Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 13 (10): 1833-1837, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.1833.1837

Quality Defect Management Ability Evaluation of Enterprises Based on Projection Pursuit and Optimal Segmentation: Explanatory Framework of Medical Analogy and Metaphor Thought

Liping Shi and Qiang Liu
School of Economics and Management, Harbin Engineering University, Harbin 150001, China

Abstract: This study follows medical analogy and metaphor thought, based on the similarities between quality defect of enterprises and disease in the medical field, analogies and metaphors the management process of disease in the medical field with the management process of quality defect of enterprises, refers to relevant literatures to establish quality defect management ability evaluation indicators system, the system includes quality defect diagnosis ability, quality defect governance ability and subsequent improvement ability of quality defect governance. Set typical thirty enterprises of Heilongjiang Province as an example, use projection pursuit to evaluate quality defect management ability of enterprises, employ optimal segmentation method to cluster and optimize the evaluation results. Study results will provide theoretical foundations for managing quality defect of enterprises and enhancing quality defect management ability.

Key words: Quality defect management ability, quality defect, evaluation

INTRODUCTION

In recent years, product quality issues of enterprises in China have emerged quickly, which seriously affect quality performance of enterprises, normal production and operation, economic efficiency. Quality defect of enterprises exists in the whole process of production and operation of enterprises objectively, which threatens quality performance, operation performance, economic efficiency, social image and public satisfaction, brings about serious and negative impacts. Therefore, managing quality defect reasonably, enhancing quality defect management ability and evaluating quality defect management ability properly are the key channels of fully understanding the quality defect management ability status. Quality defect management ability has gradually become the focus of academic research. Scholars carry out useful explorations for the relevant contents of quality defect and quality defect management, relevant literature results of quality defect management ability and quality defect management ability evaluation are lack. This study follows medical analogy and metaphor thought, based on the similarities between quality defect and disease in the medical field, analogies and metaphors the management process of disease in the medical field with the management process of quality defect, refers to relevant literatures to establish quality defect management ability evaluation indicators system. Use projection pursuit to evaluate quality defect management ability, employ optimum segmentation method to cluster and optimize the evaluation results, find out the weak linkages and bottlenecks places of affecting the enhancement of quality defect management ability in order to provide references for reducing quality defect and being beneficial to implementing quality defect management activity.

ESTABLISHIMENT OF QUALITY DEFECT MANAGEMENT ABILITY EVALUATION INDICATORS SYSTEM

Quality defect exists in the whole process of production and operations objectively, is a activity that possess obviously bidirectional attributes, its presence and spread not only leads to negative effects on economic efficiency, normal production and operation, social image of enterprises, but also results in negative effects on consumers, which mainly includes objectivity and universality, controllability, high hazard, concurrency, infectious, bidirectional attributes. Facts and practices have proved that quality defect can be controlled and eliminated, enterprises should enhance quality defect management ability in order to manage quality defect effectively.

Quality defect has some similarities in attributes with disease attributes in the medical field. Refer to the literatures that transplant, analogy and metaphor the concepts of disease diagnosis, health care and improving energy with the theories and practices of enterprises

Corresponding Author: Liping Shi, School of Economics and Management, Harbin Engineering University, Harbin 150001, China

management in the medical filed (Wang and Sun, 2005; Meng and Wang, 2003; Gao, 2002; Wang and Wei, 2005; Zou, 2007), analogy and metaphor the management process of disease(generally include disease diagnosis, disease governance and subsequent improvement of disease governance) in the medical field with the management process of quality defect, adopt literature extraction methods(Fening *et al*., 2008; Lakhal *et al*., 2006; Wang and Guo, 2007; Wang, 2005; DePasquale and Geller, 1999), collect the expert opinions of relevant fields and interviews of medium-sized enterprises, follow operability, scientific, practical, clear layer principles to establish quality defect management ability evaluation indicators system. Goal indicator is quality defect management ability, the corresponding evaluation indicators include quality defect diagnosis ability, quality defect governance ability and subsequent improvement ability of quality defect governance.

Quality defect diagnosis ability is an ability that comprehensively inspects and diagnoses quality defect through scientific methods and instruments based on principle and normal process, determine the existence types of quality defect and the states of quality defect. Quality defect diagnosis ability is the premise and basis of enhancing quality defect management ability. Its evaluation indicators include the timeliness of quality defect diagnosis, quality defect diagnosis institutions, the retrospective attributes of quality defect diagnosis, quality defect diagnosis investment, quality defect diagnosis methods, quality defect diagnosis process, diagnosing and identifying the severity levels and governance priority levels of quality defect.

Quality defect governance ability is a ability that implement governance of the quality defect diagnosed by the diagnosis programs through scientific programs and governance means, eliminate the triggering dominant quality defect, obtain governance output. Quality defect governance ability includes basic ability of quality defect governance and core ability of quality defect governance. Its evaluation indicators include quality defect governance aspiration, improvement and optimization of quality defect governance programs, the communication of quality defect governance, strategic planning of quality defect governance, standardization of quality defect governance, timeliness of quality defect governance, quality defect governance investment, completeness of quality defect governance equipment, knowledge and skills of quality defects governance, production and operation environment, rules and regulations of quality defect governance, quality defect governance infrastructure, integration of quality defect governance methods, quality defect governance philosophy, quality defect governance efficiencies(include quality performance, operation performance, economic efficiency and social image of enterprises), physiological and psychological states of employee.

Subsequent improvement ability of quality defect governance is a ability that enterprises continuously track, continuously improve, positively feedback, summarize and store the results and performances of quality defect diagnosis and governance. Its evaluation indicators include quality defect governance performance evaluation system, summary and record of quality defect governance experience and knowledge, correcting and storing quality defect governance programs, continuous improvement and optimization of quality defect diagnosis and governance processes, quality defect governance results feedback, improving the information system that can assist the enterprises in implementing quality defect diagnosis and governance activities.

EMPRICAL ANALYSIS

Select thirty typical manufacturing enterprises (the manufacturing enterprises are typical in output values, total profits, total assets, number of employee, etc) in Heilongjiang province of China as empirical objects. These enterprises are committed to planning and managing quality defect rationally in order to enhance quality defect management ability, which have good performances in quality management, quality performance, operation performance and social image. This study adopts five-point scale to design the questionnaire, conducts the investigation and research through interviewing and issuing questionnaires to middle and senior managers of the enterprises.

Reliability and validity test of scales: This study uses SPSS 17.0 software to carry out reliability and validity test of the questionnaire. For reliability test, use Cronbach's Alpha coefficients to determine the reliability of the scales. Cronbach's Alpha coefficients of scales of quality defect diagnosis ability, quality defect governance ability and subsequent improvement ability of quality defect governance are all greater than 0.7, all the scales have good reliability. For validity, use factor analysis module of SPSS 17.0 software to confirm the validity. The KMO of quality defect diagnosis ability, quality defect governance ability and subsequent improvement ability of quality defect governance scales are all greater than 0.6, the sphere test values are all less than 0.001. The cumulative interpretation rates of common factor are all higher than 60%, factor loadings values are between 0.502 and 0.857, all the scales have satisfactory validity.

Empirical methods selection: The evaluation indicators of quality defect diagnosis ability, quality defect governance basic ability, quality defect governance core ability and subsequent improvement ability of quality defect governance present complex, uncertain and nonlinear dependent relationships. In order to avoid the negative influences on evaluation results due to multicollinearity, data's high dimensionality and abnormal distribution, this study tends to use projection pursuit (The projection pursuit is an exploratory data analysis method to deal with the nonlinear high dimensionality and abnormal distribution data (Jin *et al*., 2004; Jin *et al*., 2000)) to objectively determine the weights and evaluate the quality defect management ability of thirty typical enterprises.

The model thoughts of projection pursuit are as follows:

- Firstly, establish the linear projection value Z(i):

$$Z(i) = \sum_{j=1}^{p} X(i,j)a(j) \quad (1)$$

In the Eq., X(i, j) is the nondimensionalized value of the indicator j of the evaluation object i. a(j) is projection direction:

- Secondly, establish projection indicator function Q(a):

$$Q(a) = S_Z D_Z \quad (2)$$

$$S_z = \sqrt{\frac{\sum_{i=1}^{n}(Z(i)-\bar{Z})^2}{n-1}} \quad (3)$$

$$D_z = \sum_{i=1}^{n}\sum_{j=1}^{n}(R-r_{ij})f(R-r_{ij}) \quad (4)$$

In the Eq:

$$\bar{Z} = \sum_{i=1}^{n} Z(i)/n$$

R is the window of local density; rij = |Z(i)-Z(j)|:

- Thirdly, optimize the projection direction.

Set {a(j)|j = 1, 2, 3, 4,..., p} as the optimization variables and establish the nonlinear objective optimizing function under the given constraints with a view to seeking the maximum of Q(a) and a:

$$\text{Max } Q(a) = S_Z D_Z \quad (5)$$

$$\text{S.T.} \sum_{j=1}^{p} a^2(j) = 1 \quad (6)$$

- Fourthly, have comprehensive evaluation. Use real coded accelerating genetic algorithm (Jin *et al*., 2004; Jin *et al*., 2000) to seek maximum of Q(a) and a, further seek Z(i) of each evaluation objective

Use projection pursuit to calculate quality defect management ability of thirty typical enterprises, then make a cluster analysis to the evaluation values of thirty enterprises with the help of optimal segmentation.

The steps of cluster analysis by optimal segmentation are as follows(Zhang and Zhou 2011):

- Firstly, define the diameter(Zhang and Zhou, 2011). Suppose G_{ij} is $\{x_i, x_{i+1}, x_{i+2}, x_{i+3},..., x_j\}$, j>1 and $\bar{x}_{ij}$ is the mean value, D(i, j) is the diameter of G_{ij}:

$$D(i,j) = \sum_{l=i}^{j}(x_l - \bar{x}_{ij})(x_l - \bar{x}_{ij})^T$$

- Secondly, define the objective function (Liu *et al*., 2007; Zhang and Zhou, 2011). Classify the samples n into several categories k. Suppose a method is p(n, k): $\{x_{i1}, x_{i1+1}, x_{i1+2},..., x_{i2-1}\}$, $\{x_{i2}, x_{i2+1}, x_{i2+2},..., x_{i3-1}\}$, ... $\{x_{ik}, x_{ik+1}, x_{ik+2},..., x_n\}$. Partial nodes are $n = i_{k+1} \geq ik \geq ....> i_3 > i_2 > i_1 = 1$. Define the classifying objective function:

$$e\{p(n,k)\} = \sum_{j=1}^{k} D(i_j, i_{j+1} - 1) \quad (7)$$

- Thirdly, accurate the optimal solution (Zhang and Zhou, 2011):

$$e\{p(n,2)\} = \min_{2\leq j\leq n}\{D(1,j-1) + D(j,n)\} \quad (8)$$

$$e\{p(n,k)\} = \min_{k\leq j\leq n}\{e\{p(j-1,k-1)\} + D(j,n)\} \quad (9)$$

If one wants to classify the samples into several categories k, first of all, find j_k in order to make:

$$e\{p(n,k)\} = \min_{k\leq j\leq n}\{e\{p(j-1,k-1)\} + D(j,n)\}$$

reach minimization. Namely:

$$e\{p(n,k)\} = \{e\{p(j_k - 1, k-1)\} + D(j_k, n)\} \quad (10)$$

Then, get category Gk = (j_k, j_{k+1},..., n), in which j_{k-1} fulfills the following requirements:

$$e\{p(j_k - 1, k-1)\} = \{e\{p(j_{k-1} - 1, k-2)\} + D(j_{k-1}, j_k - 1)\} \quad (11)$$

Then, get category G_{k-1} = (j_{k-1},..., j_k-1). And with the similar method, we can get all kinds of categories G_1,..., G_k

- Fourthly, generate a sequence of samples in order, make cluster analysis by optimal segmentation. Suppose the comprehensive score value which is get by projection pursuit method is z_i^*. Rank z_i^* in the sequence from big to small to generate a sequence of samples in order. The sequence is (z_1^*, z_2^*, z_3^*,..., z_m^*). Calculate all the minimum objective functions {e(p(i, k)}, 3≤i≤m, 2≤k≤m-1} with the above formula (Zhang and Zhou, 2011)

Finally, draw the objective function's e{p(m, k)} changing curve along with the partial nodes k (k = 1, 2,.., m). Take the partial nodes as the classifying method and get the result of clustering analysis (Zhang and Zhou, 2011).

Empirical analysis and results:

- Apply the procedures of projection pursuit to get a, further obtain the evaluation values of quality defect management ability of thirty typical enterprises. The optimal a of quality defect diagnosis ability is (0.158,0.2173,0.0424,0.1646,0.2339,0.1022,0.185). The optimal a of quality defect governance basic ability is (0.2237, 0.1057, 0.0985, 0.2423, 0.1497, 0.2867). The optimal a of quality defect governance core ability is (0.1877, 0.1704, 0.1934, 0.2259, 0.1934, 0.1611, 0.2088, 0.2002, 0.1731, 0.1554, 0.0983, 0.1045, 0.1832). The optimal a of subsequent improvement ability of quality defect governance is (0.1087, 0.1369, 0.2379, 0.1863, 0.0733, 0.2027)
- This study uses optimal segmentation to do cluster analysis of the evaluation results. We calculate all the minimum objective functions {e(p(i, k)}, 3≤i≤m, 2≤k≤m-1}, I = k+1, k+2,...., 30; k = 2, 3,...., 29, draw the objective function's e{p(m, k)} changing curve along with k (k = 1, 2, 3,..., 30). The results show that the objective function e{p(m, k)} has an obvious inflection point at k = 2, 3. So, we confirm the optimal category number is 3. In accordance with the procedures of optimal segmentation, we divide 30 samples into 3 categories with j_3 = 29,as a partial node. So, {z_{30}^*} is a category by itself and is the evacuation value of enterprise four's quality defect management ability. Then, we divide the remaining 29 samples into 2 categories with j_2 = 5 as the partial node. So, (z_5^*, z_6^*, z_7^*,..., z_{29}^*) is a category and is the evacuation value of enterprise 1, 3, 5, 6, 8, 10-18 and 20-30. Finally, we divide the first four samples as a category with j_1 = 1 as its partial node. So, (z_1^*, z_2^*, z_3^*, z_4^*) is a category and is the evaluation value of enterprise 2, 7, 9 and 19

On the basis of calculating the evaluation values of quality defect management ability of various enterprises by projection pursuit, use optimal segmentation method to divide the quality defect management ability into three categories, from low to high are the third category (downstream levels), the second category (middle levels) and the first category (upper levels). There exists improvement and optimization paths between categories. Each category has core leading enterprises, the enterprises within the first category are the models of the enterprises within the second category, the enterprises within the second category are the models of the enterprises within the third category, further cycle, optimize and improve the quality defect management ability of enterprises continuously. Find out the categories that the evaluation values of quality defect management ability of enterprises belong to through projection pursuit and optimal segmentation, then find out the upper categories and set the enterprises (especially the leading core enterprises) within the upper categories as the model enterprises, make horizontal contrast with the benchmark enterprises, learn, absorb and digest the skills and knowledge associated with quality defect management and refer to the quality defect management experiences and knowledge of the enterprises in the same category, enhance mutual trust and synergy in order to achieve the improvement and optimization of quality defect management ability of enterprises within all the categories.

CONCLUSION

Quality defect exists objectively in the operation and production process of enterprises, which will result in negative effects on enterprise reputation, social image, economic efficiency and external public. Implementing quality defect management activity, evaluating quality defect management ability rationally and objectively, enhancing quality defect management ability are the key paths of improving quality performance. On the basis of quality defect management ability evaluation indicators system, this study uses projection pursuit to empirically evaluate quality defect management ability of typical

enterprises, further uses optimal segmentation method to carry out cluster analysis of quality defect management ability evaluation results, analyzes the optimization and improvement paths of quality defect management ability in order to provide a feasible method for evaluating and optimizing quality defect management ability.

AKNOWLEDGMENTS

This study is supported by grant NO. 71271063 from the National Natural Science Foundation, NO. GZ2011010 from the Defense Science and Technological Industry Technology Foundation Research Programs, NO. 2008GXQ6D152 from the National Soft Science Research Program.

REFERENCES

DePasquale, J.P. and E.S. Geller, 1999. Critical success factors for behavior-based safety: A study of twenty industry-wide applications. J. Saf. Res., 30: 237-249.

Fening, F.A., G. Pesakovic and P. Amaria, 2008. Relationship between quality management practices and the performance of small and medium size enterprises (SMES) in Ghana. Int. J. Q. Reliabil. Manage., 25: 694-708.

Gao, F., 2002. Discussion about enterprise diagnosis system methods. Product. Res., 4: 42-43.

Jin, J.L., X.H. Yang and J. Ding, 2000. Acceleration genetic algorithm method based on real-coded. J. Sichuan Univ. Engine. Sci. Edition, 32: 20-24.

Jin, J.L., Y.F. Liu and J. Ding, 2004. The application of projection pursuit model in water resources engineering program optimization. Syst. Engine. Theory Methodol. Appl., 13: 81-84.

Lakhal, L., F. Pasin and M. Limam, 2006. Quality management practices and their impact on performance. Int. J. Qual. Reliability Manage., 23: 625-646.

Liu, K.L., Y.T. Wang and S.Y. Hu, 2007. The applications of fisher optimum segmentation method in the flood season staging. Adv. Water Resour. Sci. Technol., 27: 64-68.

Meng, X.Z. and H.Q. Wang, 2003. Enterprise paradigm, enterprise health and competitiveness of enterprise system. Econ. Rev., 7: 35-39.

Wang, G.C. and X. Wei, 2005. Enterprise wellness, improving your immunity. Era Trade, 8: 66-67.

Wang, K.Q. and D.C. Sun, 2005. Analysis and comparison of management science, physics and medical. Product. Res., 11: 211-213.

Wang, X.R. and C.M. Guo, 2007. Research on dynamically comprehensive evaluation new methods of integrated management system. J. Syst. Engine., 22: 156-161.

Wang, X.R., 2005. Research on management system integration and comprehensive evaluation methods. P.hd. Thesis, Nanjing University, Nanjing.

Zhang, M. and Z.F. Zhou, 2011. Enterprise credit rating model based on projection pursuit and optimal segmentation. Operat. Res. Manage., 20: 226-231.

Zou, G.L., 2007. Research on enterprise human management theory. Econ. Manage. East China, 21: 79-81.