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Risk Warning Model and its Application of Enterprise Knowledge Innovation

Zhang Liyan and Mi Jun
Faculty of Business Administration, Shanxi University of Finance and Economics, China

Abstract: This study presents a quantitative risk warning model and an early warning index system of enterprise knowledge innovation through in-depth study. The risk warning model of enterprise knowledge innovation was constructed on the base of GM(1, 1) model and can provide Theoretical guidance in the process of enterprise knowledge innovation. Meanwhile, this model was successfully applied in Shanxi everpride Company Ltd.

Key words: Enterprise knowledge innovation, innovation risk, warning model, measurement of warning degree, prediction of warning degree

INTRODUCTION

Knowledge innovation is a complicated and dynamic process which is established on the basis of cyclical usage of wisdom continuously. Human being, as the carrier of knowledge, is endowed with the ability to adapt complex situations, with major impact from both subjective and objective conditions. Therefore, the process of knowledge innovation comes with high uncertainties. For enterprises, successful transformation of their achievements in knowledge innovation could help to sharpen competitive edge and thereby follow-up testing and promotion of the knowledge innovation achievements are all aimed to develop new industrial craft, new material or even new industry. At present, topics associated with knowledge innovation have become hotspots for research.

Chinese scholar, Lin *et al*. (2011) believes that profit is the primary motivation to the cooperation on the transformation of achievements in knowledge innovation in the market economy. Guo and Li (2011) together with other scholars, made an analysis on the risks of knowledge innovation, pointing out that the innovation of enterprises mainly comes from knowledge innovation itself, collaboration among corporations as well as external elements. Liu and Li (2011), together with other scholars, studied on the collaborative scheme of profits in the cross-enterprise knowledge innovation, believing that the main conflicts in such process lie in multiple aspects including knowledge evasion, risk-taking and income distribution. Yan (2011), analyzed dimensions and paths for knowledge innovation, finding that the knowledge innovation could be represented mainly in three dimensions namely knowledge-based techniques, market and management innovation. The previous researches concentrate more on the subject, mechanism, process and environment of knowledge innovation, lacking studies on warning system of risks in the transformation phase. This study presents a quantitative risk warning model and an early warning index system of enterprise knowledge innovation through in-depth study, aiming to provide better support for enterprises in their knowledge innovation achievements transformation drive.

RISK WARNING MODEL SCHEME SET-UP OF KNOWLEDGE INNOVATION ACHIEVEMENTS TRANSFORMATION

Design: The risk warning model mainly contains the following parts: index system set-up, testing model, prediction model, signal identification system and risk forecast, among which first step(index system set-up) is fundamental and serves as preliminary for the whole model. Testing model and prediction model stand as the core of the system, facilitating to figure out the tendency of risks and predict the possible deviation of actual result from expectation. Signal identification system is established based on testing model and security line. By comparison of the two, the system could identify the degree of deviation and launch alert. The design of whole model is illustrated in the following figure.

Risk warning index system set-up of knowledge innovation achievements transformation: The Risk Warning Index System of knowledge innovation achievements transformation mainly functions as a method to analyze the deviation of risk outcome from expectation and to predict the tendency of further development. Accordingly, control measures could be taken to curb the risks so as to ensure the expected progress of knowledge innovation achievements transformation.

Corresponding Author: Zhang Liyan, Faculty of Business Administration, Shanxi University of Finance and Economics, China

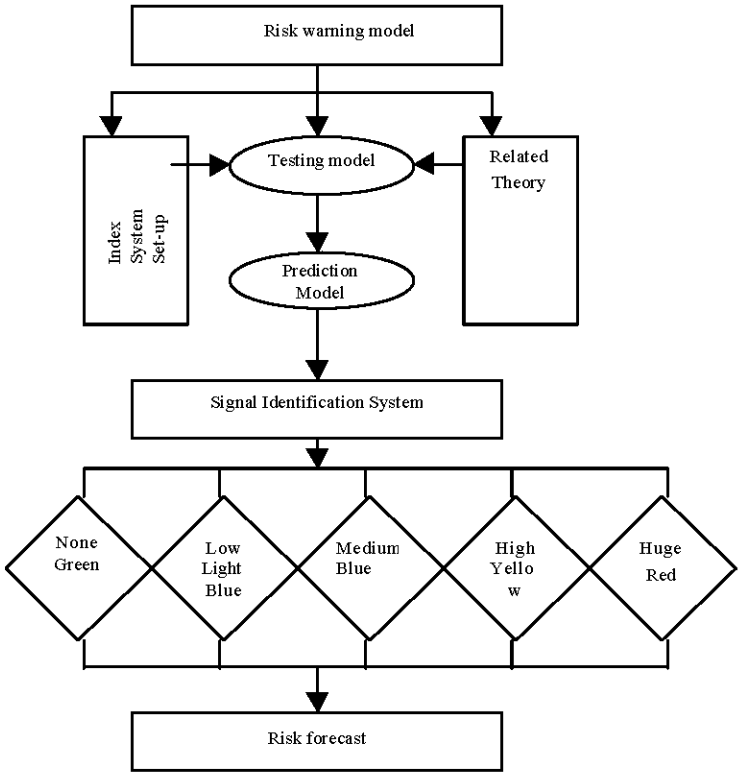

Fig. 1: Risk warning model

Based on such function requirement, the risk warning index system should be designed in a comprehensive and objective way in terms of risk description. Meanwhile, the system should also have the function to represent tendency of development. Therefore, in the process of knowledge innovation achievements transformation, a risk warning index system should be set up systematically, scientifically in a practical and forward-looking manner. In accordance with such principles, the thesis has designed the following system in Fig. 2.

Risk value testing model of knowledge innovation achievements transformation: The risk value is a measurement of the deviation of actual reformation risks from expected ones. The risk value is usually evaluated by Principal Component Analysis (PCA) or Pressure Index (PI). While PCA has a major disadvantage in deleting overlapped information, the outcome of testing may impacted by the correlation structure of the index. PI also has its shortcoming in subjectively defining the weight of each index. The thesis uses vector angle to measure the risk value. Each expected index value is regarded as a vector, so is each actual risk value. The deviation degree thereby could be figured out by calculating the angles of corresponding vectors. The multiple-index evaluation model of vector angle could represent dynamically the deviation of actual risk value of the expected one, from which the risk control of the enterprises could also be judged. The outcome of this model is only related to the index and the entity without any impact from sample volume and structure as well as index correlation, refraining from the disadvantages of both PCA and PI. Moreover, the calculation process is relatively simple with no need to develop special software.

In the process of establishing the testing model, the data in the index system should be standardized for the sake of precision.

Data standardization: Index could be divided into three types according to their natures namely performance type, cost type and interval type. For the performance type, the larger the value is, the better while for cost type, the smaller, the better. For interval type, it is the best when value stands in the certain domain [a, b]. In the knowledge innovation achievements transformation case, all the index are cost type which can be standardized in the following way:

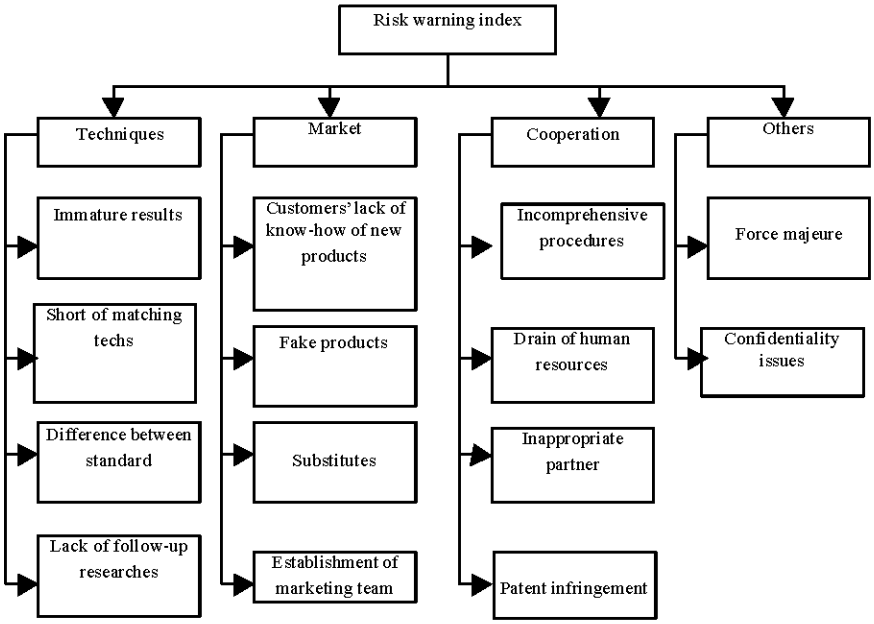

Fig. 2: Risk warning index

Table 1: Risk warning degree and security line division

Security line	$0 \le G_t < 5\%$	$0 \le G_t < 15\%$	$0 \le G_t < 30\%$	$0 \le G_t < 50\%$	$0 \ge G_t < 50\%$
Risk warning degree	None (green)	Low (light blue)	Medium (blue)	High (yellow)	Huge (red)

$$d_i^* = \frac{\sum_{i=1}^{n} d_i}{\frac{n}{d_i}} \quad (1)$$

Deviation degree: $D(0) = (d_1(0), d_2(0),..., d_n(0))$ represents the expected risk value of a company's knowledge innovation achievements transformation process in a certain period. $d_i(0)$ refers to the expected value of the index i. Meanwhile, the actual risk value of year t is set to be $D(t) = (d_1(t), d_2(t),..., d_n(t))$. Thus, each of the two sequences forms a vector of n dimensions, the angle of which reflects the deviation degree θ_t (year t). The wider the angle is, the larger the deviation is, vice versa.:

$$\theta_t = \frac{D(0)\cdot D(t)}{\|D(0)\|\cdot\|D(t)\|} = \frac{\sum_{i=1}^{n} d_i(0)\cdot d_i(t)}{(\sum_{i=1}^{n} d_i(0)^2)^{1/2}\times(\sum_{i=1}^{n} d_i(t)^2)^{1/2}} \quad (2)$$

According to the definition of the deviation degree of knowledge innovation achievements transformation process, it can be inferred that closer θ_t gets to 1, the smaller the risk value deviation is. Therefore, the risk value could be defined as following:

$$G_t = (1-\theta_t)\times 100\% \quad (3)$$

Warning signal would be identified by comparing G_t with certain security lines which has been set based on eight-year analysis of Shanxi Everpride Company's knowledge innovation achievements transformation practice as well as professional consultations. The relationship between G_t and security could be seen in the following table.

Risk value prediction model of knowledge innovation achievements transformation: Risk value prediction model of knowledge innovation achievements transformation serves to predict the possible situation and future tendency in the process, based on which the expected deviation could be concluded and warning alert be released accordingly. The sequence of deviation is a time series, the tendency of which can be predicted by varied models. Upon comprehensive analysis, grey GM(1, 1) is used here in this thesis. Grey GM(1, 1) is a prediction model on the basis of accumulated sequence which is set up in the following procedures:

Supposing: $D(0) = \{d^{(0)}(1), d^{(0)}(2),..., d^{(0)}(n)\}$ Which is a non-negative sequence of original data. After accumulating once, its 1-AGO (accumulating generation operator) data sequences is as following:

$$D^{(1)} = \{d^{(1)}(1), d^{(1)}(2),..., d^{(1)}(n)\}$$

of which:

$$d^{(1)}(m)=\sum_{i=1}^{m}d^{(0)}(m);\ m=1,2,\cdots,n \tag{4}$$

Accurate smoothness test of $D^{(0)}$: Testing if $D^{(0)}$ fit into following Eq.:

$$\begin{cases}\dfrac{\rho(m)}{\rho(m+1)}<1; m=2,3,\cdots,n-1\\ \rho(m)\in[0,\varepsilon]; m=3,4,\cdots,n\\ \varepsilon<0.5\end{cases} \tag{5}$$

of which:

$$\rho(m)=\frac{d^{(0)}(m)}{d^{(1)}(m)}$$

if $D^{(0)}$ fit into the Eq. 5, then it's an accurate smooth sequence.

Testing: Whether $D^{(1)}$ has accurate index law, when m>3:

$$\sigma^{(1)}(m)=\frac{d^{(1)}(m)}{d^{(1)}(m-1)}\in[1,1.5) \tag{6}$$

If $\sigma^{(1)}(m)$ satisfyEq. 6 then $D^{(1)}$ has accurate index law. If $D^{(0)}$ is accurate smooth sequence, $D^{(1)}$ has accurate index law, then GM (1, 1) could be established.

The tendency of the sequence could be approximately described by differential equation:

$$\frac{dd^{(1)}}{dt}+ad^{(1)}=u \tag{7}$$

Of which a, u are identifiable parameters£¬which can be fitted by least square method:

$$\begin{bmatrix}a\\u\end{bmatrix}=\left(B^{(T)}B\right)^{-1}B^{T}H_{N} \tag{8}$$

Construct data matrix: In the above Eq. 8, $H_N = [d^{(0)}(2), d^{(0)}(3),..., d^{(0)}(n)]^T$ is the constructed data matrix:

$$B=\begin{bmatrix}-0.5\left[d^{(1)}(1)+d^{(1)}(2)\right] & 1\\ -0.5\left[d^{(1)}(2)+d^{(1)}(3)\right] & 1\\ \vdots & \vdots\\ -0.5\left[d^{(1)}(n-1)+d^{(1)}(n)\right] & 1\end{bmatrix} \tag{9}$$

Drawing the prediction model:

$$\hat{d}^{(0)}(t+1)=\left[d^{(0)}(1)-\frac{u}{a}\right]e^{-at}+\frac{u}{a} \tag{10}$$

Model testing:

- e(m), the residual error, Δm, the relative error and $\bar{\Delta}$, the average relative error between $d^{(0)}m$ and $\hat{d}^{(0)}(m)$ need to be obtained:

$$e^{(0)}(m)=d^{(0)}(m)-\hat{d}^{(0)}(m),\ \Delta_m=\left|\frac{e(m)}{d^{(0)}(m)}\right|,\ \bar{\Delta}=\frac{1}{n}\sum_{m=2}^{n}\Delta_m \tag{11}$$

- $\bar{d}$, the average value of original data, $\bar{e}$ the average residual error:

$$\bar{d}=\frac{1}{n}\sum_{m=1}^{n}d^{(0)}(m),\ \bar{e}=\frac{1}{n-1}\sum_{m=2}^{n}e^{(0)}(m) \tag{12}$$

- S^2_1, the variance of original data, S^2_2, residual variance, λ, mean square deviation, P, the small possibility of error:

$$S_1^2=\frac{1}{n}\sum_{m=1}^{n}\left[d^{(0)}(m)-\bar{d}\right]^2,\ S_2^2=\frac{1}{n-1}\sum_{m=2}^{n}\left[e^{(0)}(m)-\bar{e}\right]^2 \tag{13}$$

$$\lambda=\frac{S_2}{S_1},\ P=P\left\{|e^{(0)}(m)-\bar{e}|<0.6745S_1\right\} \tag{14}$$

Generally speaking, the smaller $e(m), \Delta_m, \bar{\Delta}, \lambda$ is, the larger P is and the model becomes more accurate. If $\bar{\Delta}<0.01, \bar{\Delta}_m<0.01, \lambda<0.35, P>0.95$, then the model has an accuracy of one level.According to the grey system theory, if a∈(-2, 2), a≥-0.3, then the GM(1, 1) could be used for medium to long term prediction.

With the method introduced above, deviation degree in the knowledge innovation achievements transformation could be obtained for determining warning level and then risk forecast can be made. The forecast serves as useful information for better risk control and management, enabling the enterprise to curb the risks under expected degree.

EMPIRICAL RESEARCH

Evaluation of the risks in the knowledge innovation achievements transformation process of Shanxi Everpride Company Ltd., Shanxi Everpride Company Ltd., established in 1995, is a Hong Kong company of pharmaceutical development and production. The dual involvements in research and practical production make knowledge innovation achievements transformation an indispensible part of the company. The above-introduced risk testing model and risk warning index system have been applied to the evaluation of the company's situation

Table 2: Knowledge innovation achievements alert degree of the risk value about Shanxi Everpride Company Ltd. from 2003-2012

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
G_t(%)	20.82	17.25	16.93	15.82	18.01	11.45	9.47	8.36	8.12	7.54
Warning degree	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low
Warning light	Blue	Blue	Blue	Blue	Blue	L-blue	L-blue	L-blue	L-blue	L-blue

Table 3: Risk value forecast of Shanxi Everpride Company from 2014-2020

Year	2014	2015	2016	2017	2018	2019	2020
G_t(%)	7.12	6.93	5.87	5.43	4.98	4.43	4.32

in ten years, 2003-2012. First, warning threshold of each year has been settled based on the recorded documents. Then, taking the company's expected value of each index in 2004, the risk degrees from 2003-2012 have been concluded by the warning testing model.

IT can be seen in the Table 2 that the risk value of Shanxi Everpride Company kept dropping in the ten years from medium warning to the low level. The deviation of actual value from the expected value kept going down, representing the effective effort the company has done in controlling risks in its knowledge innovation achievements transformation practice.

Risk Value Forecast of Shanxi Everpride Company in its knowledge innovation achievements transformation, Taking the smoothness test of $D^{(0)}$, the risks value of the company during 2003-2012, it can be obtained that: when $m \geq 2$:

$$\frac{\rho(m)}{\rho(m+1)} < 1$$

$0.050<\rho(m)<0.454$, $D^{(0)}$ is smooth. Meanwhile, for $D^{(1)}$(the 1-AGO of $D^{(0)}$), when $m \geq 3$, $1.053<\sigma(m)<1.445$, so $D^{(1)}$ is accurate index. It can be concluded that the sequence composed by risk values of the company during 2003-2012 fit into the requirements to establish a grey GM (1, 1) model. Therefore, grey GM (1, 1) can be used to predict the risk warning degree of the company in year 2014 -2020. The time respond function of the established grey GM (1, 1) model is $\hat{d}^{(1)}(m+1) = -165.31e^{-0.108m} + 187.23$, of which $\alpha \in (-2, 2)$ and $\alpha \geq -0.3$. The model is valid for medium or long term forecast. Moreover, as the accuracy of the model is over 90%. The predicted values are shown in the following table.

From 2014-2020, the risk value of Shanxi Everpride Company in its knowledge innovation achievements transformation will decrease steadily, entering into the no-warning zone in 2018. Such a tendency is owing to the innovation strategy rolling out by the company during the 12th five-year plan. Shanxi Everpride Company has always given prominence to the risk control in its knowledge innovation achievements transformation process. In spite of the excellent performance, the company still needs to pay enough attention to is risk management which is of vital importance.

CONCLUSION

Upon comprehensive understanding of risk warning theories, thesis constructs a risk warning index system and set up a risk testing model with the concept of vector angles. By establishing risk forecast model on the basis of grey GM (1, 1), the thesis provides enterprises with a feasible model to evaluate risks quantitatively in knowledge innovation achievements transformation. The empirical research of Shanxi Everpride Company reveals that the risk value would keep decreasing from 2014-2020, entering into the no-warning zone in 2018.

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