

Analysis on the Optimization of Internal Technology Innovation Environment of Jilin SMEs Based on the Circular Economy Perspective

Xu Ying

Management School of Jilin University, Changchun, China, 130025

ChangChun University of Technology, changchun, China, 130012

E-mail: zjbpio@yahoo.com.cn

Abstract: It is a certain choice that developing technology innovation based on circular economy to SEM in order to deal with the adjustment of industrial structure and achieve the sustainable development. But for the consideration of cost, scale, externality, now many SMEs lack of intrinsic motivation to technology innovation based on circular economy. This paper takes the SMEs which locate in Jilin Province as sample, using the DEMATEL method, to explore the degree of force and the internal relationship of all the influence factors from the enterprise interior during the process of innovation of the circular economy technology. And then detects that the lack of capital is the main factor that limits the technology innovation of SMEs in Jilin province. The empirical result shows that the capital factor is a dynamic factor. Lacking capital that the SME of Jilin province needed should be settled by cooperative innovation through integrating the internal and external research resources.

Keywords: Circular Economy; SME; Technology Innovation; Influence Factor

1 Introduction

The development of circular economy needs the supported of technology innovation. The SME (Small and medium enterprise) is an important part in the regional innovation system, so it should undertake the responsibility of technology innovation for the circular economy^[1] Compared with other provinces, the start of Jilin province's SMEs is later, and exists a certain gap in aspects of technology innovation and core competency. Data shows that among SMEs in Jilin province 33% is primary resource-based processing industry and 31% is general manufacturing and only 17% is scientific and technological enterprises and 11% is high-tech enterprises. More than 70% enterprises in Jilin province have problems such as weakness on the base of enterprise R&D, outdated equipment, lack of sustainable development capability^[2] So facing the market competition, many SMEs in Jilin province more depend on the resource not on the technology. The development model which is "resource-production-market" leads SMEs in Jilin province have to face the stress of resource and environment more and more seriously inevitably. So it is importance to study on the influence factors of technology innovation from the angel of circular economy to SMEs in Jilin province.

At present the study on the enterprise technology innovation are abundant at home and abroad. Both theoretical research and empirical analysis from different angle explore characters of SME technology innovation and performance, relevance, strength of influence factors of SME technology innovation under the different study background. But the study on the technology innovation of SME from angle of circular economy is little, especially about quantitative analysis. So this paper using the DEMATEL method analyses on enterprise factors of SMEs in Jilin province during the process of technology innovation based on the circular economy. Analyses the internal relationships of all the influence power of those factors and then give some suggestions to optimize the internal technology innovation circumstance of SME in order to accelerate the development of the circular economy by push the technology innovation of SMEs in Jilin province.

2 Analysis on the internal barriers of technology innovation of SME in Jilin province under the background of circular economy

Now the mandatory constraints of environment is more and more enhanced, so SMEs face the seriously challenges compared with the big enterprises. The SMEs

need to develop circular economy by the technology innovation. But the practical situation is that: many SMEs are lack of motivity of technology innovation of circular economy because of the considerations of factors such as cost, scale, risk and externality. This situation is exists in Jilin province universally. Although recent years for the aim of “enhance the speed, increase the volume, strengthen the quality and improve the level” government of Jilin province has enacted many policies to accelerate the development of SMEs technology innovation such as monetary policy, fiscal policy, personnel policy and information policy. Those policies effectively improve the external environment of technology innovation of SMEs. But the internal innovation mechanism of SME forms slowly, especially the green innovation for the circular economy progress slowly. The main obstacles include:

(1) To lace of awareness of green innovation. The development of circular economy of SMEs needs the support of green technology such as reduction technology, alternative technology, resources technology, purification processing technology, clean production technology. And the traditional technology which has the traits of high consumption, low use and high pollution should to be out. This substitute of technology needs the awareness of green innovation of SMEs. This awareness can transfer the aim from maximizing the economic benefits to maximizing the ecological benefits. Because of the later starting of SMEs in Jilin province, most SMEs are in the growth stage so they pay more attention to the economic indicators such as firm size, sales growth, market share, and neglect the influence on the ecological benefits in the process of production and the products. That leads to the situation of lace of awareness of green innovation in the process of innovation.

(2) Lack of the green technology innovation capitals. Endogenous growth theory considers that the basic drive of technology innovation is the R&D input of enterprises. So the growth of the R&D input can improve the efficiency of enterprise innovation. Now in Jilin province the input of innovation is great relative to the size of enterprise. In 2007 among the 853 enterprises that have technology innovation actions, the proportion of innovation input of large size enterprises is 87.2%. And the medium size enterprises’ is 6.1%. The small size’s en-

terprises’ is 6.6%. So the amount of innovation input is not enough. From the aspect of structure of R&D capital, the capital of the environmental technology and the clean production technology is fewer.

(3) Weak foundation for the green innovation. The self-organization trait of technology growth shows that there have mutual relationships between the technology innovation and technology stock. On the one hand, technology innovation can bring out the effect of enterprise technology accumulation. And then leads to increase the technology stock of enterprise. On the other hand, the technology stock of enterprise is the material base of technology innovation. It influences the depth and breadth of the technology innovation. In the aspect of the production innovation, now in Jilin province many SMEs locate in the downstream of the industry chain. Their productions are almost the low tech-context and low value-added productions. The proportion of high-tech, high value-added and high market share is small. The transformation of technology innovation from the low-end products to the green technology is difficult. In the aspect of process innovation, the process technology, equipment and management of most enterprises is out-date. Those lead to the green process innovation of enterprise is difficult too. So SMEs lack of the capability of technology learning to carry out the technology innovation facing to the circular economy.

(4) The size of enterprise is small and the technology innovation talent is not enough. In recent years, in Jilin province the numbers of SME is increasing obviously. But the size of those enterprises is not big. Many enterprises are in the stage of growth. Compared with the developed province it has difference of stage. And the strength of those enterprises is still weak. Facing the technology innovation of circular economy, the inevitable risks due to the diseconomies of scale and transformation cost of technology system must encounter. More over, the small size of enterprise can not attract and maintain the technology talent. The green technology innovation is a practice action that technology talent is main body. The lack of technology talent and R&D team lead to the SMEs in Jilin province can not carry out the green technology innovation project.

In a word, in Jilin province the circular economic technology innovation of SMEs are faced with the problems

of awareness, technology, talent, capital, management. Among those problems which problem is important that need to be identified and analyses.

3 The analysis on the main barriers by the method of DEMATEL

3.1 Model

In order to analyses the structure of the influence factors of technology innovation, this paper use the DEMATEL model to quantification study the factors. DEMATEL (Decision Making Trial and Evaluation Laboratory) is a decision analysis method that analyses the system factors by using the graph theory and matrix tool^[3]. This method can confirm the logic relationship of factors and then shows the keystone and the internal structure of the research issue. The advantage of the DEMATEL method is that it has no limit on the amount of samples. So this method can draw a credible conclusion based on few samples.

The basic steps of DEMATEL method includes:

(1) Choose the influence factors: $f_1, f_2, \dots, f_i, \dots, f_n$.

(2) Get the influence matrix: according to the given standard get the direct influence matrix $X = (a_{ij})_{n \times n}$ by one factor compared to others.

(3) Calculate the comprehensive influence matrix: in order to analysis the indirect influence relationship calculate the comprehensive influence matrix $T = X(1 - X)^{-1} = (t_{ij})_{n \times n}$.

(4) Analysis the influence factors: analysis the t_{ij} in T , and calculate influence degree, influenced degree, central degree and reason degree of factors. All the numerical value of factors of one row of T is influence degree T_r . And all the numerical value of factors of one column of T is influenced degree T_c . The central degree of F_i is M_i and $M_i = T_r(i) + T_c(i)$. The reason degree of F_i is R_i and $R_i = T_r(i) - T_c(i)$. If $R_i > 0$ shows that this factor has a strong influence on other factors, it's reason factors. If $R_i < 0$ shows that this factor is strong influenced by other factors, it's result factors.

3.2 Data

This paper chooses eight internal influence factors of enterprise in order to do structure analysis based on the four problems mentioned above by using the method of

bibliographical research and expert interview. Those eight influence factors are the form and confirmation of innovation status of SMEs (F1), the awareness of green technology innovation of SMEs (F2), the input capital of R&D of SMEs (F3), the degree of technology accumulation of SMEs (F4), the talent of technology innovation of SMEs (F5), the degree of industry-university-research institute collaboration of SMEs (F6), the development strategy of SMEs (F7), the diathesis of entrepreneur (F8).

According to the basic steps of method of DEMATEL, based on the questionnaires and interviews of many experts and entrepreneurs construct the Direct influence matrix (table 1). In the table the score is count according to the views of experts. Firstly, using 1 to 4 figures the four degrees of influence, that is weak, common, strong and very strong. Secondly, count the influence degree. If expert considers that F_i is direct influence F_j , then count the figure at the point of the i th row and the j th column. If expert considers that F_i is no direct influence F_j , the figure is 0 at the point of the i th row and the j th column. At last gather the result of experts' form the direct influence matrix. Using the MATLAB software calculates the synthetical influence matrix (table 2) and influence degree, influenced degree, central degree and reason degree of factors (table 3).

Table 1. Direct influence matrix

F_i	F1	F2	F3	F4	F5	F6	F7	F8
F1	0	1	3	2	2	3	4	0
F2	2	0	0	0	1	1	1	3
F3	4	0	0	4	4	3	2	0
F4	2	0	0	0	4	3	2	0
F5	0	3	0	4	0	2	2	1
F6	0	0	0	4	0	0	1	0
F7	3	2	4	0	3	2	0	0
F8	4	4	3	2	0	2	4	0

Table 2. Synthetical influence matrix

F_i	F1	F2	F3	F4	F5	F6	F7	F8
F1	-0.6	-0.28	-0.01	-0.1	-0.06	-0.09	-0.09	-0.29
F2	0.213	-0.35	0.177	-1.18	-0.9	-0.77	-0.3	0.419
F3	-0.23	-0.34	-0.65	0.254	0.185	-0.02	-0.25	-0.3
F4	-0.22	-0.1	-0.32	-0.35	0.107	0.013	-0.1	-0.07
F5	-0.19	0.21	-0.18	-0.46	-0.84	-0.46	-0.23	0.25
F6	-0.24	-0.14	-0.28	0.53	0.068	-0.07	-0.02	-0.12
F7	-0.09	-0.14	0.155	-0.48	-0.16	-0.35	-0.64	-0.18
F8	0.12	-0.15	0.285	-0.98	-0.89	-0.75	-0.28	-0.37

Talbe 3. The central and reason degree of factors

Fi	influence degree	influenced degree	central degree	reason degree
F1	-1.50	-1.24	-2.74	-0.26
F2	-2.70	-1.29	-3.98	-1.41
F3	-1.35	-0.83	-2.18	-0.52
F4	-1.05	-2.76	-3.81	1.71
F5	-1.90	-2.49	-4.39	0.59
F6	-0.27	-2.49	-2.77	2.22
F7	-1.89	-1.91	-3.79	0.02
F8	-3.01	-0.66	-3.67	-2.35

3.3 Result discussion

Considers the central degree, the central degree of F3 is biggest, the next is F1. The result shows that the most important and main problem of the insufficiency of circular economic technology innovation of SMEs is the lack of capital. The next problem is the innovation status of SMEs is not formed and confirmed. The situation that lack of capital leads the most SMEs in Jilin province out of the regional innovation system. From the angel of SMEs, the market-oriented mechanism of circular economic innovation is not formed. It is noteworthy that the influence degree of factor such as the input of R&D is big, but the result shows that those factors are result factors and compound factors. In generally, the compound factor is dynamic factor which is easy to change. According to the logic diagram of result and reason, compound factor needs to analyses the internal composing more to grasp the change trend.

The result shows that influence factors of impact the circular economic technology innovation of SMEs in Jilin province are F4, F5, F6 and F7. According to the score of factor, the F6 is the biggest, and then is F4. The high level of F6 shows that the way of obtain the technology can direct influence the demand degree to the other innovation factors. Through the industry-university-research institute collaboration SMEs can

ease the lack of technology talent and knowledge and economize the technology innovation capital compared with self-innovation. The high level of F4 shows that the degree of technology accumulation can influence the usage effect of R&D capital. Now in Jilin province many green technology innovations is carried out by universities and research institutes located in Jilin province. Universities and research institutes accumulate many technologies, knowledge, talents and productions. SMEs in Jilin province can make use of those resources to reinforce the enterprise internal technology resources and to optimize of environment for innovation.

4 Conclusions

The technology innovation of SMEs is vital to the development of circular economy. This paper analyses the problems that SMEs faced when technology innovate to the circular economy by using the DEMATEL method. The most main barrier is the lack of capital. And the study shows that the concept of lack of capital is dynamic. In Jilin province SMEs can solute the problem of lack of capital by the methods that integrate research resources of internal and external that can be used and develop the collaborative innovation. So in order to push the circular economic technology innovation of SMEs in Jilin province the economic and effective way is develop the industry-university-research institute collaboration based on the circular economic technology.

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