Applied Mathematics and Nonlinear Sciences

<https://www.sciendo.com>

Application of RBF model in the relationship between organisational innovation and organisational performance of HEM enterprises

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Submission Info

Communicated by Juan Luis García Guirao

Received March 4th 2021

Accepted July 21st 2021

Available online November 12th 2021

Abstract

With the increasing dynamics of the environment, the organisational innovation of high-end equipment manufacturing (HEM) enterprises has attracted more attention. This paper introduces a radial basis function (RBF) neural network to establish a model of the effect of organisational innovation on organisational performance (OP). Organisational innovation includes five dimensions: strategic innovation, structural innovation, cultural innovation, institutional innovation and process innovation. Through the modelling results, we know that all dimensions of organisational innovation have an effect on performance. According to the degree of impact, they are strategic innovation, structural innovation, process innovation, cultural innovation and institutional innovation.

Keywords: organisational innovation, organisational performance, RBF neural network

1 Introduction

High-end equipment manufacturing (HEM) enterprises are the high-end part of the high-tech industry and traditional equipment manufacturing industry, which integrates multi-disciplinary and multi-field high technology. The development of HEM enterprises plays an important role in leading and promoting industrial transformation and upgrading. Therefore, in recent years, our country has vigorously supported and developed HEM enterprises [1]. HEM enterprises have always faced high technical requirements in the market and fast updates and iteration. Therefore, enterprises focused most of their attention on technological innovation, while ignoring

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organisational innovation. However, with the continuous expansion of scale and production capacity, the previous management model has been difficult to meet the current needs of enterprises. Many enterprises urgently need to use organisational innovation to change the status quo of business operations and improve organisational efficiency and innovation. Although organisational innovation is a risky activity [2], numerous studies have demonstrated that the effect of organisational innovation on performance is positive. For example, Robinson believes that organisational innovation promotes improvements in product quality and market share, and enhances performance [3]. Similarly, OECD points out that organisational innovation improves performance by reducing transaction costs, improving employee satisfaction (and labour productivity), obtaining non-tradable assets or reducing supply costs [4]. Some scholars also believe that organisational innovation indirectly improves organisational performance (OP) through intermediary variables such as organisational learning [5], organisational capabilities [6] and technological innovation [7]. In short, organisational innovation and OP are inextricably linked, and different scholars have chosen different aspects for research.

At present, the definition of organisational innovation is not completely unified. Scholars have defined organisational innovation according to research needs: Damanpour defines organisational innovation as a new approach to devise strategy and structure, modify management processes and administrative systems, motivate and reward employees, and achieve organisational adaptation and change [8]. Mazzanti believes organisational innovation is an activity that breaks conventions. The innovation process is accompanied by changes in organisational structure, power modes, norms, business models, relationships, etc. [9]. Armbruster considers that organisational innovation is the application of new management and work ideas in the organisation and divides it into two categories: process innovation and structural innovation [10]. From the definition, we can see that organisational innovation is a concept involving multiple dimensions. Kotter and Cohen believe that strategy, structure, culture and processes are very important parts of organisational innovation [11]. Perri proposed that organisational innovation consists of two parts: internal innovation and external innovation. Internal innovation includes innovation in organisational structure and organisational model, while external innovation includes innovation in inter-organisational relationships [12]. Zhang Meili summarised the ten elements of organisational innovation involved in previous research results, namely strategy, process, relationship, institution, market, structure, service, culture, learning and personnel, and divided them into four types of organisational innovation [13].

Based on previous studies, this paper believes that organisational innovation is to adapt to the external environment and the application of new management methods within the organisation. Our research mainly focuses on organisational elements related to internal management at the organisational level. Among the ten elements summarised by Zhang Meili, we extracted the five elements that fit the scope of this article, namely structure, strategy, culture, process and institution. Therefore, the organisational innovation studied in this article specifically includes strategic innovation, structural innovation, process renewal, cultural innovation and institutional innovation. Strategic innovation refers to the organisation's new approach to strategic positioning and business models to gain competitive advantage and create value [14]. Structural innovation refers to activities that change the way of organisation coordination, communication and contact, and the distribution of organisational responsibilities and obligations [15]. Process innovation refers to the new approach to operating procedures, methods and rule systems in production and management activities [16]. Cultural innovation is an activity that promotes or reshapes organisational culture [17]. Institutional innovation refers to a new approach to forming relevant management systems within an organisation.

Organisational innovation is a complex process involving a series of organisational elements which do not exist independently but interact with each other. The relationship between organisational innovation and OP is also difficult to express in a simple linear relationship and is more like a complex system. Organisational innovation is the input, OP is the output, and the process of organisational innovation on performance is an unknown function. Therefore, this article attempts to introduce a neural network model that further explores the functional relationship between organisational innovation and OP. Among the many neural network models, the Radial Basis Function (RBF) is a feedforward network with strong approximation ability and fast convergence.

It is very suitable for scenarios with small data levels. So, this paper introduces the RBF model to fit the effect of organisational innovation on OP and attempts to establish a model to obtain a more accurate relationship between the two so as to take more targeted innovation activities.

2 RBF neural network

RBF network is a kind of feedforward neural network and, generally, can be divided into three layers: input layer, hidden layer and output layer [18]. The RBF network structure is shown in Figure 1. When the RBF network fits the process of the system, first, the low-dimensional data samples are mapped into the high-dimensional space through the RBF so that it has the possibility of linear fitting; then, the linear approximation method is used to train the network structure. This allows the RBF network to approximate any nonlinear function and has a faster convergence speed [19].

Fig. 1 RBF neural network. RBF, radial basis function.

The sample mapping process can be abstracted as distorting an originally flat data space R in a higher-dimensional Euclidean space into R' . This distorted data expression can be calculated by the data difference in the Euclidean space. In this paper, the spatial mathematical expression after interpolation calculation is denoted as G , which can be calculated in the following form:

$$G(x_i) = d_i \quad (1-1)$$

Among them, i is the number of central points of the RBF settlement and d is the projection of the sample point on the R' plane. Mathematical expressions for calculating curved surfaces can be used in the following ways:

$$G(X) = \sum_{i=1}^n \omega_i \varphi(x - x_i) \quad (1-2)$$

Among them, $x - x_i$ is the norm of the centre of the sample point and ω is the weight of the radial basis network.

Combining Eqs (1-1) and (1-2), the following form can be obtained:

$$\sum_{i=1}^N \omega_i \varphi(x - x_i) = d_i \quad (1-3)$$

Let $\varphi_{ij} = x_i - x_j$, and the form of the formula (1-3) can be organised as:

$$\begin{bmatrix} \varphi_{11} & \varphi_{12} & \cdots & \varphi_{15} \\ \varphi_{21} & \varphi_{22} & \cdots & \varphi_{25} \\ \cdots & \cdots & \cdots & \cdots \\ \varphi_{51} & \varphi_{52} & \cdots & \varphi_{55} \end{bmatrix} \begin{bmatrix} \omega_1 \\ \omega_2 \\ \cdots \\ \omega_5 \end{bmatrix} = \begin{bmatrix} d_1 \\ d_2 \\ \cdots \\ d_5 \end{bmatrix} \quad (1-4)$$

Let $\Omega = [\omega_1 \ \omega_2 \ \cdots \ \omega_n]^T$ and $D = [d_1 \ d_2 \ \cdots \ d_n]^T$, then Eq. (1-4) can be expressed as Eq. (1-5)

$$\Phi \cdot \Omega = D \quad (1-5)$$

Among them, Ω shows the weight of the output layer of the RBF network and D is the target response vector. D is the prior condition given when calculating the surface. In this paper, the Gauss function is selected [20], and its specific form is shown in the formula (1-6).

$$\varphi(r) = \exp\left(-\frac{r^2}{2\delta^2}\right) \quad (1-6)$$

After determining D and Φ , the weights of the radial basis network can be solved according to the formula shown in Eq. (1-7) to determine the weights of the output layer of the RBF network.

$$\Omega = \Phi^{-1} \cdot D \quad (1-7)$$

3 An empirical study on the relationship between organisational innovation and OP of HEM enterprises

3.1 RBF neural network modelling

In the RBF model, organisational innovation is taken as the input X of the neural network system, OP is taken as the output Y of the system and the system dynamics process is denoted as F . At this time, the mathematical expression of the system can be expressed as follows:

$$Y = F(X) \quad (2-1)$$

Based on the research of Zhang Meili [13] and others [21,22], this article divides the organisational innovation of HEM enterprises into five dimensions: structural innovation, strategic innovation, institution innovation, process innovation and cultural innovation. These are independent variables, and OP is a dependent variable. Therefore, the input layer of the model is organisational innovation, the width of the data is $n = 5$ and a node in the output layer of the third layer is OP.

3.2 Sample collection

The survey started in May 2018 and ended in January 2019. The subjects of the survey are HEM enterprises, which are mainly located in Beijing, Shanghai, Harbin, Shenyang, Xi'an, Shenzhen and other places. HEM industry studied in this article mainly includes five major industries: aviation equipment, satellites and applications, rail transit equipment, marine engineering equipment and intelligent manufacturing equipment. A total of 430 questionnaires were issued and 324 questionnaires were returned, and the recovery rate was 75.35%. Invalid questionnaires such as missing or consistent options were excluded. In all, 307 were valid questionnaires, the effective rate is 71.40%. Among them, the aviation equipment industry recovered 66 questionnaires, accounting for 21.50%, the satellite and application industry recovered 74 questionnaires, accounting for 24.10%, the rail transit equipment recovery questionnaire 55, accounting for 17.92%, the offshore engineering equipment recovery questionnaire 59, accounting for 19.22%, and 53 questionnaires were returned for intelligent manufacturing equipment, accounting for 17.26%.

3.3 Variable measurement

This paper borrows from the existing mature scales to measure organisational innovation [23] and OP [24]. The scales have high reliability and validity. The reliability and validity are shown in Table 1. The entire scale is measured using the LIKERT 5-point scale, with 1–5 representing ‘completely disagree’ to ‘completely agree’ in turn. The input variables are the five dimensions of organisational innovation: Strategic Innovation Z, Structural Innovation S, Process Innovation P, Cultural Innovation C and Institutional Innovation I, and the output variable is OP. The scores of each variable are normalised.

3.4 Result analysis

Randomly selected 80 questionnaires are used as training samples. According to the training samples, the function of organisational innovation of HEM enterprises on OP is obtained. After 500 iterations, the network stabilises, and then the remaining 227 sample data are substituted into the function. The results of input and output weights are as follows:

Weight of variable S-OP, $w_{sp} = 0.27$

Weight of variable Z-OP, $w_{zp} = 0.31$

Weight of variable C-OP, $w_{cp} = 0.13$

Weight of variable P-OP, $w_{pp} = 0.19$

Weight of variable I-OP, $w_{ip} = 0.10$

Through the analysis results of the RBF model of organisational innovation on the performance of HEM enterprises, we know that institutional innovation, structural innovation, strategic innovation, cultural innovation and process innovation all have an effect on performance. Strategic innovation has the greatest impact, with a weight of 0.31, followed by structural innovation, third for process innovation, fourth for cultural innovation and fifth for institutional innovation. Strategic innovation is often when a company finds an industry segment that is ignored by the public, re-plans its corporate activities, seizes market opportunities and wins the market share of this segment before fierce market competition is formed. Therefore, strategic innovation has the most direct impact on OP, which is also reflected in the model results. Structure is the framework of business operations, and the process connects all points in the framework. Therefore, structural innovation and process innovation can simplify management consumption, reduce management costs, shorten work cycles, improve efficiency, and have a relatively important impact on OP. Institutions and cultures are behaviour-oriented. Although institutions are clear and culture is subtle, they all affect the OP through employee behaviour in the enterprise. Therefore, structural innovation and process innovation have a greater effect on OP, which is consistent with the results obtained by the RBF model.

4 Conclusions and recommendations

Currently, for HEM enterprises, competition in the external market is becoming increasingly fierce. The importance of organisational innovation has become increasingly prominent. In this situation, this article uses the RBF model to study the relationship between organisational innovation and OP, and attempts to clarify the important role of organisational innovation on OP. The results show that all dimensions of organisational innovation have a positive effect on performance. Arranged in descending order of the degree of influence on OP, the results are strategic innovation, structural innovation, process innovation, cultural innovation and institutional innovation.

Based on the research results, suggestions are made for HEM enterprises to organise innovation activities. First, take strategic innovations at the right time, regularly evaluate the external market environment, accurately position its own resources and capabilities, maintain a keen sense of the market, seize market opportunities and make full use of corporate resources. Second, according to the actual management needs of the organisation, appropriately reduce the organisational hierarchy, delegate decision-making power and fully release the

Table 1 Reliability and validity of variables.

Variables	Question	Factor loading	Cronbach's Alpha	AVE
Structural innovation (S)	S1: Enterprises are developing towards flatness and flexibility	0.864	0.876	0.852
	S2: Employees have more autonomy and decision-making power	0.858		
	S3: Corporate communication efficiency and information transmission speed are steadily improving	0.861		
	S4: The speed of feedback on work is increasing	0.825		
Strategic innovation (Z)	Z1: Grasp market opportunities and timely adjust the resource allocation	0.879	0.825	0.874
	Z2: Have a comprehensive understanding of internal innovation resources and capabilities	0.897		
	Z3: Regard innovation as an important part of development strategy	0.844		
Cultural innovation (C)	C1: Have a clear vision for building an 'innovative culture'	0.923	0.927	0.914
	C2: Create a strong atmosphere of innovation	0.918		
	C3: Encourage employees to make new attempts and tolerate failure	0.925		
	C4: Entrepreneurs who are innovative and daring to take risks	0.891		
Process innovation (P)	P1: The information system is continuously applied and improved	0.858	0.890	0.847
	P2: The management process cycle is more reasonable	0.843		
	P3: Product turnover cycle is shortening	0.839		
Institutional innovation (I)	I1: Establish and continuously improve and adjust employee incentive mechanisms	0.898	0.882	0.884
	I2: Develop and implement a flexible intellectual property management system	0.881		
	I3: Optimise and adjust the management system to meet the needs of innovative activities	0.873		
OP	OP1: Compared with other competitors, have higher profits	0.811	0.861	0.818
	OP2: Compared with other competitors, has a larger market share	0.787		
	OP3: Compared with other competitors, the profit growth rate is faster	0.854		

OP, Organisational performance.

staff's enthusiasm; at the same time, increase the management width, strengthen communication and exchanges between departments and thereby improve work efficiency. Third, streamlining the management process and removing complicated and redundant processes will not only help improve the work efficiency of each department and reduce management costs but also shorten the overall product cycle and improve product quality. Fourth, establish an innovative culture and vigorously promote the importance of innovation and the enterprise's innovation-oriented values in ideology; encourage innovation, tolerate failure in behaviour and provide employees with more learning and training opportunities so that employees have more inspiration and knowledge accumulation, and then it is easier to generate good ideas. Fifth, improve the incentive mechanism and internal intellectual property system, and give material and spiritual rewards to employees who have achieved important innovations in their work. While stimulating employees' enthusiasm for innovation, these rewards also set an example for other employees. At the same time, the property rights system protects the innovation achievements and interests of employees.

Acknowledgments

The authors acknowledge the National Natural Science Foundation of China (Grant: 71872056).

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