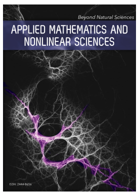
sciendo Applied Mathematics and Nonlinear Sciences 8(2) (2023) 299–310



Applied Mathematics and Nonlinear Sciences

https://www.sciendo.com

Application of hybrid kernel function in economic benefit analysis and evaluation of enterprises

Jianzhong Li†

College of Economics and Management, Hubei University of Automotive Technology, Shiyan, Hubei 442002, China

Submission Info

Communicated by Juan Luis García Guirao
Received April 11th 2022
Accepted April 14th 2022
Available online September 5th 2022

Abstract

The economic benefit of enterprises is an effective index to measure the economic activities, which forms the basis and starting point. Therefore, in this paper, the traditional analysis methods of enterprise in terms of economic benefits are compared and based on its evaluation principles, the advantages, theory and realisation process of the kernel function in enterprise economic benefits analysis are analysed. Then, different kernel functions are selected to analyse the total output value, product sales rate, sales revenue, total profit and total profits after taxes of five enterprises, and their economic benefits are evaluated by the cumulative contribution rate of principal components. Finally, the mixed kernel function based on the combination of polynomial kernel function and Gaussian kernel function is used to optimise the analysis effect, which is meant to help enterprise leaders make more scientific decisions and lay a foundation for the sound development of enterprises.

Keywords: Kernel function, economic benefits of enterprises, cumulative contribution rate

1 Introduction

Enterprises are the pillars of the national economy, and their operating conditions are directly related to the development of China's national economy and the consolidation of the socialist system [1, 2]. The benefit is the key to the survival and development of any enterprise. At present, for state-owned enterprises, only by carrying out effective reforms can improve the economic benefits, strengthen the management, coordinate the development and maximise the economic benefits in the face of fierce market competition. The economic benefit is the soul of an enterprise and improving economic benefits remains the core issue of all economic management activities [3]. With the deepening of the standardisation of financial information disclosure in numerous listed companies under the post-financial crisis stage and the strengthening of financial management, more listed

†Corresponding author.
Email address: hunanren2021@sina.com

sciendo ISSN 2444-8656 doi:10.2478/amns.2022.1.00017

companies pay attention to the early warning of the impending financial crisis [4, 5]. Therefore, the prediction, tracking, analysis and application with regard to an impending financial crisis with early warning information in listed companies have become the focus of recent academic research.

The economic benefit analysis of enterprises can adopt specific methods such as statistics and mathematics, and enterprises should decide according to the purpose of analysis, the characteristics of enterprises, and the nature and content of data to be mastered. Traditional methods of enterprise economic benefit analysis include comparative analysis, ratio analysis, trend analysis, proportion analysis and factor analysis [6–8]. However, the disadvantages are that they are inaccurate and can neither reflect the internal relationship between financial indicators nor can they analyse the prominent items reflected in the economic benefit indicators of enterprises. When compared with the traditional principal component analysis, kernel function analysis usually involves more evaluation indexes, where the first fitting process is essentially the development of orthogonal transformation in feature space, and the correlation calculation of principal components is completed [9, 10]. In addition, it can be used to calculate nonlinear data so that some hidden and difficult-to-find internal relations among indicators can be fully displayed, and the contribution rate of principal components is higher [11, 12]. But among them, the selection and parameters of kernel functions have not been well solved [13]. Therefore, this paper analyses the development of enterprises through the combination of different kernel functions, aiming at accurately and completely reflecting the economic benefit indicators of enterprises, and providing a basis for the follow-up financial analysis.

2 Traditional analysis methods of economic benefits of enterprise

2.1 Evaluation principle

From the angle of combining macro-economic benefits with micro-economic benefits, the economic benefit of enterprise analysis is the management work of checking, examining and evaluating the formation and realisation degree of economic benefits in the process of production and operation [14, 15]. To realise the development of diversified enterprises, a modern information system that can reflect the internal relations of economic development must be established. Economic benefit analysis of enterprises can effectively, quickly, timely and correctly correct wrong macroeconomic decisions. In a certain sense, it is a modern management means to provide information to decision-making departments at all levels, which is also an indispensable way of thinking for enterprise development.

Among them, the most complicated and key problem is to use an objective and correct standard to make a correct judgement on the evaluation of the economic benefits of enterprises. As shown in Figure 1, the establishment of criteria for measuring the economic benefits of enterprises should proceed from the internal structure of economic benefits, and make a scientific basis as the benchmark for evaluation.

In the analysis of economic benefits of enterprises, the objective reality and social benefits are deviated and mutually restricted, which can be divided into the following four principles: the unity of use-value and value; unity of enterprise economic benefits and social-economic benefits; unity of long-term economic benefits and current economic benefits; unity of direct economic benefits and indirect economic benefits.

2.2 Analysis method

Through investigation and summary, as shown in Figure 2, there are four traditional analysis methods for the economic benefits of enterprises [16, 17]:

(1) Factor analysis method

A variety of different factors will eventually have a comprehensive impact on the enterprise, and they will become comprehensive influencing factors. These factors are not fixed and will be influenced by external factors. By decomposing the influencing factors of a comprehensive economy, we can find out

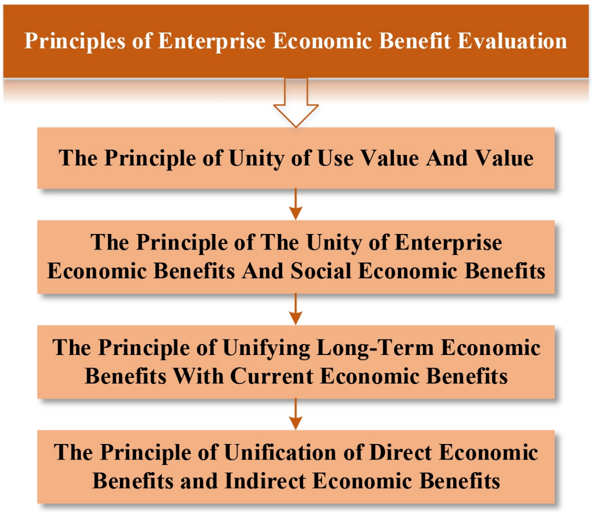


Fig. 1 Principles of enterprise economic benefit evaluation.

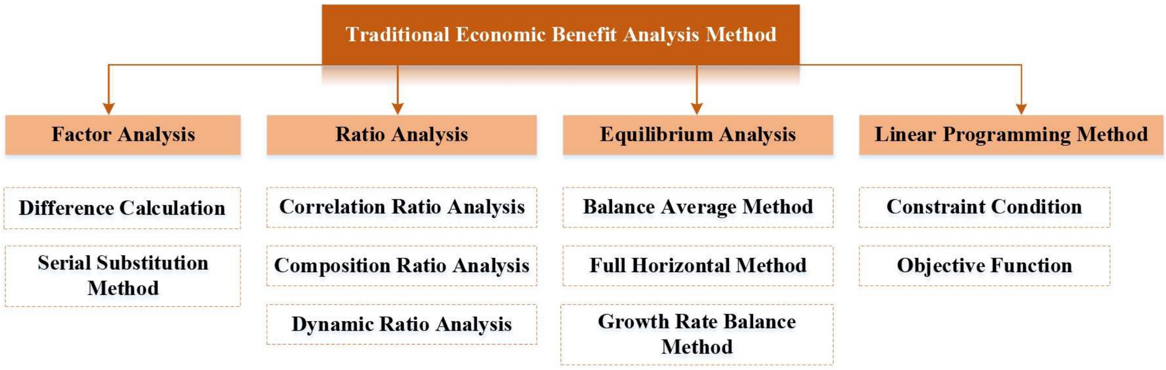


Fig. 2 Traditional economic benefit analysis method.

the specific factors that affect the completion of comprehensive indicators, and the responsibilities will be divided.

(2) Ratio analysis method

Ratio analysis is essentially a special form of comparative analysis, which calculates the relative number of indexes and analyses the economic phenomena. The commonly used ratio analysis methods include correlation ratio analysis, composition ratio analysis and dynamic ratio analysis.

(3) Balance analysis method

The balance analysis method is an analysis method used to find out the interdependence among various economic factors with a balanced relationship, and compare the actual balance relationship with the planned balance relationship to determine the impact of changes in various economic factors on economic indicators. By adopting this method, we can find the imbalance in the production and business activities of enterprises, to take timely measures to organise a new balance, which ensures the sustained and stable development of economic activities. The balance analysis method includes the balance average method, full balance method and growth rate balance method.

(4) Linear programming method

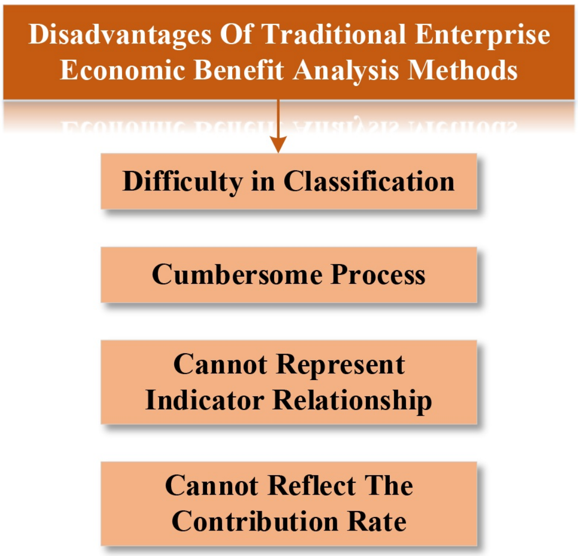


Fig. 3 Weakness of traditional economic benefit analysis methods.

How to make rational use of the existing resources of enterprises to obtain the greatest economic benefits is the core issue of enterprise management decisions. Using linear programming for economic benefit analysis is mainly a process of establishing a mathematical model according to relevant data and adopting certain methods to solve the optimal scheme. The mathematical model of linear programming is divided into two parts, namely, constraints and objective functions. The constraint condition refers to the condition that a set of inequalities or equations reflect the relationship between limited resources and unknown numbers and limit the range of unknown numbers. While the objective function refers to the best result that can be achieved under certain conditions in the form of a certain function. However, there are some weaknesses of traditional enterprise economic benefit analysis methods, as shown in Figure 3.

The traditional method determines the selection range of evaluation indexes, which makes the classification and division of evaluation indexes more difficult and cannot be directly selected and adopted. Different evaluation criteria should be adopted for different evaluation indexes, and the process is complicated; The analysis method is not unified, and the relationship among various economic indicators cannot be clearly expressed; The evaluation accuracy is low and its error is large, which can't clearly reflect the contribution rate of each economic index of the enterprise.

3 Application base of the kernel function in economic benefit analysis of enterprise

When using a support vector machine for classification, regression and data analysis, the basis and premise of obtaining better classification, approximation effect and principal component expression are being applied to understand the ways and means to select and construct appropriate kernel functions and choose appropriate parameters [18]. Therefore, it is necessary to research the theory and application of kernel function for better and deeper research.

3.1 Advantages of kernel function

Application of kernel function is a method with an obvious dimension reduction effect. It does not operate in the whole high-dimensional feature space, but in a relatively small linear subspace, and its dimension is much smaller than that of the high-dimensional space, which has the following advantages in data analysis of enterprise economic benefits [19]:

(1) It abides by the principle of structural risk minimisation, and has a good operation effect;

(2) For different space requirements, selecting different kernel functions and parameters can change the nature of feature space and the functions of various kernel functions;

(3) Kernel function method can simply reduce the dimension of vector space, thus solving the problem of difficult operation and avoiding the phenomenon that the dimension is too high to be calculated;

(4) It does not need to know the specific function forms and parameters in nonlinearity, but only needs to calculate the inner product.

(5) It is not easily interfered with by other factors, and even if the data is nonlinear, the implicit correlation can be found.

3.2 The basic principle of kernel function

In the support vector machine classifier, we need to select function $K(\cdot,\cdot)$. In general, there exists a Hilbert space, and this space H may be a finite or infinite-dimensional space. The selection of function $K(\cdot,\cdot)$ can also be represented that a mapping $\Phi(\cdot)$ needs to be selected to map the input space x where X resides to another space H.

When we evaluate similarity, a mapping must be studied from the input space $X = R^n$ to the Hilbert space. When choosing different functions $K(\cdot,\cdot)$, or different mappings and their corresponding Hilbert Spaces, it is equivalent to selecting different inner products, so the results will be different.

Assuming a mapping is:

$$\Phi : \begin{matrix} x_1 = {x_1}^2 \\ x_2 = {x_2}^2 \end{matrix} \tag{1}$$

or

$$\Phi(x) = \Phi(x_1, x_2) = \begin{pmatrix} x_1^2 \\ {x_2}^2 \end{pmatrix} \tag{2}$$

At this time, the space mapped to Hilbert H is still two-dimensional.

$$K(x,x') = (\Phi(x), \Phi(x')) = {x_1}^2 {x_1}'^2 + {x_2}^2 {x_2}'^2 \tag{3}$$

Therefore, the kernel function (kernel or positive definite kernel) lets X be a subset of R^n. A function $K(x,x')$ defined on $X \times X$ is called a kernel. If there exists a mapping from X to a Hilbert space H as follows:

$$\Phi : \begin{matrix} X \to H \\ x \mapsto \Phi(x) \end{matrix} \tag{4}$$

Then,

$$K(x,x') = (\Phi(x) \cdot \Phi(x')) \tag{5}$$

where $(\cdot)$ represents the inner product of H.

3.3 Analysis Methods of economic benefits of enterprises

3.3.1 Selection of kernel function

In economic benefit analysis, it is not necessary to know the specific form of ϕ to make feature extraction, which ultimately translates to solving $K_{ij} = (\phi(x_i) \cdot \phi(x_j))$. Therefore, different kernel functions may be selected and different results may be obtained. Common kernel functions include:

(1) Polynomial kernel: the common form is: $K(x, y) = [s(x \cdot y) + c]^d$. The polynomial kernel function represents nonlinear feature mapping, which is one of the kernel functions commonly used in data analysis.

(2) Gaussian kernel: $K(x, y) = \exp\left(-\frac{\|x-y\|^2}{2\sigma^2}\right)$. Which is also the most commonly used kernel function in the research of support vector machines.

(3) Exponential radial basis function: $K(x, y) = \exp\left(-\frac{\|x-y\|}{2\sigma^2}\right)$. When the problem is discontinuous, the kernel function represented by it can be applied to generate a linear piecewise solution.

(4) Neural network core: $K(x, y) = \tanh[s(x \cdot y) + c]$

In addition, there are some kernel functions, such as Fourier series kernel function, spline kernel function and tensor product kernel function.

3.3.2 Nuclear principal component analysis

The analysis method mainly uses the idea of kernel function to increase the dimension of data, extracts the eigenvalues and eigenvectors after inner product operation in the feature space, and then reduces the dimension [20]. The specific steps are shown in Figure 4.

(1) After standardising the original index, input sample X to calculate the inner product of the selected kernel function, thus obtaining the matrix K;

(2) Because obtaining $\sum_{i=1}^{n} x_i = 0$ is difficult, so we solve the matrix $\widetilde{K}, \widetilde{K} = K - AK - KA + AKA$, where the $A_{ij} = 1/n$;

(3) The eigenvalues λ_i and eigenvector V_i are calculated according to the main components of the matrix $\frac{\widetilde{K}}{l}$;

(4) Find the largest eigenvalue λ_m and eigenvector V_m;

(5) Calculate the contribution rate of the principal component, find out the first n principal components whose cumulative contribution rate is greater than 85%, extract the principal components, write down the evaluation function, and calculate the evaluation coefficient.

3.3.3 Steps of the algorithm

Assuming that n sample data vectors $x_k (k = 1, 2, \cdots, n)$, $x_k \in R^p$ in the input space R^p, where $x_k \in R^p$. The covariance matrix is as follows:

$$C = \frac{1}{n} \sum_{j=1}^{l} x_j x_j^T \tag{6}$$

For principal component analysis, by solving the characteristic equation $\lambda v = Cv$, the eigenvalues can be obtained with a larger contribution rate and the corresponding eigenvectors.

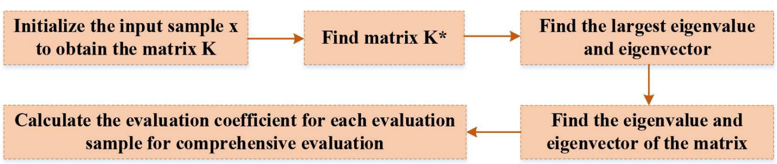


Fig. 4 Steps of kernel principal component analysis.

The nonlinear mapping function ϕ is introduced, and the sample data vector $x_k(k=1,2,\cdots,n)$ in the input space R^p is transformed into the sample data vector $\phi(x_k)(k=1,2,\cdots,n)$ in the feature space F, and assume that

$$\sum_{k=1}^{n}\phi(x_k)=0 \tag{7}$$

Then the covariance matrix in the feature space F is

$$\bar{C}=\frac{1}{n}\sum_{j=1}^{l}\phi(x_j\phi'(x_j))^T \tag{8}$$

Therefore, Principal Components Analysis (PCA) in the eigenspace F is the solution of the eigenvalue λ and eigenvector $V\in F$ in the eigen equation $v=\bar{C}v$, and then there is

$$\lambda(\phi(x_k)\cdot v)=\phi(x_k)\cdot\bar{C}v,(k=1,2,\cdots,n) \tag{9}$$

Among them, v can be linearly represented by $\phi(x_i),\ i=1,2,\cdots,n$, that is

$$v=\sum_{i=1}^{n}\alpha_i\phi(x_i) \tag{10}$$

Therefore

$$\lambda\sum_{i=1}^{n}\alpha_i(\phi(x_k)\cdot\phi(x_i))=\frac{1}{n}\sum_{i=1}^{n}\alpha_i\left(\phi(x_k)\cdot\sum_{j=1}^{n}(\phi(x_j))\right)(\phi(x_j)\cdot\phi(x_i))\quad k=1,2,\cdots,n \tag{11}$$

Define kernel function as follows:

$$K(x_i,x_j)=\phi(x_i)\phi(x_j) \tag{12}$$

Then

$$n\lambda K\alpha=K^2\alpha \tag{13}$$

$$n\lambda\alpha=K\alpha \tag{14}$$

By solving the type, can get the characteristic value of $\lambda_k,\ k=1,2,\cdots,n$ and its corresponding eigenvectors $\alpha^k,\ k=1,2,\cdots,n$. Therefore, the space vector v^k in F is $v^k=\sum_{i=1}^{n}\alpha_i^k\phi(x_i)$.

For the choice of principal components, it is only necessary to calculate the projection of the test sample data vector $\phi(x)$ onto the vector v^k in F space

$$(v^k\cdot\phi(x))=\sum_{i=1}^{n}\alpha_i^k(\phi(x_i)\cdot\phi(x))=\sum_{i=1}^{n}\alpha_i^kK(x_i,x) \tag{15}$$

And the comprehensive evaluation function of economic benefits can be defined as:

$$F(x)=\sum_{k=1}^{r}\sum_{i=1}^{n}\omega_k\alpha_i^kK(x_i,x) \tag{16}$$

where r satisfies $\sum_{i=1}^{r}\alpha_i/\sum_{i=1}^{n}\alpha_i\geq 85\%$; ω_k is the contribution rate of the corresponding k-th principal component. If the parameters in the kernel function are properly selected as $r=1$, i.e.

$$F(x)=\sum_{i=1}^{n}\omega_1\alpha_i^1K(x_i,x) \tag{17}$$

If $\sum_{i=1}^{n}x_i=0$, the K needs to be replaced as $\widetilde{K}$, that is $\widetilde{K}=K-AK-KA+AKA$, where $A_{ij}=1/n,\ i,j=1,2,\cdots,n$.

4 Economic benefit evaluation and decision-making scheme

4.1 Evaluation indicators of basic conditions in enterprises

Profit index is an important evaluation index to evaluate the economic benefits and decision-making schemes of enterprises. According to the internal relations of accounting elements, it can be found that total profit, product sales revenue, total output value and overall sales rate are all important indicators to evaluate the economic benefits and decision-making level of enterprises. As shown in Table 1, we select the relevant economic benefit evaluation indexes of five enterprises in a certain area in 2020, analyse the main components of these indexes, evaluate the overall economic benefits of the enterprises and provide correct suggestions for the management to make more reasonable and scientific decisions.

4.2 Evaluation methods

As mentioned above, the kernel principal component analysis method is used to comprehensively evaluate the economic benefits of enterprises:

(1) The indicators of economic benefits are converged, the possible negative values are directly converted into positive indicators, and the original data are standardised by Matlab6.5 [21]:

$$x'_{ij} = \frac{x_{ij} - \bar{x}_j}{\sqrt{\mathrm{var}(x_j)}}, (i = 1, 2, \cdots, n; j = 1, 2, \cdots, m) \tag{18}$$

$$\bar{x}_j = \frac{1}{n} \sum_{i=1}^{n} x_{ij} \tag{19}$$

$$\mathrm{var}(x_j) = \frac{1}{n-1} \sum_{i=1}^{n} (x_{ij} - \bar{x}_j)^2 \tag{20}$$

The results of data processing are shown in Table 2.

(2) Select the appropriate kernel function for many times of trials and comparison according to this data. In this paper, a variety of kernel functions are selected for comparison. Taking the polynomial kernel

Table 1 Evaluation index of economic benefits of enterprises.

Number	**Total output value (ten thousand yuan)**	**Product sales rate (%)**	**Sales revenue (ten thousand yuan)**	**Total profit (ten thousand yuan)**	**Total profits and taxes (ten thousand yuan)**
A	1500	100.6	1172	25	67
B	1002	105.3	954	80	76
C	4890	83.9	2754	198	407
D	20,205	94.2	22082	1021	983
E	589	98.0	674	493	26

Table 2 Standardisation results of evaluation index data.

Number	**X_1 Total output value (ten thousand yuan)**	**X_2 Product sales rate (%)**	**X_3 Sales revenue (ten thousand yuan)**	**X_4 Total profit (ten thousand yuan)**	**X_5 Total profits and taxes (ten thousand yuan)**
A	−0.267	0.642	−0.239	−0.593	−0.502
B	0.557	0.901	0.583	−0.237	−0.347
C	−0.429	−1.290	−0.493	−0.320	−0.352
D	3.278	1.829	3.512	3.290	3.200
E	−0.015	−0.483	−0.089	−0.072	−0.126

function as an example, the matrix K is obtained as follows:

$$K = \begin{Bmatrix} 5.728, & 3.354, & 5.702, & 5.578, & 5.575 \\ 3.351, & 2.152 & 3.354, & 3.245, & 3.275 \\ 5.301, & 3.357, & 5.709, & 5.584, & 5.543 \\ 5.759, & 3.294, & 5.597, & 5.487, & 5.431 \\ 5.506, & 3.321, & 5.541, & 5.430, & 5.327 \end{Bmatrix}$$

(3) Find the eigenvalue of matrix. $\frac{\widetilde{K}}{n}(n=6)$. $(i=1,2,\cdots,6)$, that are $\lambda_1 = 1.127$; $\lambda_1 = 0.063$; $\lambda_1 = 0.003$.

(4) Find the maximum eigenvalue, that is the maximum eigenvector under the condition of $\lambda_{\max} = 1.127$:

$$V_{\max} = (-0.432, -0.027, 0.0785, -0.492, 0.343)$$

(5) Then the evaluation function is $F = 0.919F_1$, in which:

$$F_1 = -0.432X_1 - 0.027X_2 + 0.785X_3 - 0.492X_4 + 0.343X_5$$

4.3 Evaluation results

The contribution rate of each characteristic value under this analysis is shown in Table 3.

According to the nuclear principal component analysis method, after evaluating the actual operation of the enterprise, it is found that the contribution rate of X_1 total output value is the largest, which shows that the total industrial output value occupies a major position in the enterprise operation. Among the five enterprises, the total industrial output value of enterprise D ranks first, so it has an obvious effect on dimension reduction. The ranking of economic benefits of enterprises is shown in Table 4.

It can be seen from Table 4 that enterprise D has the best economic benefit, and enterprise E has the lowest economic benefit, which is positively related to its total output value and sales revenue. From the perspective of the main components that affect the economic benefits, the total industrial output value is the most important factor in the enterprise's economic benefits. Therefore, to achieve high economic benefits, the total industrial output value must be increased. While only the self-value of the products be improved, can we occupy a place in the complicated market and really enhance the economic benefits of enterprises.

Table 3 The contribution rate of each characteristic value under polynomial kernel function.

	X_1 **Total output value (ten thousand yuan)**	X_2 **Product sales rate (%)**	X_3 **Sales revenue (ten thousand yuan)**
Eigenvalue	1.127	0.063	0.003
Contribution rate	93.98%	4.75%	1.27%
Cumulative contribution rate	93.98%	98.73%	100%

Table 4 Ranking of Economic Benefits of Enterprises.

Enterprise number	**Evaluation coefficient**	**Ranking**
A	0.837	2
B	−0.509	4
C	−0.378	3
D	3.233	1
E	−0.835	5

5 Analysis of mixed kernel function on economic benefits of enterprises

When selecting kernel functions to solve data problems, one of the usual methods is to select different kernel functions to find the kernel function with the smallest result error, which is called the effective kernel function; The second is the kernel function given by many experiments the second way are selected in this paper.

5.1 Gaussian kernel function

When the Gaussian function is selected as the kernel function, the values in matrix K tend to be 1, and the cumulative contribution rate of the first three principal components tends to be stable when σ is above 10 according to this data. As shown in Table 5, when $\sigma = 50$, the cumulative contribution rate of the first three principal components is 87.82%.

Although this analysis method requires that the cumulative contribution rate should be higher than 85%, compared with the polynomial kernel function, its first principal component contribution rate is as high as 93.98%. Therefore, the Gaussian function is not suitable for the evaluation data of the five enterprises selected in this paper.

5.2 Neural network kernel function

When using the neural network kernel function, it is necessary to determine the values of s and c in the formula. After many trial values, it is found that when $s = 0.005$ and $c = 2$, the eigenvalues are all positive, and there is no correlation between the value of c and the eigenvalues. The cumulative contribution rates of the three principal components are shown in Table 6.

Similarly, when the kernel function is selected as the neural network kernel function, the first two principal components need to be selected to ensure that the cumulative contribution rate is higher than 85%. Compared with the polynomial kernel function, the neural network kernel function whose first principal component contribution rate is as high as 93.98%, is also not suitable for the enterprise data selected in this paper.

5.3 Mixed kernel function

The basic idea of the hybrid kernel method is that the combination of different kernels will have better properties. Because polynomial kernel functions have good global and poor locality, while Gaussian kernel functions have good locality and poor extrapolation ability, these two kernel functions can be mixed together to form a new mixed kernel function as follows:

$$K_{mix}(x,y) = \omega(s(x*y)+c)\hat{}d + (1-\omega)\left(\exp\left(-\frac{\|x-y\|^2}{2\sigma^2}\right)\right) \tag{21}$$

Table 5 The contribution rate of enterprise economic benefit under Gaussian kernel function when $\sigma = 50$.

	Eigenvalue	Contribution rate	Cumulative contribution rate
X_1	0.286	45.65%	45.65%
X_2	0.203	22.58%	68.23%
X_3	0.128	19.59%	87.82%
X_4	0.059	7.51%	95.33%
X_5	0.012	4.67%	100%

Table 6 Contribution rate of enterprise economic benefit under neural network kernel function.

	Eigenvalue	Contribution rate	Cumulative contribution rate
X_1	0.016	52.38%	52.38%
X_2	0.008	41.82%	94.20%
X_3	0.001	5.80%	100%

Table 7 Contribution rate of enterprise economic benefit under mixed kernel function.

	Eigenvalue	Contribution rate	Cumulative contribution rate
X_1	0.016	99.80	99.80%
X_2	0.008	0.2%	100%

Among them, ω is the weight to adjust two kernel functions.

When polynomial kernel function and Gaussian kernel function are selected as the kernel function, the Optimal solution of s, c, d, σ are $s = 0.05$, $c = 0$, $d = 5$, $\sigma = 50$. According to the Mathematical Programming with Equilibrium Constraints (MPEC) model, the kernel parameters are optimised, that is $\omega = 0.8$ [22]

$$K_{\text{mix}}(x,y) = 0.8(0.05*(x*y)+0)^5 + (1-0.8)\left(\exp\left(-\frac{\|x-y\|^2}{2*50^2}\right)\right) \tag{22}$$

The contribution rate of enterprise economic benefits obtained according to the mixed kernel function is shown in Table 7.

When the mixed kernel function is selected, the contribution rate of the first principal component is 98.80, which is higher than the 93.98% obtained from the polynomial kernel function, indicating that it is more appropriate to apply a mixed kernel function to this data than polynomial kernel function. Therefore, the application of the kernel function mixed with polynomial kernel function and Gaussian kernel function to the economic benefit analysis of enterprises is more effective than the application of a single kernel function.

6 Conclusion

This paper introduces and compares the traditional analysis methods of enterprise economic benefits, and studies the application of mixed kernel function in enterprise economic benefits, where the economic benefits of five enterprises are evaluated by nuclear principal component analysis. The analysis results show that the total industrial output value is the most important factor in the economic benefits of enterprises. By comparing the contribution rate of the first principal component, when the mixed kernel function is used, the contribution rate of the first principal component is 98.80%, which is higher than 93.98% of the polynomial kernel function and 87.82% of the Gaussian kernel function. It shows that the mixed kernel function proposed in this study has higher accuracy and better effect in analysing and evaluating the economic benefits of enterprises, which can provide a basis for the follow-up financial analysis.

Declarations

Conflict of interest

The authors declare that there are no conflicts of interest.

Funding

This work was supported by the Key project of philosophy and Social Sciences Research of the Department of Education in Hubei Provincial, the project number is 2018GB152.

Data availability

The dataset can be accessed upon request.

References

[1] Ye Hua. Predicament and Solution of Enterprise Economic Benefit Audit [J]. Times Finance, 2021, (12), 47–49. (in Chinese)
[2] Liu Fengming. Talking about How to Effectively Improve the Economic Benefits of Enterprises by Means of Accounting Audit [J]. Financial and Economic Circle, 2021, (12), 148–149. (in Chinese)
[3] Song Jia. The Application of Multivariate Statistical Analysis in the Economic Benefits of Enterprises [J]. Productivity Research, 2020, (3), 141–143. (in Chinese)
[4] Li Rende, Huang Guoan. Economic Benefit Evaluation of Enterprises Based on Structural Equation Model. Technology and Innovation Management, 2010, (4), 451–454. (in Chinese)
[5] Aminian F, Suarez E D, Aminian M, et al. Forecasting Economic Data with Neural Networks [J]. Computational Economics, 2016, 28(1), 71–88.
[6] Huang H, Jia R, Shi X, et al. Feature Selection and Hyper Parameters Optimization for Short-Term Wind Power Forecast [J]. Applied Intelligence, 2021, 1–19.
[7] Li Guozheng, Wang Meng, Zeng Huajun. Introduction to Support Vector Machine [M]. Electronic Industry Press, 2004, 30–39. (in Chinese)
[8] Han H, Cao Z, Ren B G N. PCA-SVM-Based Automated Fault Detection and Diagnosis (AFDD) for Vapor-Compression Refrigeration Systems [J]. Hvac & R Research, 2010, 16(3).
[9] Liu Ming. Research on Sigmoid Kernel Function in Support Vector Machine [D]. Xidian University Dissertation, 2009. (in Chinese)
[10] Mohamed N. Nounou, Bhavik R. Bakshi, Prem K. Goel, Xiaotong Shen. Improving Principal Component Analysis Bayesian Estimation. Proceedings of the American Control Conference Arlington, 2001, 359–367P.
[11] Dong Yulin, Xia Zunquan, Wang Mingzheng. An MPEC Model for Selecting Optimal Parameter in Support Vector Machines. The First International Symposium on Optimization and Systems Biology, 2007, 351–357.
[12] Li Jingping, Xie Bangchang. Multivariate Statistical Analysis Method and Application [M]. Beijing: China Renmin University Press, 2008. (in Chinese)
[13] Jinbo Bi, Kristin P. Bennett. A Geometric Approach to Support Vector Regression. Neural Computation, 2003, 263–270P.
[14] Zhou Zun. Research on Coal Mine Safety Economic Benefit and Coal Mine Management Countermeasures [J]. Modern Economic Information, 2015, (14). (in Chinese)
[15] Yong Wang, Yan Hong, Li Linfeng. Analysis and Evaluation of Economic Benefits of Enterprise Informatization [J]. Modern Information, 2006, (02), 160–163. (in Chinese)
[16] Shi Luan. Introduction to the Analysis Method of Enterprise Economic Benefit [J]. Breeding Technical Consultant, 2010, (08), 207. (in Chinese)
[17] Yan Kongxiao. Decision-Making and Evaluation Analysis of Economic Benefits of Construction Enterprises [J]. China Collective Economy, 2020, (34), 26–27. (in Chinese)
[18] Chen Hnog-Gunn, Crisp D J, Bongner R E. Target Detection in Radar Imagery Using Support Vector Machines with Training Size Biasing. Proceeding of the Sixth International Conference on Control, Automation, Robotics and Vision, Singapore, 2000, 221–228P.
[19] Li Guozheng, Wang Meng, Zeng Huajun. Introduction to Support Vector Machines. Electronic Industry Press, 2004, 3, 30–39. (in Chinese)
[20] Su In L, Batzoglou S. Application of Independent Component Analysis to Microarrays. Genome Biology, 2003, 189–196P.
[21] Cao Hongcui, Wu Qixun. Principal Component Analysis and Cluster Analysis of Trace Elements in Glycyrrhiza uralensis Fisch. Journal of Gansu Union University, 2010, 24(2), 61–63. (in Chinese)
[22] Smits G F, Jordan E M. Improved SVM Regression Using Mixtures of Kernels. Proceedings of the 2002 International Joint Conference on Neural Networks, 2002, 2785–2790P.