A Research on the Early Warning of Strategic Crisis in Resources and Technology-Driven Multiplex Enterprises

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Abstract

Based on the analysis on the diversifying strategies of resources and technology-driven enterprises and the accompanying crisis, this paper employs an improved radar model and a comprehensive evaluation method, selects 15 indicators in resource crisis, technological crisis, the degree of diversification, market crisis, management crisis and financial crisis, studies the crisis level of resources and technology-driven enterprises quantitatively and give early warning on strategic crisis. By introducing the concept of S, this paper solves the special status of critical indicators in the early warning of strategic crisis.

Keywords: Early warning of strategic crisis, Radar figure, Diversification, Enterprise crisis

1. Introduction

Core competitiveness is regarded as an enterprise’s ability to acquire competition advantages on a long term, an enterprise’s special technology and ability which can endure the test of time, can be extended and won't be imitated by its rivals as well as the source for an enterprise to gain advantages for sustainable competition. With increasingly fierce competition, core competitiveness strategy has attracted more attention from enterprises. Any strategic activity conducted by an enterprise is accompanied by all kinds of risks, hence forming strategic crisis. Early warning refers to the process measuring the departure degree from the early warning limit and send early warning (Zhu, 2002). Strategic crisis early warning (strategic risk early warning) refers to the process predicting strategic crisis and give warning about it.

2. Theories and Methods of Enterprise Strategic Crisis Early Warning

2.1 Major Theoretical Achievements on Early Warning Management of Enterprise Strategy in China and Abroad

Originally proposed by American scholars in 1960s, early warning management evolves from the theories of crisis management and risk management. Foreign researches on crisis management and crisis early warning management mainly concentrate on how to deal with crisis and to cast aside crisis. The main research achievements are as follows:

Robert Heath thinks that crisis managers should consider how to reduce risks, how to prepare for crisis management, how to plan, how to train staff, according to which he proposes the 4R Model: Reduction, Readiness, Response and Recovery (Heath, 2001).

According to Lawrence Patton, it is the key to crisis management to enhance crisis prediction. In his book *Organizational Management Crisis*, he systematically elaborates on the confirmation and prediction of organizational crisis as well as a series of theoretical issues including crisis and public opinion, crisis and media, crisis and staff, crisis and crime, crisis and environment and crisis and weather and so on (Patton, 2002).

Harvard University compiles *Crisis Management* after summing up the existing crisis management theories, in which the causes and methods of diagnosis for crisis, measures to get rid of inner crisis and reverse market crisis and the methods to reduce crisis through information-based system and to restore crisis with effective measures are systematically studied (Harvard University, 2002).

In Chinese academic circle, the researches on crisis management didn’t start until 1980s and it is in 1990s that the researches on enterprise crisis began. Up to now, some major achievements are as follows:

Yongjian Bao and Baizhu Chen claim that all crises are attributed to some internal reasons and many of them are similar. Regarding crisis management as a systematic management, they propose the 5P crisis management theory: Perception, Prevention, Preparation, Participation and Progression (Bao, 2003).

Based on his analysis on the eight signs of enterprise crisis, Weilun Su analyzes and studies the eight indicators involved in the monitoring methods of crisis, the measurement of crisis degree, the prevention against crisis and crisis early warning (Su, 2000). This book is viewed as a good example offering an all-round study on crisis management in China.
2.2 The Process of Early Warning for Enterprise Strategic Crisis

Generally, crisis early warning can be divided into three stages:

(1) Crisis identification and analysis: Some possible crisis factors should be confirmed, identified and classified first of all, and then the causes for different factors, the interaction and influences among different crises, the result of crisis and the overall influences on enterprises should be analyzed and studied, hence offering evidence for crisis early warning and crisis control.

(2) Crisis early warning: This means that enterprises predict an enterprise’s overall crisis condition by selecting proper early warning indicators and send early warning signals according to the degree of crisis so that crisis managers can take corresponding measures to reduce the possibility of crisis and the loss it may cause. This is the critical section in crisis early warning.

(3) Crisis control: based on crisis identification, analysis and early warning, strategies for crisis control should be established and specific measures and methods of different crisis factors should be figured out as well.

2.3 The Construction of a Model for Strategic Crisis Early Warning

Although the concept of strategic crisis early warning has existed for many years, there is no widely accepted definition of it laid down in relevant documents home and abroad. However, it has been accepted that strategic crisis early warning is a process to optimize crisis early warning and control technology and to achieve effective control over crisis with the lowest cost based on identifying and analyzing strategic crisis.

Currently, multivariate discriminant analysis, analytic hierarchy process, Logistic regression analysis, nerve net and some other methods are employed in the researches on strategic crisis early warning to establish crisis early warning identification and monitoring system to identify, analyze a variety of symptoms in strategic crisis incubation period and to send early warning and conduct control. Major representatives include Huaiyi Zhu, Dongchuan Sun, Xiaoping Shen (2002) who established a strategic crisis early warning system based on the nerve net method and offered the method of construction (Zhu, 2002); Hengjiang Liu and Jixiang Chen (2003) established a three-dimensional strategic crisis early warning system (Liu, 2003); Zehai Song (2005) established a strategic crisis management system involving crisis identification, early warning and management and so on.

Corresponding with strategic crisis early warning, the researches on enterprises’ financial early warning are quite necessary as well. We can borrow some theories and methods from financial early warning to study strategic crisis early warning. Only by employing strategic crisis early warning and financial early warning in a more reasonable way will multiplex enterprises achieve sound development. The existing resources can be taken full advantage of in diversification operation to expand business domain, enlarge business range, earn more profit growth points and lessen the fluctuation of incomes of an enterprise. From the perspective of an enterprise’s operation, any activity is accompanied by risks and the diversification strategy is intended to choose alternatives for risk system. Therefore, it is of particular importance to establish the core competitiveness of diversification operation. It is shown in practice that it is the basis for an enterprise’s survival and development at a critical moment to exercise its own core competitiveness. In order to achieve that, it is necessary and urgent to study the core competitiveness and strategic crisis early warning of multiplex enterprises. Based on the analysis on the diversification strategy of resources and technology-driven enterprises and the accompanying crisis, this paper proposes a strategic crisis early warning system centered upon the evaluation of core competitiveness and uses radar model in financial analysis to have quantitative research on strategic crisis condition in order to achieve better early warning for strategic crisis.

3. The Construction of Strategic Crisis Early Warning Model for Resources and Technology-Driven Multiplex Enterprises

3.1 Influential Factors of Strategic Crisis and the Selection of Early Warning Indicators

Here, driving factors mean those promoting enterprises’ development. Generally speaking, an enterprise’s strategic driving factors mainly include resources, technology, sales and so on. Resources-driven enterprises are expected to enter the upstream market and to strengthen their control over resources; technology-driven enterprises are expected to constantly innovate and develop new products to strengthen their core competitiveness; sales-driven enterprises should enhance their methods and influences of sales promotion to create market and open up new market. Of course, any activity is accompanied by risks, and the same holds true for the diversification strategy.

First, since the diversification strategy is based on the double driving forces of resources and technology, it is of particular importance to control resources and to pursue technology, especially those enterprises depending on
non-renewable resources. The control degree over the limited resources directly influences an enterprise’s status in competition. Generally, the higher the degree of control is, the more obvious an enterprise’s competition advantages will be. Capital scale, laborers’ quality or skills, production management, especially technological level, will all possibly lead to differences in resources. Although economic activities are intended to convert natural resources or conditions into valuable products or services, the pace and scale of conversion has to depend on the level of productivity, that is, the progress degree in science and technology. Therefore, in order to be set free from the restraints of resources, technological innovation has to be conducted and the crisis in resources and technology should be taken into consideration first of all.

Second, the diversification strategy aims at dispersing operation risks. However, excessive input in sidelines will also reduce an enterprise’s competition advantages. Therefore, the diversification degree and the market condition are also accompanying risks in the diversification strategy.

Finally, any enterprise will be faced with crisis in management and finance, so will the resources and technology-driven multiplex enterprises. With the development of enterprises and the diversification strategy, the staff scale is getting larger and capital is growing. As a result, the management of staff and capital will be more difficult.

On the whole, the major crises facing those resources and technology-driven multiplex enterprises include: resource crisis, technological crisis, the degree of diversification, market crisis, management crisis and financial crisis. Accordingly, this paper selects the following major indicators in different crises.

Four indicators compose resource crisis, including the discourse power in resources, the reserve-production ratio, the reserve replacement rate and strategic reserve limit. Here, the discourse power in resources refers to the control degree over raw materials and their replacements, especially those non-renewable raw materials. Only by strengthening the control over limited resources and their replacements will enterprises’ core competitive advantages be strengthened. Generally, this indicator can be got by being compared with the resources owned by the most powerful unit in the industry; the reserve-production ratio reflects the ability of the reserved resources in sustaining the current production level, which is manifested in the length of production. Supplies tend to be safer with a higher ratio between reserve and production, which can be reflected in this formula: the reserve-production ratio= the reserved resources by the end of a year/production ability of the year; the reserve replacement rate reflects the ratio between the newly-detected recoverable resources and reserve consumption (generally the output of the year) in a certain period (generally one year). The greater the reserve replacement rate is, the higher degree of resource safety will be, which is expressed in the formula: the reserve replacement rate= the newly-detected recoverable resources in a year/the reserve consumption of the year; the strategic reserve degree reflects the length of time during which reserved resources can be consumed. The greater the reserve degree is, the longer the reserve can support enterprises’ demands for consumption in emergency periods, the more obvious it will stabilize domestic market and the higher the safety degree will be. Otherwise, the safety degree will be lower. The formula of its calculation is: strategic reserve limit= the total of strategic reserve/ daily consumption.

There are three main indicators in technological crisis (Wu, 2003): the proportion of the R&D staff, the proportion of R&D funds input, technological level. The proportion of the R&D staff reflects something about the staff in an enterprise directly devoted to research and development, which is expressed in the formula: the proportion of the R&D staff= the number of the R&D staff/the total number of staff; the proportion of R&D funds input, reflecting the importance attached by enterprises to R&D, is expressed in the formula: the proportion of R&D funds input= the funds for R&D/sales income; technical level reflects the relevant level of an enterprise’s technology among similar enterprises over the world, which can be figured out by being compared with the highest technological level in the same industry.

Two main indicators make up the diversification degree: Herfindahl-Hirschman Index and the proportion of assets for the main business. In the formula of Herfindahl-Hirschman Index

\[ HHI = \sum \left(X_i / \sum_i X_i \right)^2 = \sum_i S_i^2 \]

\(X\) refers to the total sales volume of an enterprise and \(X_i\) refers to the sales volume of the main business of an enterprise; in addition, \(S_i = X_i / X\) means the proportion of the \(i\)th main business in the total sales volume; \(N\) means the number of main business conducted by an enterprise. The proportion of assets for the main business refers to the proportion of main business assets in total assets.

There are two indicators in market crisis: the market share of products (products in the main business) and the proportion of the sales staff. The market share of products reflects the market status of products and their...
infiltration into market while the proportion of the sales staff reflects an enterprise’s expectation for its market share.

Two indicators are included in management crisis: the growth rate of staff and the complication degree of interpersonal relationships. The growth rate of staff, reflecting the changes in staff, is expressed in the formula: the number of staff in the current period/ the number of staff in the previous period; the complication degree of interpersonal relationships can be expressed in the formula created by famous French sociologist Graicunas \( S = n(2^{\frac{m}{n}} + n - 1) \), in which \( n \) refers to the number of subordinate individuals or units. Therefore, the amount of mutual relationships tends to be increased sharply with the increase of subordinate individuals or units.

Two main indicators are included in financial crisis: the debt ratios and the degree of financial leverage. The former reflects the proportion of debts in an enterprise’s total assets with the formula of the volume of debts/ the total volume of assets. The higher the debt rate is, the higher profit rate the shareholders will earn from their investment under the precondition that the interest rate of debt is lower than the rate of return on assets. However, the higher the rate is, the poorer the debt-paying ability will be and the greater financial risks there will be. On the contrary, lower debt ratios reveal that clients have a cushion in funds when paying off debts. Generally speaking, debt ratios lower than 50% are favorable. The degree of financial leverage is expressed in the formula

\[
DFL = \frac{EBIT}{EBIT - I}
\]

in which \( EBIT \) refers to the profit before interest and tax and \( I \) refers to debt interest.

3.2 The Construction of a Model for Enterprises’ Strategic Crisis Early Warning Evaluation

Radar Analysis is a comprehensive method employed to evaluate financial conditions in Japan, which is named so because the figures about financial ratios drawn in this way look like radar. By improving the traditional radar analysis on finance to have more quantitative analysis, we can study the strategic crisis level of a multiplex enterprise quantitatively. In this figure, the value of indicators represent the crisis level and the area of the whole figure stands for the overall crisis level of a whole enterprise, hence sending early warning in the case of strategic crisis.

Radar analysis is improved to accomplish early warning in the following steps:

1. Supposing there are \( N \) indicators (\( N \geq 4 \)) in the evaluated project, they are to be sequenced in terms of weight and the weight of each indicator is \( \omega_i \). We require \( N \geq 4 \) because if \( N \geq 4 \), the angle between indicators won’t be greater than right angle, hence guaranteeing the area of the very section in proportion to enterprises’ crisis level (Fu, 2007).

2. The angle between evaluation indicator are calculated: \( \theta_i = 2\pi \omega_i \), in which \( \omega_i \) stands for the weight of the ith evaluation indicator.

3. Evaluation indicators are chosen and they should be standards and endowed with proper weights by experts.

4. Indicators are divided into key ones and non-key ones and it is supposed that there are \( m \) key indicators altogether.

5. Key indicators are arranged ahead of non-key ones and indicators are sequenced according to their weights. Standardized indicators are marked on the drawn circle starting from the horizontal forward direction counterclockwise.

6. A polygonal section is formed by connecting the points standing for all evaluation indicators, the area of which reveals the potential crisis facing an enterprise.

7. The area of the polygonal section and \( S \) are calculated with the formula

\[
S = \prod_{i=1}^{m} (1 - l_i) \sum_{i=1}^{N} \frac{1}{N} l_i \sin \theta_i,
\]

in which \( l_i \) means the evaluation level after standardization and it is agreed that \( l_i + \theta_i = \theta_1 \).

Since the value of indicators stands for the level of crisis, higher crisis level stands for greater risks facing enterprises, hence greater possibility for them to have strategic adjustment.

According to the above, if the area of the polygonal section, the overall crisis level, is greater than a pre-set top limit, the relevant enterprise needs to have strategic adjustment.

Because \( l_i \in [0,1] \), if the crisis level equals zero after the standardization of key indicators, the crisis level of the indicator is extremely low and therefore other indicators need to be examined; if it equals 1, the crisis level is extremely high and \( 1 - l_i = 0 \), hence \( S = 0 \); if \( S \) approaches 0, the crisis level of certain key indicator after
standardization approaches 1 and it has quite high level of crisis, hence calling for strategic adjustment. According to the above, key indicators are characterized by its absolutely decisive role in evaluating enterprises’ crisis condition. Therefore, only when an enterprise’s crisis level is lower than the top limit and S doesn’t approach 0 will it be free from strategic adjustment. In this model, the top limit can be set by experts or be calculated according to experience.

4. Analysis on the Established Model

First, the indicator system should be confirmed by converting those in opposite direction to the crisis level into the same direction, standardizing them and establishing key and non-key indicators; second, the weight of indicators should be confirmed and they are sequenced in terms of weight; finally, radar analysis is improved to conduct the specific steps of enterprises’ strategic crisis early warning, to draw a figure revealing the crisis level and send early warning accordingly.

Supposing the selected indicator system, its standardization and weight is just like the one shown in Table 1, the resources crisis and technological crisis are key indicators to show their crisis level as for those resources and technology-driven multiplex enterprises. Then a crisis level figure (as is shown in Figure 1) can be drawn after an analysis based on the above mentioned model, in which the top limit is 1 and the critical value of S is 0.001.

Through calculation, the crisis level in Figure 1 is 0.9153≤1 and S=0≤0.001, showing that this enterprise needs strategic adjustment. The causes lie in that it doesn’t attach enough importance to R&D, leading to an insufficient number of R&D staff or even null. Actually, the R&D staff and input in them act as a guarantee for enterprises’ development. As is revealed in a relevant survey made by Chongqing investigation leading group of National Bureau of Statistics (2009), 167 key enterprises increase their input in R&D and attach great importance to R&D staff in 2005. First, due to the emphasis on R&D, these enterprises’ capital input was sharply increased; second, the R&D staff got stronger in number and quality; third, due to the effect of a stimulation system based on staff’s income, the R&D staff’s income was constantly increased.

Supposing the weight of indicators is shown in Table 1, when all the standardized indicators have the value of 0.5, the crisis level is 0.4786≤1, S=0.0037≤0.001, showing this enterprise doesn’t need strategic adjustment; if the value of all standardized indicators reaches an ideal one: 0.2 0.2 0.8 0.2 0.7 0.7 0.5 0.5 0.5 0.8 0.7 0.1 0.9 0.5 0.8, the crisis level is 0.7067≤1 and S=0.0032≤0.001, showing no need for strategic adjustment; if the key indicators in the previous group of data fail to reach an ideal value: 0.2 0.2 0.8 0.2 0.9 0.9 0.5 0.5 0.5 0.8 0.7 0.1 0.9 0.5 0.8, the crisis level is 0.8165≤1 and S=0.00042≤0.001, calling for strategic adjustment because two indicators reach the value of 0.9 which stands for high risk and lead to the value of S approaching 0.

As is shown in the above empirical research, by employing such an early warning evaluation model to evaluate an enterprise’s strategic crisis level, we can get a quite intuitive and vivid figure and have a quantitative research on crisis level, hence producing favorable early warning effects. In addition, the introduction of S into this model also solves key indicators’ absolutely decisive characteristics.

5. Conclusion

The employment of radar analysis in the model of enterprise strategic crisis early warning not only maintains the intuitive and vivid features of radar figures but realize both qualitative and quantitative evaluations on enterprises’ conditions. It helps to quantitatively evaluate crisis conditions, send early warning and control strategic crisis as well as to quantitatively analyze the crisis conditions of a multiplex enterprise in different periods and the comparison between different enterprises in the same industry or between one’s own enterprise and others in terms of historical crisis in order to remain invincible in fierce market competition. By introducing the concept of S, key indicators’ absolutely decisive characteristics are solved.

Finally, the research on resources and technology-driven multiplex enterprises’ strategic crisis early warning is a quite challenging topic. In this paper, an improved radar model and a comprehensive evaluation method are employed to quantitatively study the crisis level of resources and technology-driven multiplex enterprises and give corresponding strategic crisis early warning. Based on the existing research achievements in China, this paper selects 15 specific indicators including the resources crisis, the technological crisis and so on. Due to the limitations in the author’s academic quality as well as materials, this research stills calls for further improvement and research. For example, the indicators related to the finiteness of resources need to be deepened, the quantitative research on the discourse right of resources and enterprises’ technological level also need to be standardized, so does the setting of the critical value of the top limit of crisis and S.
Table 1 The standardization and weight of indicators

<table>
<thead>
<tr>
<th>Types of Crisis</th>
<th>Indicators of Crisis</th>
<th>Standardization</th>
<th>The Value of Standardized Indicators</th>
<th>Weight of Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources Crisis</td>
<td>Discourse right of Resources $S_1$</td>
<td>$1 - S_1$</td>
<td>0.6</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Reserve-production Ratio $S_2$</td>
<td>$1/S_2$</td>
<td>0.7</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Reserve replacement rate $S_3$</td>
<td>$S_3$</td>
<td>0.8</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Degree of Strategic Reserve $S_4$</td>
<td>$1/S_4$</td>
<td>0.5</td>
<td>8%</td>
</tr>
<tr>
<td>Technological Crisis</td>
<td>The proportion of R&amp;D Staff $S_5$</td>
<td>$1 - S_5$</td>
<td>1.0</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>R&amp;D funds input ratio $S_6$</td>
<td>$1 - S_6$</td>
<td>0.5</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Technological level $S_7$</td>
<td>$1/S_7$</td>
<td>0.5</td>
<td>8%</td>
</tr>
<tr>
<td>Degree of Diversification</td>
<td>HHI coefficient $S_8$</td>
<td>$1 - S_8$</td>
<td>0.5</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>The proportion of assets for main business $S_9$</td>
<td>$1 - S_9$</td>
<td>0.5</td>
<td>4%</td>
</tr>
<tr>
<td>Market Crisis</td>
<td>Market share of products $S_{10}$</td>
<td>$1 - S_{10}$</td>
<td>0.5</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>The Proportion of sales staff $S_{11}$</td>
<td>$1 - S_{11}$</td>
<td>0.5</td>
<td>4%</td>
</tr>
<tr>
<td>Management Crisis</td>
<td>Staff growth rate $S_{12}$</td>
<td>$S_{12}$</td>
<td>0.5</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>The complication Degree of interpersonal relationships $S_{13}$</td>
<td>$1 - 1/S_{13}$</td>
<td>0.3</td>
<td>4%</td>
</tr>
<tr>
<td>Financial Crisis</td>
<td>Level of debts $S_{14}$</td>
<td>$S_{14}$</td>
<td>0.5</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Degree of financial leverage $S_{15}$</td>
<td>$1/S_{15}$</td>
<td>0.3</td>
<td>4%</td>
</tr>
</tbody>
</table>
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Figure 1. Strategic Crisis Level of an Enterprise