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Mature Cluster's Risk Evaluation

Fei Gao, Kai Li, Yaning Li
School of Business Administration, Northeastern University, Shenyang 110004, China
Tel: 86-131-4982-3459 E-mail: fgao@mail.neu.edu.cn

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Abstract

In view of the adverse effect of declining cluster, a method of analyzing and assessing declining risks of mature cluster is studied. Through analyzing causes of declining risks, an evaluation index system for declining risks is built. According to the index system, the characteristic patterns of different risk levels are described. Owing to the complexity and uncertainty of cluster system, a TOPSIS comprehensive evaluation method based on fuzzy nearness degree is proposed to assess declining risks.

Keywords: Cluster, Decline, Risk, Fuzzy nearness degree

1. Introduction

Cluster does not always develop forward. Its evolution presents a nonlinear trajectory. Declining cluster's adverse effects attract people's attention to the study of declining risks of cluster. Tichy (1998, p.215) discusses the life cycle and structural risks of cluster. On the basis of Tichy's research, Fritz (1998, p.180) analyzes cyclical risks of cluster. Bent Dalum (2005, p.230) digs out causes of cluster's risks from dimensions of Technological Change and Institutional Change. Harrison (1994, p.5) and Pouder (1996, p.1192) analyze declining risks of cluster with the knowledge of New Economic Sociology. It should be pointed out that clusters at different phases of their life cycle are faced with different risks. Above researches haven't aimed at risks of different phases specifically and lacks qualitative evaluation on risks, which increases the difficulties in risk management of cluster.

In view of mature cluster's importance to the development of regional economy, this paper focuses research on mature cluster's risks and establishes mathematical evaluation model of risk level through analyzing risks' features. Owing to the complexity and uncertainty of cluster system, a TOPSIS comprehensive evaluation method based on fuzzy nearness degree is proposed, so as to avoid subjective arbitrariness in classification and weight assignment of linear aggregation model.

2. Feature analysis on mature cluster's risks

2.1 Causes of mature cluster's risks

Based on researches of Tichy and Fritz, Cai Ning (2003, p.60) divides the declining risks of cluster into "cyclical risks", "structural risks" and "network risks" . Cyclical risks happen suddenly and can not be artificially controlled. It is caused by cyclical fluctuations of external economy and may occur at any phase of cluster's life cycle. Structural risks refer to the risks brought about by cluster's aging. It is primarily influenced by the advanced nature of alternative products, the extent of changes in market demands and cluster's innovation capability. Cai Ning constructs the analysis framework of cluster's "network risks" from three dimensions of network structure, network resource and network activity.

The first kind of network structure risks comes from network structure's effects on cluster's innovation capability. Håkansson (2006, p.256) believes that network structure takes on the functions of organizing firms' innovation activities. Markusen (1996, p.300) points out that the more mature a cluster is, the more likely it becomes a closed network. The closed cluster's product network and knowledge network reduce ties with outside, and actors within cluster can't be aware of external changes timely. As continuous increasing of cluster's network intensity and network density, the high degree of knowledge flowing within cluster makes most firms depend on technology imitation and lost of enthusiasm on technology innovation. The second kind of network structure risks arises from high degree of asset specificity. Taking Tichy's viewpoint as a reference, Hub-and-Spoke Cluster whose center is large leading firm has the biggest risks. When such kind of cluster is at its maturity phase, it is characterized with dependence of small firms on large leading firms, which induces the risks of over-specialization and technology rigidity. Once a central firm fails, the whole cluster will be affected.

Network resources including culture, trust and material resources also give rise to network risks. Burt (2000, p.350) points out that over-embedded in a network atmosphere will reduce the inflow of new information and induce rigidity risks. Bennett and Harrison (1994, p.6) points out that the regional embedded network are coordinated and managed by trust mechanism. However, this kind of non-expansion trust based on genetic, blood and geographical relationships may be temporary, because the radius of cooperation between firms in this kind of network are short, which leads to the fierce competition. At the same time, firms embedded in the same network atmosphere are likely to have the same strategy when facing the same situation, which reduces the chances of success and make markets crowded.

Actors' activities are also important factors giving rise to risks of mature cluster. Porter (1998, p.80)points out actors' connection with each other by network activities will lead to additional management cost of network. Cai Ning (2003, p.60) believes that incomplete contract, moral hazard, opportunism and lazy behaviors may increase the costs of network, resulting in the weakening of network's advantages. As network costs increased, firms and intermediary institutions withdrawal from cluster gradually, leading to the breakage of industrial chain and the decrease of service level, which further accelerates cluster's declining.

2.2 Features of different risk levels

The above analysis provides theoretical basis for selection of risk indexes as showed in table 1. According to the risks level, this paper divides mature cluster's operation conditions into three kinds: normal operation, risky operation and declining operation. Linguistic variables including "low", "medium", "high", "very high" are used to describe features of different risk levels.(Table 1)

3. Cluster's risk evaluation based on fuzzy nearness degree

When evaluating cluster's risks, the first step is to set up an expert panel who value risk indexes on a scale of 0-10 with Delphi method. Cauchy Membership Function is selected in this paper to calculate indexes value's degree of memberships to linguistic variables. Suppose the membership functions of linguistic variables are as follows.

$$\mu_{low}(x)=\begin{cases}1, & x\le 3\\ \left[1+\left((x-3)/2\right)^2\right]^{-1}, & x>3\end{cases} \tag{1}$$

$$\mu_{medium}(x)=\left[1+\left((x-5)/2\right)^2\right]^{-1} \tag{2}$$

$$\mu_{high}(x)=\left[1+\left((x-8)/2\right)^2\right]^{-1} \tag{3}$$

$$\mu_{veryhigh}(x)=\begin{cases}1, & x\ge 9\\ \left[1+\left((x-9)/2\right)^2\right]^{-1}, & x<9\end{cases} \tag{4}$$

Suppose universe U is the set of risk indexes value, denoted as $U=\{u_1,\cdots,u_{21}\}$;V is the linguistic variables set, denoted as $V=\{v_1,\cdots,v_4\}=\{low, medium, high, very\ high\}$;W is the set of cluster's operation conditions, denoted as $W=\{w_1,w_2,w_3\}=\{normal\ \ operation, risky\ \ operation, declining\ \ operation\}$.

Determine the relationship between risk indexes value and linguistic variables, namely the relationship between U and V with formula (1)—(4). On this step, the relationship of risk index $u_i\in U\,(1\le i\le 21)$ and linguistic variables set V is described by a fuzzy subset $\tilde{s}_i=\left(s_{1i},s_{2i},s_{3i},s_{4i}\right)^T$, getting the fuzzy matrix $\tilde{S}$.

According to the relationship between linguistic variables and operation conditions showed in table 1, namely the relationship between V and W, determine the relationship between U and W. On this step, the relationship of risk index $u_i\in U\left(1\le i\le 21\right)$ and operation conditions set W is described by a fuzzy subset $\tilde{r}_i=\left(r_{1i},r_{2i},r_{3i}\right)^T$, getting the fuzzy matrix $\tilde{R}$.

In order to make a fuzzy evaluation on cluster's risks level, the fuzzy subset corresponding to different level of risks are introduced as $\tilde{D}_1=(1,0,0)$, $\tilde{D}_2=(0,1,0)$, $\tilde{D}_3=(0,0,1)$.

Facts have proved that it is effective to make multi-objective decision with the method of asymmetric nearness degree. The definition of asymmetric nearness degree is

$$N\left(\tilde{A},\tilde{B}\right)=1-\frac{2}{n\left(n+1\right)}\sum_{k=1}^{n}\left|\mu_A\left(V_k\right)-\mu_B\left(V_k\right)\right|K \tag{5}$$

When calculate the nearness degree $N\left(\tilde{r}_i,\tilde{D}_j\right)$ between $\tilde{r}_i(i=1,2,\cdots,21)$ and $\tilde{D}_j\,(j=1,2,3)$, considering the difference of membership degrees that belong to different grades play different roles, $\tilde{r}_i$ needs to be standardized. Put r_{ji} in the front. $\forall j'$, j'', if $\left|j'-j\right|>\left|j''-j\right|$ (namely j'' is more far from j), put $r_{j'i}$ before $r_{j''i}$. Consider another situation when $\left|j'-j\right|=\left|j''-j\right|$, if $j'<j''$, put $r_{j'i}$ before $r_{j''i}$. Then, record standardized $\tilde{r}_i$ as $\tilde{r}_i'$. Standardizing $\tilde{D}_j$ accordingly, get $\tilde{D}_j'$. Therefore, evaluating $N\left(\tilde{r}_i,\tilde{D}_j\right)$ is equal to evaluating $N\left(\tilde{r}_i^{\,j},\tilde{D}_j'\right)$. Asymmetry nearness degree between each risk index and fuzzy subsets corresponding to different level of risks is recorded as follows:

$$\tilde{Z}_i=\left(Z_{1i},Z_{2i},Z_{3i}\right)^T=\left(N\left(\tilde{r}_i,\tilde{D}_1\right),N\left(\tilde{r}_i,\tilde{D}_2\right),N\left(\tilde{r}_i,\tilde{D}_3\right)\right)^T \tag{6}$$

Ynder the whole risk indexes system, the asymmetry nearness degree between $U=\left\{u_1,\cdots,u_{21}\right\}$ and fuzzy subsets is

$$Z=\left(Z_{ij}\right)_{3\times21}=\left(\tilde{Z}_1,\tilde{Z}_2,\cdots,\tilde{Z}_{21},\right) \tag{7}$$

According to the method of TOPSIS, define referenced grade W^+ and W^- as follows.

$$\tilde{C}^+=\left(C_1^+,C_2^+,\cdots,C_{21}^+\right)=\left(\max_{j=1,2,3}N\left(\tilde{r}_1,\tilde{D}_j\right),\max_{j=1,2,3}N\left(\tilde{r}_2,\tilde{D}_j\right),\cdots,\max_{j=1,2,3}N\left(\tilde{r}_{21},\tilde{D}_j\right)\right) \tag{8}$$

$$\tilde{C}^-=\left(C_1^-,C_2^-,\cdots,C_{21}^-\right)=\left(\min_{i=1,2,3}N\left(\tilde{r}_1,\tilde{D}_j\right),\min_{i=1,2,3}N\left(\tilde{r}_2,\tilde{D}_j\right),\cdots,\min_{i=1,2,3}N\left(\tilde{r}_{21},\tilde{D}_j\right)\right) \tag{9}$$

Grade W^+ is a kind of virtual evaluation grade defined by formula (8) , which indicate grade W^+ (ideal grade) is most proper for each risk index ; Likewise , Grade W^- is a kind of virtual evaluation grade defined by formula (9) , which indicates grade W^- (Negative ideal grade) is most improper for any risk index. In order to get the evaluation result under the whole index system, the nearness degree between operation condition j and actual risk level of cluster is recorded as follows.

$$\tilde{C}_i=\left(C_{1i},C_{2i},\cdots,C_{21i}\right)=\left(N\left(\tilde{r}_1,\tilde{D}_i\right),N\left(\tilde{r}_2,\tilde{D}_i\right),\cdots,N\left(\tilde{r}_{21},\tilde{D}_i\right)\right),(j=1,2,3) \tag{10}$$

Calculate the symmetry nearness degree between $\tilde{C}_j$ and $\tilde{C}^+$, $\tilde{C}^-$.

$$\delta\left(\tilde{C}^+,\tilde{C}_j\right)=\frac{\sum_{k=1}^{21}\mu_{C_j}\left(u_k\right)}{\sum_{k=1}^{21}\mu_{C^+}\left(u_k\right)} \tag{11}$$

$$\delta\left(\tilde{C}^-,\tilde{C}_j\right)=\frac{\sum_{k=1}^{21}\mu_{C^-}\left(u_k\right)}{\sum_{k=1}^{21}\mu_{C_j}\left(u_k\right)} \tag{12}$$

Calculate $\delta\left(\tilde{C}^+,\tilde{C}_j\right)\big/\delta\left(\tilde{C}^-,\tilde{C}_j\right)$. If $\delta\left(\tilde{C}^+,\tilde{C}_p\right)\big/\delta\left(\tilde{C}^-,\tilde{C}_p\right)=\max_{j=1,2,3}\delta\left(\tilde{C}^+,\tilde{C}_j\right)\big/\delta\left(\tilde{C}^-,\tilde{C}_j\right)$, a conclusion could be made that the declining risk level of cluster should be in operation condition W_p.

4. Conclusion

On the basis of extracting features of mature cluster's declining risks, this paper established a risk indexes system. A TOPSIS comprehensive evaluation method based on fuzzy nearness degree was proposed to evaluate the level of declining risks. Firstly, asymmetry nearness degrees between risk indexes system and operation conditions were calculated. Secondly, according to the method of TOPSIS, the positive and negative ideal grades were defined. Lastly, symmetry nearness degrees between each operation condition and ideal grades were compared to determine the risk level of mature cluster. The method developed in this paper is meaningful to comprehensive management and risk control of clusters. The adopted membership function could be further amended according to actual situation when in application.

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Table 1. Features of different risk level

Risk indexes	Mature cluster's operation conditions		
	Normal operation	Risky operation	Declining operation
Regional economic conditions	High	Medium	Low
Advanced nature of alternative products	Low	High	Very high
Changes of market demands	Low	High	Very high
Government support efforts	High	Medium	Low
Completeness of scientific personnel	High	High	Low
R & D investment levels	High	Medium	Low
Number of patent applications	High	Medium	Low
Innovation achievements transformation	High	Medium	Low
Regional knowledge flow level	High	Very high	Meidum
Technological imitation level	Low	Very high	Very high
Product network's openness	High	Medium	Low
Knowledge network's openness	High	Medium	Low
Assets specificility	Medium	Very high	Low
Cluster's culture penetration	High	Very high	Low
Trust and cooperation between actors	High	Very high	Low
Convergence of strategy	Medium	Very high	Low
Congestion in factors market	Medium	High	Very high
Congestion in production market	Medium	High	Very high
Completeness of industrial chain	High	Medium	Low
Service level of intermediary institutions	High	Medium	Low