Analysis and Quantitative Research on Early Warning Model for Enterprise Human Resource Based on Extension Theory

Fangjing Li
Xi'an International University, Xi'an710077, China

Abstract

This paper explains the early warning process and the early warning indexes of human resource imbalance from the perspective of the imbalanced structure of human resource. Based on this, an early warning evaluation model for enterprise human resource management is established based on the extension theory. Through the identification of the parameters in the early warning model and the actual case of enterprise human resources, the application of the early warning model for human resources is quantitatively analyzed. The research shows that this method provides managers with effective early warning measures and research analysis to deal with the crisis of human resources imbalance.

Keywords: enterprise human resource, extension theory, early warning model, quantitative analysis

1. INTRODUCTION

In the 21st century, talented individuals are the most essential factor in scientific and technological progress and enterprise development. Human resource management is the management of the talented, which has become the focus of attention of the enterprises (Shi and Fu, 2013). In the development of an enterprise, three common crises include human resource crisis, industry crisis, and product and service crisis (Schuler and Jackson, 2014), where human resource crisis is the most influential one. Generally speaking, human resource means the management and the structure of the business in the aspect of the talented (Xu and Ding, 2015). The matching degree between human resource and enterprise development strategy, to a certain extent, determines the successful implementation of enterprise strategy. The crisis of human resource management will lead to the loss of the talented, which on the one hand brings about a negative impact on their own business, and on the other hand indirectly enhances the competence of the talented in its competitors (Dai, 2014). Therefore, it is necessary for the managers to control enterprise human resources, including the comprehensive monitoring of the management of enterprise human resources, the explicitation and the trend of various human resource data and the early detection of management problems (Lowe et al., 2013). The construction of human resource early warning system is an essential guarantee of realizing the strategic goal of enterprises (Li and Wang, 2014). However, in China, such a system has not yet been formed. The establishment of an early warning model on the basis of extension theory provides the enterprises with a quantitative processing tool to strengthen crisis prevention and monitoring management.

Human resource structure imbalance refers to that the management of human resource structure deviates from the strategic development of the enterprise and operates in a low efficiency. At the same time, the internal structure of human resource also has large fluctuation, personnel error and other problems (Popov and Popova, 1993). In order to cope with the crisis of structural imbalance of enterprise human resources and to maintain the sustainable development of the enterprises, a number of theories and strategies are applied to the management and the early warnings of enterprise human resources. Extension theory is employed to establish an early warning model for the imbalance of human resources structure, thereby monitoring and diagnosing the imbalance of human resource (Black, 2000; Cigoli and Metere, 2016; Tripathi et al., 2005). Various resources are employed reasonably and efficiently to develop appropriate strategies and solutions for different levels of alarms, so as to avoid greater losses and to increase the efficiency of human resource management. Due to limited application of extension theory in enterprise human resource management, this paper combines the extension theory from the perspective of the crisis management of enterprise human resource and explores the construction of early warning model for human resource.
2. EARLY WARNINGS OF THE IMBALANCED STRUCTURE OF ENTERPRISE HUMAN RESOURCE

2.1 Implications of the early warnings of the imbalanced structure of enterprise human resource

The phrase “early warning” first appeared in the field of military, which implies the preventive measures taken to cope with sudden attacks. When the form and the predetermined setpoint of the defensive target are to meet or exceed the set value, it indicates that the probability of a sudden attack will be greatly increased, so an alarm will be issued in advance to allow the decision makers to make a corresponding decision (Latham, 2003; Hafeez and Abdelmeguid, 2003). Therefore, early warning, by nature, is an internal mechanism for information feedback. Early warning of human resource structure imbalance refers to anticipatory assessment about structure imbalance of enterprise human resources caused by various reasons, as well as prior identification and determination of the risks of human resource structure imbalance in the enterprise by means of quantitative methods, thereby identifying the future issue of over-imbalance of human resource structure and its causes in advance.

2.2 Early warning process of the imbalanced structure of enterprise human resources

In order to better understand the early warnings of imbalanced enterprise human resource, the following part will explain the process of constructing early warnings in the case of imbalanced enterprise human resources. This section will provide technical guidance for the establishment of early warning evaluation model in the following sections (Cai, 1999; Yao and Zhu, 2008).

(1) Collect and filter early warning messages. The collection of early warning information is the basis and the source of the early warning process. Therefore, this is the first step in the early warning of human resource structure imbalance, also the starting point of the early warning process, which is called “locate the source” (Jackson and Schuler, 2003).

(2) Select the indexes of early warning and clearly identify the meanings and the fact of alarms, in other words, design an early warning index system. Relevant indexes that accurately reflect human resources structure imbalance are selected according to certain principles. The selection of early warning indexes is a crucial link in the early warning process of the structure imbalance of enterprise human resource.

(3) Determine the degree of early warning, to be specific, the relevancy degree between the early warning indexes and the corresponding degree of risk. Only through different degrees of early warning, are managers in the enterprise able to make corresponding judgments and appropriate strategies for human resource management.

(4) Build up an early warning model. As the early warning method is used to realize the purpose of forecasting the warning degree, the selection of the appropriate early warning method can effectively achieve early warnings.

(5) Issue an alarm. It is necessary to decide whether the various warning indexes and factors break through the early warning lines of the risk of human resource structure imbalance, as well as whether to issue an alarm according to the judgment results.

The operation flow chart of the early warning process of enterprise human resource structure imbalance is shown in Figure 1.
3. EARLY WARNING MODEL FOR THE STRUCTURE IMBALANCE OF ENTERPRISE HUMAN RESOURCES BASED ON EXTENSION THEORY

3.1 Steps of constructing an early warning evaluation model based on extension theory

1. Determine the classic domain

\[
R_{0j} = \left( N_{0j}, c_i, x_{0ji} \right) = \left[ \begin{array}{c}
N_{0j} \\
c_1 \\
x_{0j1} \\
c_2 \\
x_{0j2} \\
\vdots \\
\vdots \\
c_n \\
x_{0jn}
\end{array} \right] = \left[ N_{0j} \right] c_1 \left[ \begin{array}{c}
a_{0j1}, b_{0j1} \\
a_{0j2}, b_{0j2} \\
\vdots \\
\vdots \\
a_{0jn}, b_{0jn}
\end{array} \right]
\]

(1)

As shown in Equation (1), \( N_{0j} \) represents \( j \) different levels. \( c_i (1, 2, \ldots, n) \) means the characteristics of the hierarchy \( N_{0j} \). \( x_{0ji}=(a_{0ji}, b_{0ji}) \) stands for the range of the values specified by the characteristics \( c_i \) of \( N_{0j} \). The concept of classical domain is the range of data corresponding to each eigenvalue.

2. Determine the section domain

\[
R_p = \left( P, c_i, x_{pi} \right) = \left[ \begin{array}{c}
P \\
c_1 \\
x_{p1} \\
c_2 \\
x_{p2} \\
\vdots \\
\vdots \\
c_n \\
x_{pn}
\end{array} \right] = \left[ P \right] c_1 \left[ \begin{array}{c}
a_{p1}, b_{p1} \\
a_{p2}, b_{p2} \\
\vdots \\
\vdots \\
a_{pn}, b_{pn}
\end{array} \right]
\]

(2)

In Formula (2), \( P \) represents the entire grade. \( x_{pi} \) is the range of \( P \) corresponding to \( c_i \), as in the section domain of \( P \).

3. Determine the matter elements of the objects that need to be identified
Assume \( P \) is the object to be identified. In Equation 3, matter object is used to represent the detection data or the detection result of \( P \), the object to be identified:

Formula (3) concerns \( P \)'s to-be-identified matter object, where \( P \) represents a certain object. \( x_i \) is the value of \( P \) corresponding to \( c_i \), that is, the specific data of the object to be identified with respect to each characteristics.

4. Determine the weight coefficient

Determine the conditions that must be met by the weight coefficients \( \lambda_i = \{\lambda_1, \lambda_2, \ldots, \lambda_n\} \) of each characteristics. If the \( k \)th characteristics element is a condition that must be satisfied, then \( \sum_{i=1, i \neq k}^{n} \lambda_i = 1 \).

5. The first evaluation

The value \( x_i \) of characteristics \( c_i \) that must be satisfied is used for evaluation: ① If \( x_k \notin x_{0ji} \), so it is regarded that \( P \) does not satisfy the necessary condition and \( P \) is considered as the unqualified object. ② If \( x_k \in x_{0ji} \), it goes into the next step.

6. Calculate and determine the relevance degree of each level of the objects that need to be identified.

The calculation of the relevance degree of the objects that need to be identified is shown in Formula 4.

\[
K_j (x_i) = \begin{cases} 
\rho (x_{0ji}, x_{0il}) - \rho (x_{0ji}, x_{pi}) & \rho (x_{0ji}, x_{0il}) \neq \rho (x_{0ji}, x_{pi}) \\
0 & \text{otherwise}
\end{cases}
\]

In Formula (4), \( \rho (x_{0ji}, x_{0il}) \) represents the \( x_{0ji}, x_{0il} \) distance respectively.

7. Calculate the degree of relevance

The degree of relevance \( K_j (p) = \sum_{i=1}^{n} \lambda_i K_j (x_i) \) of each characteristic of object \( P \) with respect to \( j \) on each level.

8. Grade evaluation

If \( K_{j0} (p) = \max_{j \in \{1, 2, \ldots, m\}} K_j (p) \), \( p \) is evaluated as Grade \( j_0 \).

3.2 Evaluation index and evaluation level

Due to the independence of each index in the evaluation model of extension theory, there exist relevant characteristics among the related indexes of enterprise human resource early warning. Evaluation indexes are determined, including the matching degree of human resource goal and enterprise strategy development direction, the execution of human resource system, human resource efficiency, income, value added, returns and so on (Chang et al., 2014). The specific classification results are shown in Table 1.

Table 1 Matching degree of Human Resource Objectives and Enterprise Strategy Development Direction and Human Resource Benefit Level Classification Criteria

<table>
<thead>
<tr>
<th>Early warning level</th>
<th>Matching degree of Human Resource Objectives and Enterprise Strategy Development Direction</th>
<th>Rank</th>
<th>The Benefit of Human Resources</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe</td>
<td>Match perfectly</td>
<td>0~2</td>
<td>No affect or with few affect</td>
<td>0~2</td>
</tr>
<tr>
<td>Attention</td>
<td>Basic match may need to be coordinated</td>
<td>2~4</td>
<td>Affecting a small number of follow-up strategies</td>
<td>2~4</td>
</tr>
</tbody>
</table>

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In the early warning system, in order to improve the accuracy of the early warnings of enterprise human resource structure imbalance, in the following section, indexes are classified as “safe”, “attention”, “alert”, “dangerous”, and “crisis” for early warning modeling. The status of early warning mode is based on the relevant data obtained via monitoring. Data is substituted in the calculation model, and the relevance degree of each index is calculated. Then, the threshold value of the calculated values are obtained, and the alarm levels of enterprise human resource structure imbalance are determined. The indexes of early warning will be non-dimensionalized, so that each index will share a unified standard for early warning processing, as shown in Table 2.

<table>
<thead>
<tr>
<th>Early warning level</th>
<th>The implementation of human resources system</th>
<th>Human resources system to obtain degrees</th>
<th>The retention and development of human resources system</th>
<th>Human Resources Coordination</th>
<th>The Matching degree</th>
<th>The Benefit of Human Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe</td>
<td>≥90%</td>
<td>≥90%</td>
<td>≥90%</td>
<td>≥90%</td>
<td>0~2</td>
<td>0~1</td>
</tr>
<tr>
<td>Attention</td>
<td>80%~90%</td>
<td>80%~90%</td>
<td>75%~85%</td>
<td>80%~90%</td>
<td>2~4</td>
<td>1~3</td>
</tr>
<tr>
<td>Alert</td>
<td>70%~80%</td>
<td>60%~80%</td>
<td>60%~75%</td>
<td>60%~80%</td>
<td>4~7</td>
<td>3~7</td>
</tr>
<tr>
<td>Dangerous</td>
<td>50%~70%</td>
<td>40%~60%</td>
<td>40%~60%</td>
<td>40%~60%</td>
<td>7~9</td>
<td>7~9</td>
</tr>
<tr>
<td>Crisis</td>
<td>≤50%</td>
<td>≤40%</td>
<td>≤40%</td>
<td>≤40%</td>
<td>9~10</td>
<td>9~10</td>
</tr>
</tbody>
</table>

The early warning index system combines the common elements of general enterprise human resources structure imbalance, but also leaves flexible choices for specific enterprises. In this way, an early warning index system that combines commonality and personality not only has a guiding role in the management of resource structure imbalance in most enterprises, but also takes into account the specificity of specific enterprises with a certain flexibility. Therefore, the relationship of the early warning index system for enterprise human resource structure imbalance is illustrated as Figure 2.

Figure 2. Diagram of early warning index system for enterprise human resources
3.3 Determine index weights of early warning model

The human resource early warning model takes into account the difference among the enterprise development strategies and the degree of interest of various factors, as well as the contribution size and direction of each early warning index, which will be more appropriate with the actual situation of the enterprise. This paper adopts the pairwise comparison matrix to conduct quantitative analysis on the specific weight coefficients of early warning indexes of enterprise human resource structure imbalance.

The comparison matrix is:

\[
\begin{array}{cccccc}
1 & 2 & 2 & 1/4 & 1/2 & 1/8 \\
1/2 & 1 & 1/2 & 1/4 & 1/2 & 1/8 \\
1/2 & 2 & 1 & 1/3 & 2 & 1/6 \\
4 & 4 & 3 & 1 & 3 & 2 \\
2 & 2 & 1/2 & 1/3 & 1 & 1/3 \\
8 & 8 & 6 & 1/2 & 3 & 1 \\
\end{array}
\]

The weight coefficients of each index in the early warning model for enterprise human resources are \( \lambda = (0.1588, 0.4941, 0.6237, 0.3473, 0.4559, 0.0927) \). This set of weight coefficients reflects the importance of human resource structure to the imbalance indexes.

According to the indexes in the early warning mode in Table 1, the modes of safe, attention, alert, dangerous and crisis respectively represent \( R_0^1, R_0^2, R_0^3, R_0^4, R_0^5, c_i (i=1,2,3,4,5,6) \) indicating the characteristics of each early warning index. Through quantitative analysis, the safety rating scale of enterprise human resources is as shown in formula (5).

\[
R_0^1 = \begin{bmatrix}
\text{Safe} & c_1 & (0.9,1) \\
\text{c_2} & (0.9,1) \\
\text{c_3} & (0.85,1) \\
\text{c_4} & (0.9,1) \\
\text{c_5} & (0.2) \\
\text{c_6} & (0.1)
\end{bmatrix}, \ldots, R_0^5 = \begin{bmatrix}
\text{Crisis} & c_1 & (0.5) \\
\text{c_2} & (0.4) \\
\text{c_3} & (0.4) \\
\text{c_4} & (0.4) \\
\text{c_5} & (9,10) \\
\text{c_6} & (9,10)
\end{bmatrix}
\]

\[
R_p = \begin{bmatrix}
\text{level} & c_1 & (1) \\
\text{c_2} & (1) \\
\text{c_3} & (1) \\
\text{c_4} & (1) \\
\text{c_5} & (10) \\
\text{c_6} & (10)
\end{bmatrix}
\]

4. QUANTITATIVE ANALYSIS ON THE APPLICATION OF CASE

In order to be able to directly guide the enterprise’s grasp of the early warning model, this paper selects two enterprises as the reference. The steps mentioned in 3.1 are followed to conduct a quantitative analysis on the safety levels of different enterprises. Assume that the two enterprises are A and B. The matter element models for human resource imbalance of the two enterprises are as follows.

Enterprise A

\[
R_A = \begin{bmatrix}
\text{N} & c_1 & 0.94 \\
c_2 & 0.9 \\
c_3 & 0.85 \\
c_4 & 0.89 \\
c_5 & 8.5 \\
c_6 & 9
\end{bmatrix}
\]

The value of the associated function is

\[
K_{IA}(v_i) = \begin{bmatrix}
2 & -0.4 & -0.7 & -0.8 & -0.88 \\
0 & 0 & -0.5 & -0.75 & -0.8333 \\
0 & 0 & -0.4 & -0.625 & -0.75 \\
-0.0833 & 0.1 & -0.45 & -0.725 & -0.8167 \\
-0.08125 & -0.75 & -0.5 & -0.5 & -0.25 \\
-0.8889 & -0.8571 & -0.6667 & 0 & 0
\end{bmatrix}
\]
Calculate the relevance degree of the grade of human resource structure imbalance in Enterprise A: 

\[ K_{ja}(P) = (-0.1642, -0.4502, -1.0537, -0.9113, -1.4169) \]

According to the grading standards in Step 8 in section 3.1, Enterprise A is currently at the “safe” mode in terms of human resource imbalance. To be specific, in the case of Enterprise A, the distribution of human resource structure is reasonable, the utilization of resources is sufficient and the efficiency of human resource is favorable. The human resource structure is under sustainable development and it has a complementary effect on the overall future development of this enterprise. It is due to this consistency that human resources of this enterprise are positively valued, and Enterprise A continues to develop under its guidance.

Enterprise B

\[
R_B = \begin{bmatrix}
N & c_1 & 0.35 \\
  & c_2 & 0.6 \\
  & c_3 & 0.55 \\
  & c_4 & 0.4 \\
  & c_5 & 3 \\
  & c_6 & 6
\end{bmatrix}
\]

The value of the associated function is

\[
K_{jb}(v_i) = \begin{bmatrix}
-0.6111 & -0.5625 & -0.5 & -0.3 & -0.75 \\
-0.4286 & -0.3333 & 0 & 0 & -0.3373 \\
-0.4 & -0.3077 & -0.1 & -0.125 & -0.25 \\
-0.5556 & 0.5 & -0.3333 & 0 & 0 \\
-0.25 & -0.5 & -0.25 & -0.5714 & -0.6667 \\
-0.5556 & -0.4286 & -0.3333 & -0.2 & -0.4286
\end{bmatrix}
\]

Similarly, the relevance degree of the grade of human resource structure imbalance in Enterprise B: 

\[ K_{jb}(P) = (-0.1642, -0.4502, -1.0537, -0.9113, -1.4169) \]

At this stage, the human resource imbalance of Enterprise B is at the “dangerous” mode. In other words, the matching degree of human resources goal and business strategy development direction is not high, and enterprise human resource structure and human resources development is poorly coordinated. Without timely adjustment of the enterprise human resource structure and optimized allocation of human resources, the enterprise would face brain drain and other crises, thereby leading to possible corporate bankruptcy.

The above two examples show that the extension matter element analysis technology of the early warning evaluation model is successfully applied to the early warning analysis on Enterprise A and Enterprise B. Therefore, this feasible method provides a new quantifiable path for human resource structure imbalance in large-scale enterprises that involves multi-level and multi-system integration. The method of matter-element analysis based on extension theory overcomes the shortcomings of the traditional early warning model that ineffectively monitors the complex performance of the object. It also provides an effective method of calculation for determining the correlation function between the relevance and the divergence of the early warning index information for complex cases. Matter-element analysis technology is applied to the construction of the early-warning system of enterprise human resource structure imbalance. Classification and issue of the alarm are based on the characteristics of the sample data itself. There is no need to preset the weight of each early warning index, which reflects the objective reality of the enterprise, with the advantages of intuition and operability meanwhile.

5. CONCLUSION

This paper is based on the lack of research on the early warning of human resource in the enterprise. First of all, the paper explains the meaning of human resource structure imbalance and the process of imbalance, as well as the process of human resource imbalance warning. On this basis, an early warning evaluation model for enterprise human resource is established, with the help of matter-element analysis of the extension theory. Besides, through the determination of the indexes and the weights of human resources, the quantitative analysis
method is used to quantitatively analyze and verify the feasibility of the early warning evaluation model. Research significance of this paper is as follows.

(1) This paper conducts qualitative and quantitative description of human resource structure imbalance and provides valuable reference data for enterprises to adopt the corresponding strategic measures.

(2) Through the adoption of matter-element method, based on the extension theory, the key indexes of enterprise human resource are identified, and the crisis signal and early warning levels are effectively classified and divided. In this way, timely adjustments are made in accord with the development trend of enterprise human resource structure imbalance, and the actual situation of changes in human resources structure development is favorably reflected.

(3) Because there exists relative independency among the classic domain of the indexes, the early warning model and the calculation of relevancy degree, the early warning model holds favorable adaptability and high stability.

6. REFERENCES