained the meaning of multiplier effect on the collaboration management and studied its rationality. Intellectual capital, capital of R&D, the import of technology and capital of human resources make great contributions to obtain foreign advanced technology. An open system is a positive factor in promoting FDI. He Jinsheng combined the "fermentation" theory in biology and knowledge management. He believed that the process of industrial clusters' knowledge creation is like the process of the fermentation of knowledge. He made a detailed analysis of the process of knowledge innovation of industry cluster from different levels[4].

After gathering and analyzing related literatures we found that although scholars have done a variety of studies from a different perspective on multinational R&D centers, knowledge spillover and knowledge multiplier, however, the evaluation of multinational R&D centers of knowledge spillover effect in a specific region's is uncommon. By constructing multinational R&D centers' knowledge multiplier model and using the data of Beijing, Shanghai and Tianjin, we conducted a empirical research on multinational R&D centers' knowledge spillover.

2 MODEL BUILDING

Knowledge multiplier is a new concept, and it's similar to the knowledge fermentation model.

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Knowledge fermentation model was first developed by Professor He Jinsheng in Tianjin University. He viewed that the intellectual activity and biological fermentation process have a great similarity, so he proposed the theory of knowledge fermentation. The "knowledge fermentation" is defined as the process of knowledge digested, choice, competition, adaptation, transformation, evolution, innovation and integration under the coordination of the organization's leadership, which shows in Figure 1.

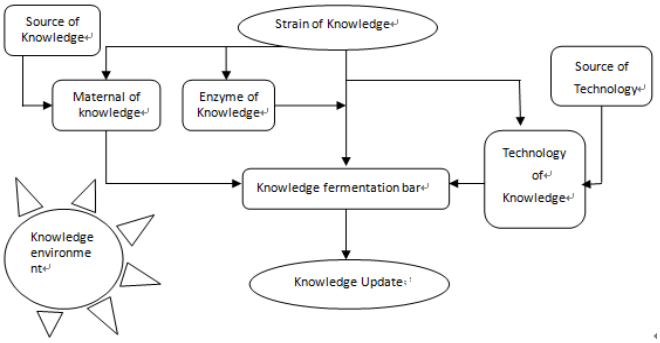

Figure 1.The "knowledge fermentation" model

2.1 *The construction of the multinational corporation R&D centers' knowledge multiplier*

Based on the "knowledge fermentation" model we summary the efficiency of the knowledge multiplier as the process that enterprise and local government in order to make more effective use of knowledge that multinational R&D centers overflowed, building a series of knowledge multiplier including international talent exchange centers, intellectual property exchange centers and incubator parks. Knowledge multiplier help to exchange, share and integrate the knowledge which was spilled.

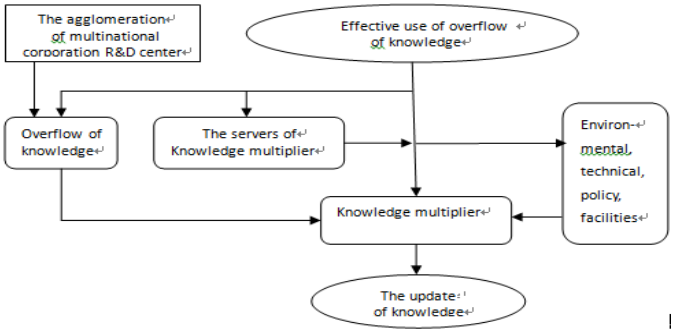

Figure 2. The knowledge multiplier mode

2.2 *Ways to achieve the effect of knowledge multiplier*

The knowledge spillover in international talent exchange centers, intellectual exchange centers and incubator parks. From government financial and policy support can achieve knowledge multiplier effect, specifically the revenue and technological achievements. The multinational corporation R&D centers' knowledge multipliers include:

(1) International talent exchange centers. The purpose is to develop the talent through introduce foreign capital, technology, intellectual resources[5]. Through select group of cadres, young technical staff, youth managers training abroad, in order to train a group of skilled, management, international awareness and skills of young talents. The R&D staff in the international talent exchange center can get a lot of useful knowledge through training, exchange, etc. By absorption, digestion, integrating acquired knowledge to create new knowledge. The international talent exchange center is a platform that they can send their knowledge to the people in need. International talent exchange centers can effectively accelerate the growth of knowledge spillovers and achieve a multiplier effect.

(2) Intellectual property rights exchange center. It's the center of patents, copyrights and trademarks, and set up a market of intellectual property, intellectual work using its strong management of intellectual property database and power center. Eventually fused into a improved functionality IP professional service chain. It includes the information dissemination, patent evaluation, account transactions, technical achievements, investment and financing services, patent pool formation, forensic and many other functions.

(3) Business incubator. It refers to the high-tech innovation service center, also called innovation center. The original meaning refers to a special equipment help to incubate eggs. Later, it introduce to the economic sphere. It's a centralized space where provide money and management which the primary stage of enterprise need. Business incubator provides convenience to science and technology enterprise let them become bigger and stronger. A successful incubator is inseparable from the five elements: shared space, service system, business incubators, incubator managers, preferential policies to support enterprises.

We can build another knowledge multiplier model according to several aspects of knowledge spillovers in multinational R&D centers and taking into account input and output and some environmental factors of the knowledge multiplier.

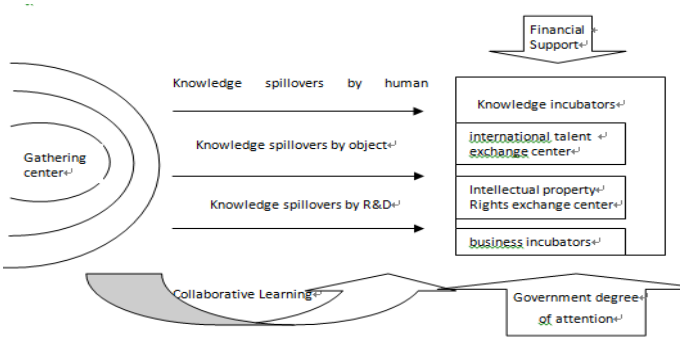

Figure 3. Model of knowledge multiplier

3 EVALUATION INDEX SYSTEM BUILDING

The knowledge multiplier have three main input indicators: the knowledge generated by the multinational corporation R&D centers, financial support from the government and the emphasis on knowledge multiplier. Two output indicators: R&D results and R&D revenue. Due to the statistical yearbook didn't make specialized statistic on the date of knowledge multiplier input and output, so we have to take into account the availability of data. We take Beijing, Shanghai, Nanjing as three large knowledge multipliers. Ultimately we selected three input and output indicators to be verified considering the human, material and financial resources and other factors. Figure 4 shows the comprehensive evaluation system.

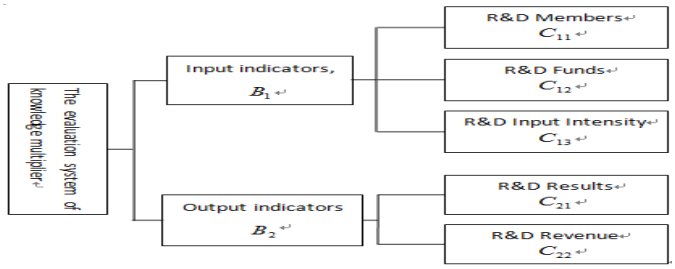

Figure 4.The evaluation index system

Table 1.The evaluation index data

	The technology contract number			The technology contract amount			Patent licensed number		
	2010	2011	2012	2010	2011	2012	2010	2011	2010
Pekin	59969.00	53552.00	50847.00	2458.50	1890.28	1579.54	2883.00	1588.00	1120.00
Shang Hai	27998.00	29332.00	26185.00	588.52	550.32	525.45	1137.00	9160.00	6867.00
Tian Jin	13409.00	11726.00	9541.00	251.22	171.59	119.79	3363.00	2528.00	1930.00

Science and technical personnel number			R&D funds			R&D funds/GDP		
2010	2011	2010	2010	2011	2010	2010	2011	2010
65.10	60.60	52.98	1063.40	936.64	821.82	5.95	5.76	5.82
38.89	37.53	33.46	679.29	597.71	481.70	3.37	3.11	2.81
36.70	31.60	29.40	360.50	297.80	229.60	2.80	2.60	2.30

4 EVALUATION MODEL OF KNOWLEDGE SPILLOVER EFFECT BASED ON AHP AND VIKOR ALGORITHM

4.1 *Using AHP algorithm to determine the index weight coefficient of every layer*

AHP is a practical method of decision analysis. It puts the qualitative and quantitative factors into consideration and treats fairly.

1) Determine the index system and analysis the relationship between various factors.

2) Determine the importance of each factor on each floor. Compared to its important degree draw the layer sequence of judgment matrix. The judgment matrix multiplied by the eigenvector to get the relation function. Then calculate the weight by figure up the judgment matrix eigenvector and the maximum characteristic root. $W=(w_1,w_2,...,w_n)$, $AW^T=\lambda_{\max}W$, $|A-\lambda_{\max}I|=0$

3) Consistency check. We used a function to check the consistency and avoid excessive error. λ_{max} is the largest eigenvalue. *n* is judgment matrix's order number.

$$CR=CI/RI, CI=(\lambda_{\max}-n)/(n-1)$$

Table 2. Random index

N	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.96	1.12	1.24	1.32	1.41	1.45

The judgment matrix is satisfactoriness if *CR*<0.1; If not, then adjust the judgment matrix until *CR*<0.1.The value of each factor weight vector can be obtained using the above method.

4.2 *Using VIKOR algorithm to calculate the compromise solution*

VIKOR is a multiple attribute decision making method proposed by Opricovic. It's a decision making method based on the ideal point. We first defined the positive-ideal solution and negative-ideal solution. The positive-ideal solution refers to the optimal value of each alternative in each assessment criteria, while the negative-ideal solution refers to the worst value of each alternative in each assessment criteria. Then line up priorities according to the close degree between assessment value of each alternative and ideal solutions. Its biggest characteristic is to maximize benefits and minimize negative impacts.

1) Define the positive-ideal solution and negative-ideal solution

$$f_j^*=[(\max_j f_{ij} \mid i\in I_1),(\min_j f_{ij} \mid i\in I_2)]\forall_i; \quad (1)$$

$$f_j^{'}=[(\min_j f_{ij} \mid i\in I_1),(\max_j f_{ij} \mid i\in I_2)]\forall_i; \quad (2)$$

j is city number. *i* is assessment criteria number. f_{ij} is the ith value of jth city. f_j^* and $f_j^{'}$ is the positive-ideal solution and negative-ideal solution respectively.

2) Calculate different cities' group benefits and individual regret value. S_j is group benefits and R_j is individual regret value. w_i isith index weight which can be calculated by AHP.

$$S_j=\sum_i^n w_i(f_i^*-f_{ij})/(f_i^*-f_i^{'})\forall_j; \quad (3)$$

$$R_j=\max_i[w_i(f_i^*-f_{ij})/(f_i^*-f_i^{'})]\forall_j; \quad (4)$$

3) Calculate the interest rate of each solution

$$Q_j = v(S_j - S^*)/(S^` - S^*) + (1-v)(R_j - R^*)/(R^` - R^*) \quad \forall_j ; \qquad (5)$$

$$S^* = \min_j S_j ; \quad S^` = \max_j S_j ; \quad R^* = \min_j R_j ; \quad R^` = \max_j R_j$$

vis the coefficient of decision-making mechanism. We will take more consideration to maximize benefits if v is bigger than 0.5, and will take more consideration to minimize loss to make decisions if v is smaller than 0.5.We define v is 0.5 in order to take a compromise perspective in our equation.

4) Ranking according to the data of Q_j, S_j, R_j.

5) We can determine the optimal city when the results meet the following two conditions.

Condition 1: $Q^{"} - Q^{'} \geq 1/(J-1)$. $Q^{"}$ is the second solution sorted by Q. $Q^{'}$ is the best solution sorted by Q.

Condition 2: At least one of the S and R is the top order which belong to the optional solution.

5 CASE ANALYSIS

In order to prove the AHP&VIKOR algorithm model in testing the applicability of the knowledge multiplier effect, we make a case analysis. Due to the raw data with different dimension and different orders of magnitude, so it is necessary to carry out dimensionless process. Efficiency indicators and cost indicators are applied to below functions.

$$y_{ij} = x_{ij} / \max_i (x_{ij}), \quad y_{ij} = \min_i (x_{ij}) / x_{ij}$$

Table 3.The average for each indicator of three cities

City	Efficiency Indicators			Cost Indicators		
Pekin	54789.33	1976.11	18641.33	59.56	940.62	5.84
ShangHai	27838.33	554.76	9135.33	36.63	586.23	3.10
TianJin	11558.67	180.87	2607.00	32.57	295.97	2.57

1) f^* =（1,1,1,1,1,1）,
$f^`$ =（0.21,0.09,0.14,0.55,0.31,0.44）

2) This paper used the Delphi method to determine multinational corporation R&D centers' knowledge spillover of judgment matrix. Calculate each index weigh according to relative experts.

W=（0.15,0.24,0.19,0.13,0.18,0.11）;

3) Wegained the three cities' S, R, Q according to VIKOR algorithm.

Table 4. Three cities' S, R, Q

	A1	A2	A3
S	0.42	0.59	0.58
R	0.18	0.19	0.24
Q	0.00	0.59	0.97

4) Different cities' order according to S,R ,Q.

Table 5. Three cities' order

	A1	A2	A3
S	1	3	2
R	1	2	3
Q	1	2	3

5) The values of Beijing and Tianjin are satisfied with condition 1, and all citiesare satisfied with condition 2. So we can define that Beijing is the highest efficiency city, and Tianjin is the last one. The result is acceptable in the actual evaluation.

6 CONCLUSION

This study introduced the fuzzy mathematics and systematic theory into the analysis and evaluation of the knowledge spillover multiplier effect. Expounds the connotation of knowledge multiply effectors and elements. We were established knowledge multiplication model and the comprehensive evaluation system based on the "knowledge fermentation" model and made empirical analysis. We made a combination of qualitative and quantitative evaluation to value the effect of regional knowledge multiplication. We provided a new vision for the development of evaluation theory.

The results have shown that this model is effective and has high resolution. The evaluate results were more realistic and objective to be trusted. It is a more practical evaluation method for the valuation of the effect of knowledge multiplication. It provided a scientific basis for a specific area cluster innovation, identify their knowledge multiplication effect and diagnosis themselves shortage. Our study help to deepen the understanding of knowledge spillover effect of multinational corporation R&D centers in different regions, and provide a scientific basis for regional economic development policy.

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