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*Full length research paper*

# Construction of the prediction model of business operation performance in the electronic industry

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**No more than three years after the occurrence of sub-prime crisis in USA, the global financial market is facing again the strict threat of the European Debt Crisis, and if it cannot be solved, its impact will be far beyond financial crisis. Fast change of economic cycle has led to financial difficulty and credit bankruptcy in lots of enterprises in Taiwan with bad business operation performance; hence, lots of enterprises have to implement no-pay day or even lay-off. In addition, the confidence of lots of stock investors is affected, and many of them hesitate to buy more stocks. First, this article collected two sets of financial report data from 350 electronic related companies with stocks listed in regular and OTC stock market in Taiwan in the second season of 2011 and third season of 2011, meanwhile, Grey Relational Analysis and Data Envelopment Analysis where used to investigate the business operation performance of each enterprise and to rank the result. Then, dichotomy method was used in this article to divide this ranking into two types of good and bad performance to be used as dependent variable (Y), meanwhile, the financial report data was collected and arranged to be used as independent variable (X), then models such as ZSCORE model (abbreviated as ZSCORE), the association of Support Vector Regression and ZSCORE model (abbreviated as SVR+ZSCORE), Artificial Fish Swarm Algorithm (AFSA) optimized Support Vector Regression parameter in association with ZSCORE model (abbreviated as AFSASVR+ZSCORE) and Fruit Fly Optimization Algorithm optimized Support Vector Regression parameter in association with ZSCORE model (abbreviated as FOASVR+ZSCORE), will be used respectively to set up enterprise's operation performance detection model, meanwhile, the classification prediction capability of each model will be compared, and the result will be provided to the business operation and management personnel as reference.**

**Keywords:** Grey Relational Analysis; ZSCORE; Artificial Fish Swarm Algorithm; Fruit Fly Optimization Algorithm; Support Vector Regression

## INTRODUCTION

The financial Tsunami that occurred in 2008 led to serious shrinkage in global trading quantity, in 2009, GDP in lots of countries shows recession one after another. Within less than three years, many advanced countries in Europe have had debt crisis, and all the countries around the world have to face again the strict challenge of debt crisis in Europe. Lots of large enterprises in Taiwan with bad operation performance might have to face operation difficulty, and enterprise bankruptcy is usually the final result. Therefore, no-pay day is frequently adopted by these enterprises, or even lay-off is adopted to deal with such difficult situations. This shows that the management in lots of enterprise cannot manage the business operation risk well. Therefore, lots of management experts and scholars in the research of enterprise operation risk field start to pay great attention to enterprise operation and management issue for enterprise in Taiwan, meanwhile, complicated actuarial valuation and quantitative technique are used to construct the evaluation model of business operation performance.

Hence, this article also studies the business operation and management performance issues for enterprises in Taiwan. First, this article has collected the corporate

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financial data of 350 enterprises in Taiwan, and Grey Relational Analysis and Data Envelopment Analysis methods where adopted to study the business operation performance of these enteprises and to perform the performanc ranking; the top three and last three enterprises in business operation performance where investigated. Then, dichotomy method was adopted to divide this ranking into two types of good performance (represented by 0) and bad performance (represented by 1) to be used as dependent variables (Y). In the mean time, related financial report data of ZSCORE are collected, and they are calculated and arranged to be used as independent variables (X), then several exploring techniques are used respectively, for example, ZSCORE model (abbreviated as ZSCORE), the association of Support Vector Regression) SVR and ZSCORE model (abbreviated as SVR+ZSCORE), Artificial Fish Swarm Algorithm (AFSA) optimized Support Vector Regression parameter in association with ZSCORE model (abbreviated as AFSASVR+ZSCORE) and Fruit Fly Optimization Algorithm (FOA) optimized Support Vector Regression parameter in association with ZSCORE model (abbreviated as FOASVR+ZSCORE) to set up corporate operation performance detection model, meanwhile, the classification prediction capability of each model is compared to be used as reference by the business operation and management personnel.

The main structure of this article is: First section will be introduction of the research objective of this article. The second section will be introduction of grey relational analysis, Support Vector Regression, Artificial Fish Swarm Algorithm and Fruit Fly Optimization Algorithm. Third section will be introduction of sample data and empirical analysis used in this article. In fourth section, research conclusion and suggestion are proposed.

## METHODOLOGY

### Grey Relational Analysis

Grey system theory was proposed by professor Deng (1982), which, under the situation of system uncertainty and information incompleteness, performed model setup, relational analysis and forecast related to the system so as to understand the system. Before performing Grey Relational Analysis, in order to let the sequence satisfy comparability, normalization treatment needs to be done on the data of the sequence, which is called the formation of grey relation, that is, the sequence can be made to satisfy comparability; before performing grey relational analysis, the reference sequence (mother sequence) has to be confirmed first, then the closeness between other sequence (comparison sequence, son sequence) and reference sequence is compared so as to find out the level of grey relation and make the grey relation ordinals, then through the rankings, the advantage and disadvantage is judged so as to assist decision making. The steps of grey relational analysis are as followings:

From the original decision matrix D, we can find out standard sequence $A_0$ and Inspected Sequence $A_i$. Standard sequence is a set $A_0 = (x_{01}, x_{02}, \ldots, x_{0j}, \ldots, x_{0n})$ formed by the ideal target value of each influencing factor, it has a total of *j* terms, wherein $j = 1, 2, \ldots, n$. In addition, the performance value of Inspected Sequence is $A_i = (x_{i1}, x_{i2}, \ldots, x_{ij}, \ldots, x_{in})$, wherein $i = 1, 2, \ldots, m$. Normalize the data of original decision matrix D.

Calculate grey relational distance $\Delta_{0ij}$, wherein $\Delta_{0ij}$ is to evaluate the difference between each normalized value and normalized reference data.

$$\Delta_{0ij} = \left| x_{0j}^{*} - x_{ij}^{*} \right|$$

Calculate Grey Relational Coefficient $\gamma_{0ij}$.

$$\gamma_{0ij} = \frac{\Delta_{min} + \zeta \Delta_{max}}{\Delta_{0ij} + \zeta \Delta_{max}}$$

Calculate Grey Relational Grade $\Gamma_{0i}$ by the following equation:

$$\Gamma_{0i} = \sum_{j=1}^{n} \left[ \omega_j \times \gamma_{0ij} \right]$$

Rank the Grey Relational Ordinal and follow Grey Relational Grade value to perform performance ranking.

### Support Vector Machines

Support Vector Machines (SVM) is the machine learning system developed by professor Vapnik (1995) in Bell Lab according to statistics theory. Its basic concept is to construct optimal hyper-plane in sample space or feature space so that the distance between hyper-plane and the sample set of different type is maximal. The best classification of the super plane is as shown in figure 1.

Here we consider two types of nonlinear classification situations in n dimension. Given that the first training sample se: {(xi, yi), i=1, 2, …, l}. First, through a nonlinear mapping, the input data space is mapped to high dimension feature space:

$$x \to \varphi(x) = (\varphi_1(x), \varphi_2(x), \ldots, \varphi_m(x), \ldots)$$

In the high dimensional feature space, if the training sample set is linear separable, then there is classification

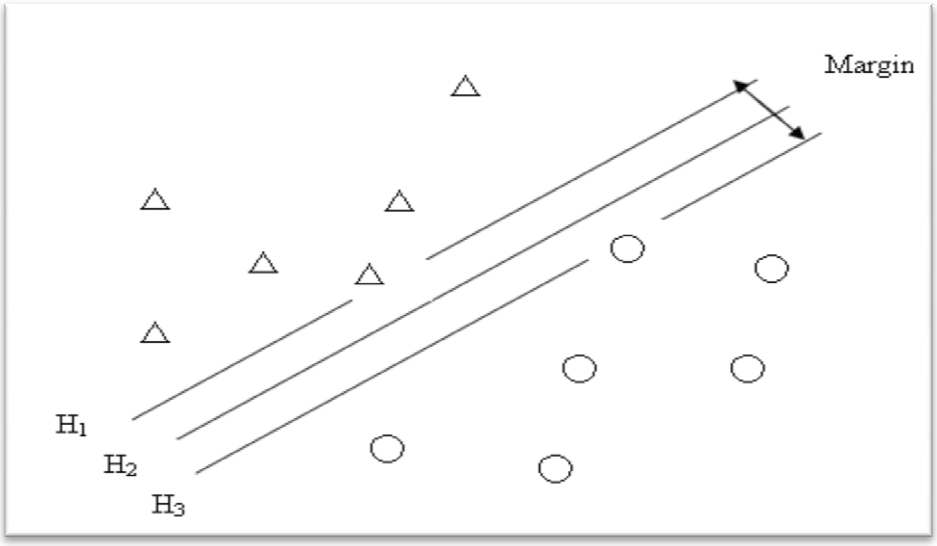


**Figure 1**: Illustration of the best classification of super plane.

hyper-plane <w, $\varphi(x) > +b = 0$ to separate the training sample correctly. Through normalized weight vector w and deviation b, the following inequality then exists:

$$y_i[< w, \varphi(x_i) > +b] \geq 1 \qquad i = 1,2,...,l$$

In high dimensional feature space, the distance from any training sample point to classification hyper-plane is:

$$d(w_i, w, b) = \frac{|< w, \varphi(x_i) > +b|}{\|w\|}$$

Hence, in the two training samples, the smallest distance to classification hyper-plane is usually 1/‖w‖, that is, the classification margin of both of them is 2/‖w‖. Therefore, the finding of optimal classification hyper-plane is to find, under the limiting condition of inequality, the hyper-plane with maximal classification interval, that is, the search of hyper-plane with minimal weight vector norm ‖w‖.

Since support vector machine is mainly used for classifying sample data, and it cannot predict on continuous data. Therefore, to satisfy the need to predict the continuous data, Support Vector Regression (SVR) theory is developed according to SVM theory. In SVR, there are two parameters that will affect directly the prediction capability of the model, which are respectively C value and σ value; hence, in the third model of this article, Fruit Fly Optimization Algorithm is adopted to adjust dynamically these two parameters. For the Matlab Toolbox of SVR, it can be accessed through the following web site: http://www.hackchina.com/en/cont/101624

## Artificial Fish Swarm Algorithm

Artificial Fish Swarm Algorithm (AFSA) is a newer Evolutionary Computation method, which was proposed in 2002 by Mainland China scholar Xiao-Lei Li (2002), and it is currently widely used in all kinds of fields (Peng, 2001; Saeed, 2009). It starts from the construction of fish behaviour, and then through the local optimization behaviour of fish individual, eventually, a global optimal value is shown in the entire group. Such algorithm has good capability to surmount the local value and to get the global value. In such swam activity process is achieved through the self-adaptive behaviour of each fish individual. Through the observation of fish behaviour, we can conclude them as three behaviours. In this article, these behaviours are self-written into program code using Matlab program design.

Random food search: When fish has nothing to do, it tends to swim freely; when the fish finds food in the neighbourhood, it will swim towards that direction. If the current state of the artificial fish is Xi, and within its sensing range, a state Xj is selected randomly, if Yi<Yj, then it will move one step towards that direction; on the contrary, state Xj is selected once again in random to judge if the above condition is satisfied; after several repeats, if the forwarding condition is still not satisfied, then it will move forward in random one step.

Clustering behaviour: They can usually form very large swarm. Suppose the current state of artificial fish is Xi, then the partner number within the current visible scope (that is, Dij< Visible) is nf, then if nf/N<δ, it means that the partner centre has more food and is not crowded, if at this moment, Yi<Yc, then it will move one step towards the partner centre location; otherwise, the food search behaviour will be implemented.

Tail chasing behaviour: When certain fish finds lots of food on that site, other fishes will follow and gather very soon. Suppose the artificial fish has current state of Xi, then if the optimal state neighbour within the current

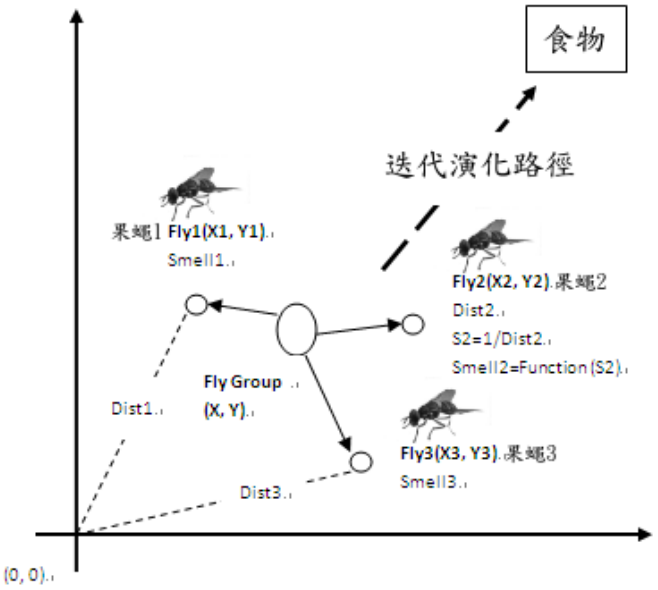


**Figure 2**: Illustration of iterative food search made by fruit fly swarm

visible range is explored to be Xmax, and if Xi<Xmax, and if the partner number within the visible range of Xmax is nf, and if nf/N<δ is satisfied, it means that there is more food around the neighbourhood of Xmax and is not crowded, then it will move one step towards Xmax; otherwise, the food search behaviour will be implemented.

The design steps of Artificial Fish Swarm Algorithm: First, individual model for Artificial Fish (AF) is constructed. During the process of finding optimization process, fish itself will select appropriate behaviour, and the final global optimization result can be searched out through certain warm or individual.

## Fruit Fly Optimization Algorithm

Fruit Fly Optimization Algorithm (FOA) is developed by Taiwanese scholar Pan (2011), which is a new method based on fruit fly food searching behavior to find out the global optimization. Fruit fly itself has sense and perception better than other species, especially in smelling and vision. The organ for the sense of smell of fruit fly can make good search of all kinds of smell floating in the air, or smell the food source that is 40 km away from it. Then it can fly close to the food location and use sensitive vision to find out the food and companion gathering location and fly towards it. The food finding characteristics made by the fruit fly can be summarized into several necessary steps and program examples to be provided to the reader as reference; the steps are as follows: Random initial fruit fly location, which is as shown in figure 2.

Init X_axis
Init Y_axis

The random direction and distance given to the fruit fly individual to use sense of smell for food search.

Xi= X_axis + Random Value
Yi= Y_axis + Random Value

Since the food location cannot be obtained, hence, the distance (Dist) to the origin is estimated first, then the smell concentration judgement value is calculated (S), and this value is the reciprocal of distance.

Dist=√(X_i^2+Y_i^2 ); Si=1/Disti

Substitute smell concentration judgment value (S) into smell concentration judgment function (or called fitness function) so as to find out the smell concentration (Smelli) of the individual location of the fruit fly.

Smelli = Function (Si)

Find out the fruit fly with highest smell concentration in this fruit fly swarm (Finding the maximum)

[bestSmell bestIndex] = max (Smell)

Remain optimal smell concentration value and x, y coordinate, at this moment, fruit fly swarm will use vision to fly towards that location.

Smellbest = bestSmell
X_axis = X(bestIndex)
Y_axis = Y(bestIndex)

Enter iterative optimization finding, then repeat the implementation of steps 2-5 and judge if smell concentration is superior to the previous iterative smell concentration, if so, please implement step 6.

Method for construction Hybrid Model

If we take a detailed look the ZSCORE model proposed by professor Altman(1968), we will find that it seems to be similar to multiple regression model, and the difference is that ZSCORE model does not have constant $\alpha$. Therefore, we can re-write ZSCORE model into:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.99X_5 + \varepsilon \quad (1)$$

Wherein $\varepsilon$ is the error item, which belongs to the random variable; therefore, this article has referred to the method of Pai (2005) to represent ZSCORE model into the following equation:

$$Z_t = L_t + N_t \quad (2)$$

Wherein $L_t$ is the linear part, and $N_t$ is nonlinear part; let $\tilde{Y}_t$ be the estimation value of ZSCORE model at time point $t$ and $\varepsilon_t$ be the estimated residual. Therefore, the residual at time point $t$ is:

$$\varepsilon_t = Z_t - \tilde{Y}_t \quad (3)$$

In this article, the residual item is predicted by SVR model, AFSASVR model and FOASVR model, and it can be represented by:

$$\varepsilon_t = f(X_{1_{t-1}}, X_{2_{t-1}}, X_{3_{t-1}}, X_{4_{t-1}}, X_{5_{t-1}}) + \Delta_t \quad (4)$$

Wherein, $f$ is a nonlinear function, and $\Delta_t$ is a random error item; hence, the associated prediction of hybrid model is:

$$\tilde{Z}_t = \tilde{Y}_t + \tilde{N}_t \quad (5)$$

Wherein, $\tilde{N}_t$ is the prediction value of equation (4), and the prediction values of the linear part and nonlinear part of the result can enhance the accuracy of the entire business operation performance prediction model.

## Empirical study

### Sample data and variable

In this article, two sets of financial report data of the second quarter of 2011 and of the third quarter of 2011 are taken from Infortimes Database, if the enterprises with defective value are subtracted, the financial data includes 350 enterprises, and such data are selected according to the financial variables in ZSCORE program, and the objective is to construct respectively three SCORE related models. This article has calculated five financial variables of ZSCORE model, and the equation and five financial variables of ZSCORE are follows:

- Z = 1.2 X1 + 1.4 X2 + 3.3 X3 + 0.6 X4 + 1.0 X5
- Wherein Z is ZSCORE, and X1 to X5 are defined as follows
- X1: Business operation capital divided by total asset;
- X2: Retained earnings divided by total asset;
- X3: Net profit before interest and before tax divided by total asset;
- X4: Market value of shareholder right divided by the face value of total debt;
- X5: Sale value divided by total asset.

The descriptive statistical values of these financial variable data are as shown in table 1.

### Grey Relation and Data Envelopment Analysis of business operation performance

In this article, all the financial variables are adopted to be used as the evaluation indexes of business operation and management performance for grey relational analysis, and for the investigation of business operation performance of Taiwan's electronic industry in 2011, and the index value will be the higher the better. Moreover, all the evaluation indexes will be analyzed by the grey relation as proposed by professor Deng, in the mean time, the grey relational Matlab toolbox as developed by Wen et al., (2006) will be used to find out Grey Relational Grade for subsequent ranking. Since most Z values are in the range from 0 to 5, hence, 5 is used to represent top 175 enterprises with good management performance, and 0 is used to represent last 175 enterprises with bad management performance, and they are used as dependent variable (Y) for constructing the model, and grey relational analysis result is as shown in figure 3. The diagram to the right is the analysis result of the second quarter data, and the diagram to the left is the analysis result of the third quarter, hence, there are a total of two sets of data. In this article, the maximal values of all the financial variables (X1-X5) are used as the standard sequence, wherein the bold dotted line represents the standard sequence, and the fine solid lines represent inspected sequence. Each data has five nodes to represent 5 column indexes of that enterprise. If the inspected sequence is closer to the standard sequence, it means that the business management performance of that enterprise is better.

From grey relational analysis result, it was found that enterprises of top three rankings in the business operation and management performance in the second quarter are respectively Teapo Electronic Corporation (2375), Unizyx (3704) and Silicon Integrated Systems Corp. (2363), and enterprises of the last three rankings are respectively Microtek International Inc. (2305), Enlight Corp (2438) and Pal Wonn (Taiwan) Co., Ltd. (2429); in the third quarter, enterprises with top three operation and management performance are respectively Unizyx(3704), Teapo Electronic Corporation (2375) and Silicon Integrated Systems Corp.(2363), enterprises with last three operation and management performance are Nanya Technology Corporation (2408), Pal Wonn (Taiwan) Co., Ltd. (2429) and Enlight Corp. (2438).

In addition, this article has adopted traditional Data Envelopment Analysis to perform enterprise's business management performance evaluation. In the analysis, Data Envelopment Analysis software DEAP is adopted for the research. The input items in Data Envelopment Analysis are the accounting items of total assets and total debts in the financial report of the second quarter and third quarter, and the output items are two sets of data of business income accounting items, the obtained two sets of technical efficiency values are used as the evaluation indexes of the enterprise operation and management performance and are performed with ranking process, similarly, 5 is used to represent top 175 enterprises with good operation and management performance, 0 is used to represent the last 175 enterprises with bad operation and management performance, and they are used as the dependent variable (Y) for model construction. The implementation screen of DEAP software is as shown in figure 4.

From Data Envelopment Analysis result, it was found that enterprises of top three operation and management

**Table 1**: The descriptive statistical values of five financial variables of ZSCORE in 2011

| Quarter | Statistical value | X1 | X2 | X3 | X4 | X5 |
|---|---|---|---|---|---|---|
| **Second quarter** | Max | 0.9746 | 0.5801 | 0.1180 | 34.0053 | 2.0057 |
| | Min | 0.0020 | -1.1340 | -0.2087 | 0.0479 | 0.0053 |
| | Avg | 0.4760 | 0.1077 | 0.0172 | 2.4238 | 0.4178 |
| | Std | 0.2158 | 0.1855 | 0.0344 | 2.9200 | 0.3084 |
| | N | 350 | 350 | 350 | 350 | 350 |
| **Third quarter** | Max | 0.9742 | 0.6783 | 0.2029 | 314.3249 | 2.7499 |
| | Min | 0.0037 | -1.3103 | -0.2931 | 0.0215 | 0.0071 |
| | Avg | 0.4633 | 0.1181 | 0.0255 | 3.7617 | 0.6271 |
| | Std | 0.2147 | 0.2093 | 0.0529 | 17.0069 | 0.4577 |
| | N | 350 | 350 | 350 | 350 | 350 |

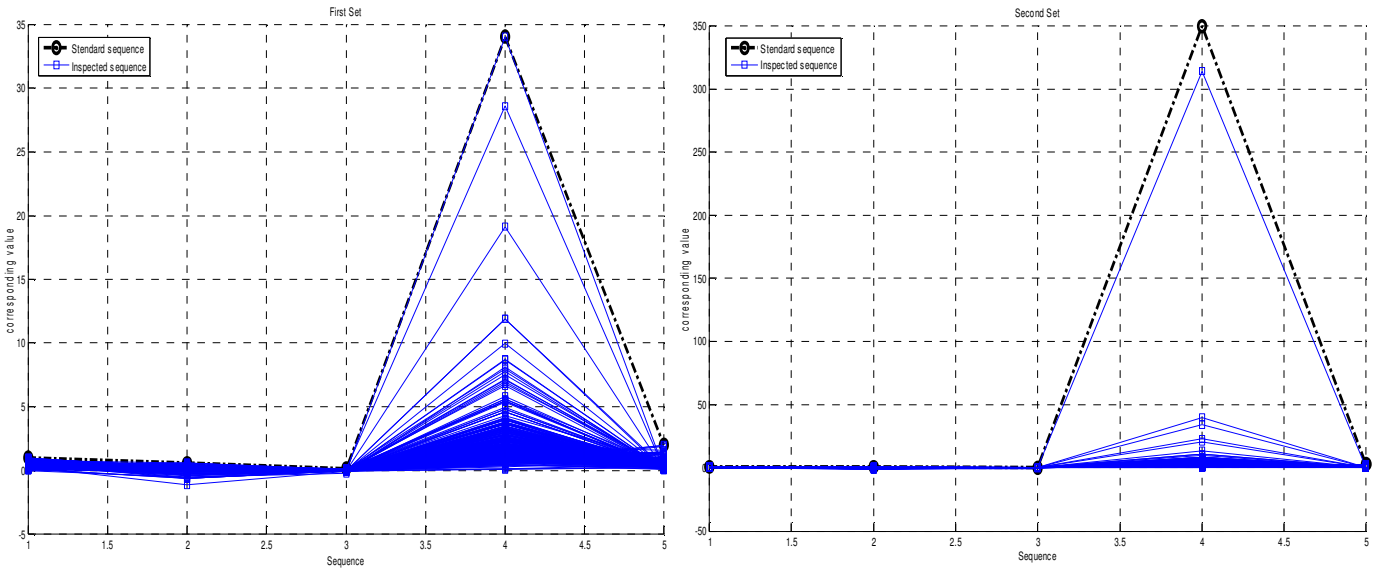


**Figure 3**: Linear sequence diagram of grey relational analysis

performance for the second quarter are Edom Technology (3048), Supreme Electronics Co., Ltd. (8112) and Apacer Technology Inc. (8271), and enterprises of last three business operation and management performance are Enlight Corp. (2438), Paragon Technologies Co., Ltd. (3518) and FIC Global Inc. (3701); in the third quarter, enterprises of the top three business operation and management performance are respectively ICP Electronics Inc. (3022), Mercuries Data System Ltd. (2427) and Formosa Advanced Technologies Co., Ltd. (8131), and enterprise of the last rankings are Chia Group (4942), Qisda (2352) and Ledtech (6164).

## The construction of the business operation performance prediction model for four types of electronic industries

First, five financial variables of the second and third quarter of 2011 are used to construct ZSCORE model. Since ZSCORE model uses Z value 2.675 as the division point, when the value is higher than it, it is a normal company, when the value is lower than it, it is then seen as company in crisis. However, most of the Z values are in the range from 0 to 5, hence, this article has defined that if the prediction value of the ZSCORE model is larger than 5

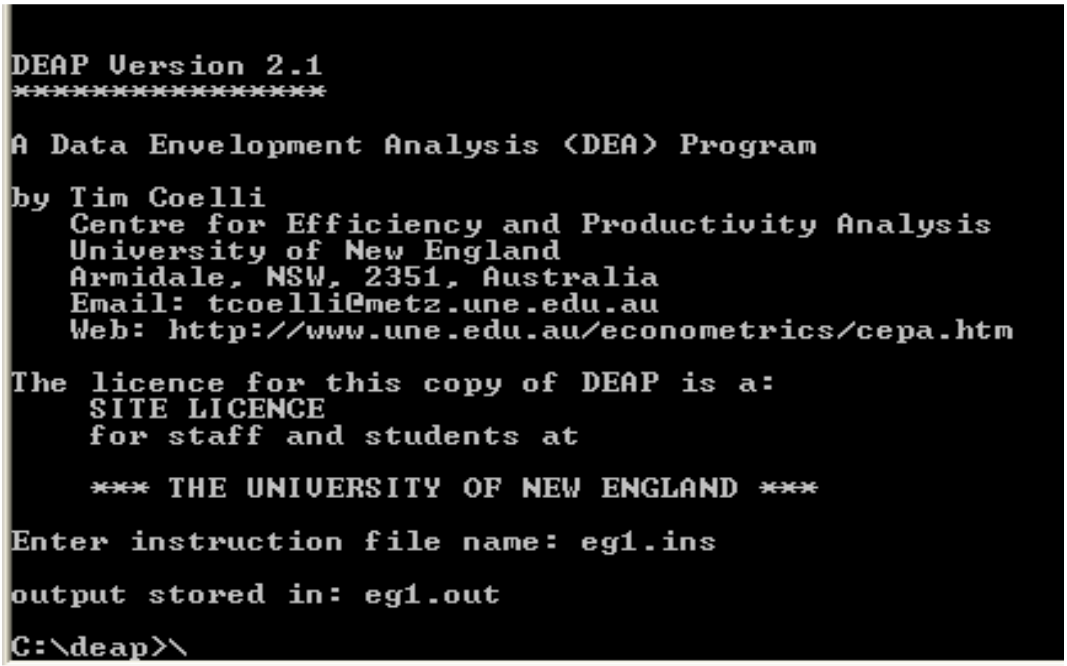


**Figure 4:** The implementation screen of Data Envelopment Analysis software DEAP

then it is represented by 5; when the prediction value of ZSCORE model is smaller than 0, then it is represented by 0, meanwhile, the dependent variable(Y) of the analysis result in the last section is subtracted by the Z value of the prediction result to be used as the error item $\Delta_t$. Figure 5, the upper diagram is the data distribution chart of error item calculated from the second quarter data of 2011, and this article has defined the association of grey relational analysis result and Z differential value and financial variables (X1-X5) as the first set of sample data, and Data Envelopment Analysis result and Z differential value in association with all the financial variables (X1-X5) are the second set of sample data. The lower diagram is the distribution chart of error item data as calculated from the third quarter data of 2011, similarly, grey relational analysis result and Z differential value in association with all the financial variables (X1-X5) are the third set sample data, and Data Envelopment Analysis result, Z differential value in association with all the financial variables (X1-X5) are the fourth set sample data. Each group of 350 sample data are finely divided into 5 small sets, and 4 sets are used as training data to construct the model, one small group is used as test data to test the prediction accuracy of a model and to perform cross verification, then newer Artificial Fish Swarm Algorithm (AFSA) optimized Support Vector Regression (SVR) model, Fruit Fly Optimization Algorithm, (FOA) optimized Support Vector Regression model and regular Support Vector Regression model are adopted respectively to predict the differential area part in figure 5. That is, error item $\Delta_t$ is added with the prediction value of ZSCORE model to become hybrid models such as AFSASVR+ZSCORE, FOASVR+ZSCORE and SVR+ZSCORE so as to enhance the detection capability of the business operation performance by ZSCORE model, and it is hoped that the result can be provided to the business management level as reference. The enterprise only needs to substitute the related index into the model to judge if any problem arises in the business operation and management.

In the initial parameter setup of Artificial Fish Swarm Algorithm of the AFSASVR model, the visible range of fish (visual) is 1, step value is 0.01, repeat frequency of random food finding (Trynumber) is 5, fish swarm scale is 20 fishes, iterative frequency is 100. First, the best fitness value in the initial swarm is set up as C value and σ value of SVR, then search iteration is performed to search optimal C value and σ value. In SVR aspect, after the setup of C value and σ value, independent variables (X) of four sets of training data are sent into SVR for the training. Then Root Mean Square Error (RMSE) equation is used to calculate the error between internet output value and dependent variable (Y), then through iterative adjustment, RMSE is minimized. Through the random food search behavior, clustering behavior and tail chasing behavior of the fish swarm, the RMSE between internet output value and dependent variable (Y) can be adjusted to minimum.

Figure 6 shows, among four sets of training data, the RMSE convergence trend chart during the AFSA iterative adjustment of the C and e value of SVR parameter for the training of SVR model in the first small group among the five small groups. From the training result, it can be found that in the upper left side of the figure, the C value of first

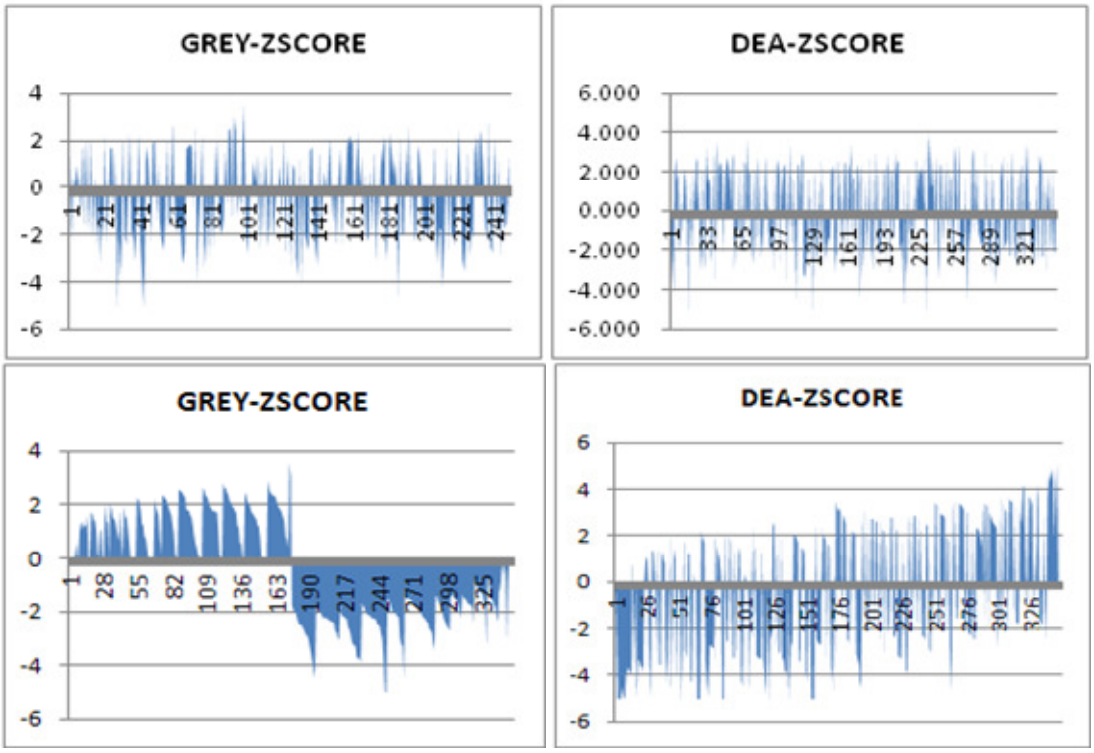


**Figure 5:** Illustration of the differential area between dependent variable(Y) and Z value

set of data is 12.3407, e value is 0.7381; the C value in the second set of data in the upper right side is 10.3332, e value is 0.8979; the C value in the third set of data at the lower left side is 14.1172, e value is 0.9010; the C value of the fourth set of data at the right lower side is 8.9625, e value is 1.1266.

In the setup of FOA initial parameter, the random initialization fruit fly swarm location interval is [0,1], the iterative fruit fly food search random flying direction and distance interval is [-10,10], fruit fly swarm scale is 20, iterative frequency is 100. The method used by FOA to optimize SVR it to calculate first the distance between the individual location of fruit fly to the origin coordinate (0,0) and then calculate the reciprocal so as to find the judgment value (S) of smell concentration, then it is substituted into the C value and σ value of SVR, then the input training data is entered to get the internet output value, then with the target value, RMSE (or called Fitness) is calculated, and this value is the smaller the better. Finally, the optimal smell concentration judgment value (S) is reserved to be used as C value and σ value of SVR, and iteration will then be performed based on this method.

Through the smell random food search of the fruit fly and through the clustering at the location with the highest concentration of smell by vision we can adjust the C value and σ value of the SVR to the optimal so that the RMSE between internet output value and the target value can be adjusted to a minimal value.

Figure 7 shows, among four sets of training data, the RMSE convergence trend chart during the use of FOA to adjust iteratively the C value and e value of SVR parameter for the first small group among the finely divided five small groups in the training of SVR model. From the training result, it is clear that the C value of the first set of data in the upper left side is 1.7789, e value 0.1894; the C value of the second set of data in the upper right side is 2.3053, e value is 0.1689; the C value of the third set of data in the lower left side is 1.7840, e value is 0.1930; the C value of the fourth set of data in the lower right side is 6.8097, e value is 1.5259.

## General comparison of the detection capability of the business operation performance prediction model of four electronic industries

In this article, the output result of the alarm model of the business operation performance of four electronic industries are defined according to ZSCORE that when the value is smaller than or equal to 2.675, it is classified as 0, when the value is larger than the value of the alarm model of the business operation performance of four electronic industries, it is then classified as 1 so as to observe the prediction capability of four models. After using four sets of sample data, each containing 5 small groups, to perform the cross verification of the prediction

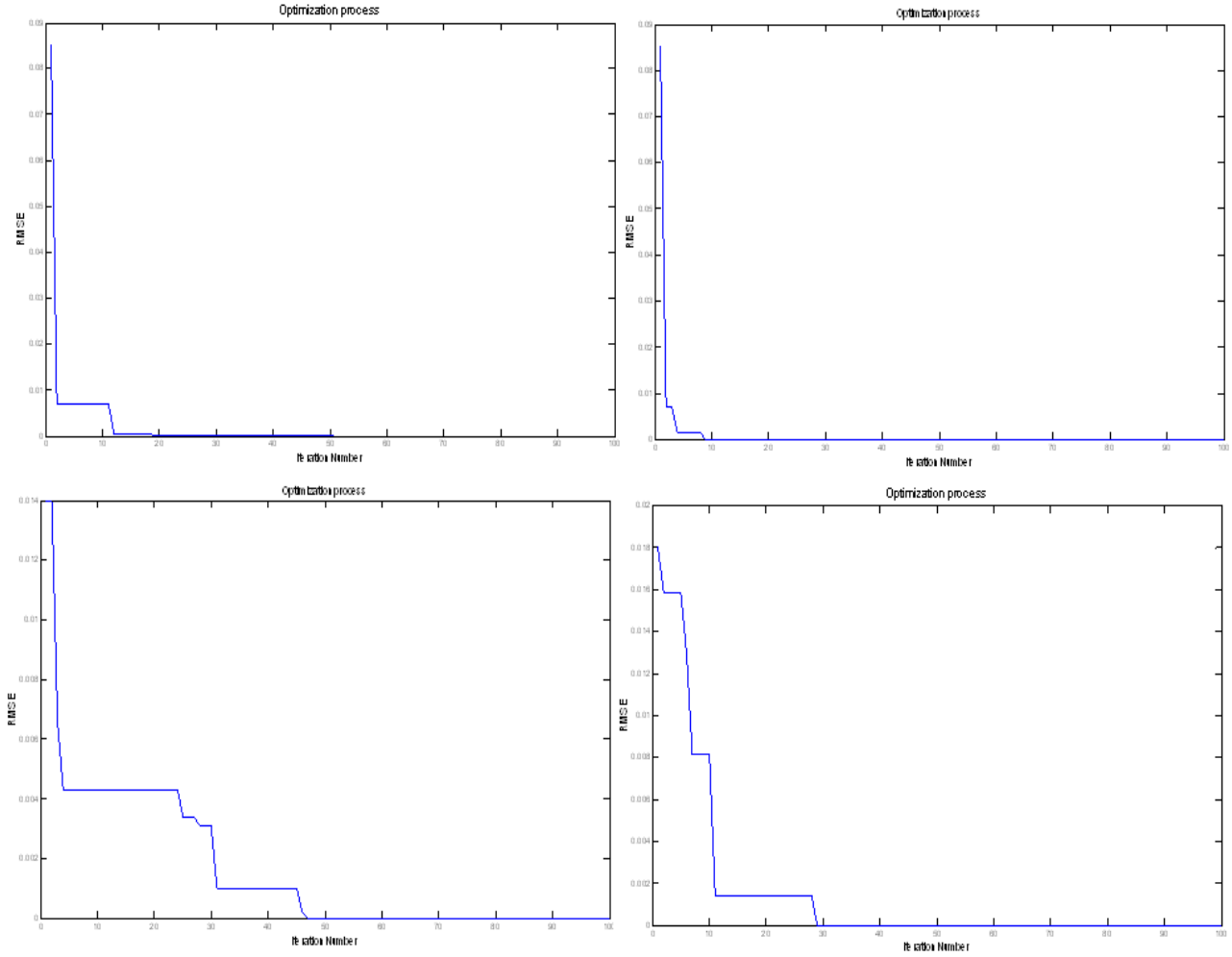


**Figure 6:** RMSE convergence trend chart when AFSA is used to adjust SVR parameter in the training stage

result of the three types of hybrid models, then in association with the result data generated by ZSCORE, and through the use of statistical software of SPSS, the result can be plotted into ROC curve, which is as shown in figure 8. Bradley (1997) pointed out that the larger the area above reference line and below the curve, the more accurate the classification capability of the model. From the figure, it can clearly seen that when 4 sets of data are used to construct the alarm model of electronic business operation performance, the model with best classification is usually the Fruit Fly Optimization Algorithm optimized Support Vector Regression model hybridized ZSCORE model. The next ones are respectively AFSASVR+ZSCORE, SCR+ZSCORE and ZSCORE, hence, it is clear that the forecast capability of the ZSCORE model is not good, the coefficient in the model and the accounting items need to be re-defined. Next, when we observe from the output result of the ROC curve analysis of table 2, wherein Sensitivity (Sen) means the percentage of the number with prediction result of 1 to the number of real value of 1, Specificity (Spe) means the percentage of the number with prediction result of 0 to the number of real value of 0, and Hand (2001) pointed out that Gini Index is equal to $2 \times AUC - 1$. Since these index values are the larger the better, four sets of data analysis results in the table show that Fruit Fly Optimization Algorithm optimized Support Vector Regression model hybridized ZSCORE model has values such as specificity, sensitivity, area under the curve (AUC) and Gini Index all higher than that of other models, hence, they have very good alarming capability.

## Conclusion

This research studied the business operation and management performance in Taiwan's electronic industry, in addition to finding enterprises of top three and last three

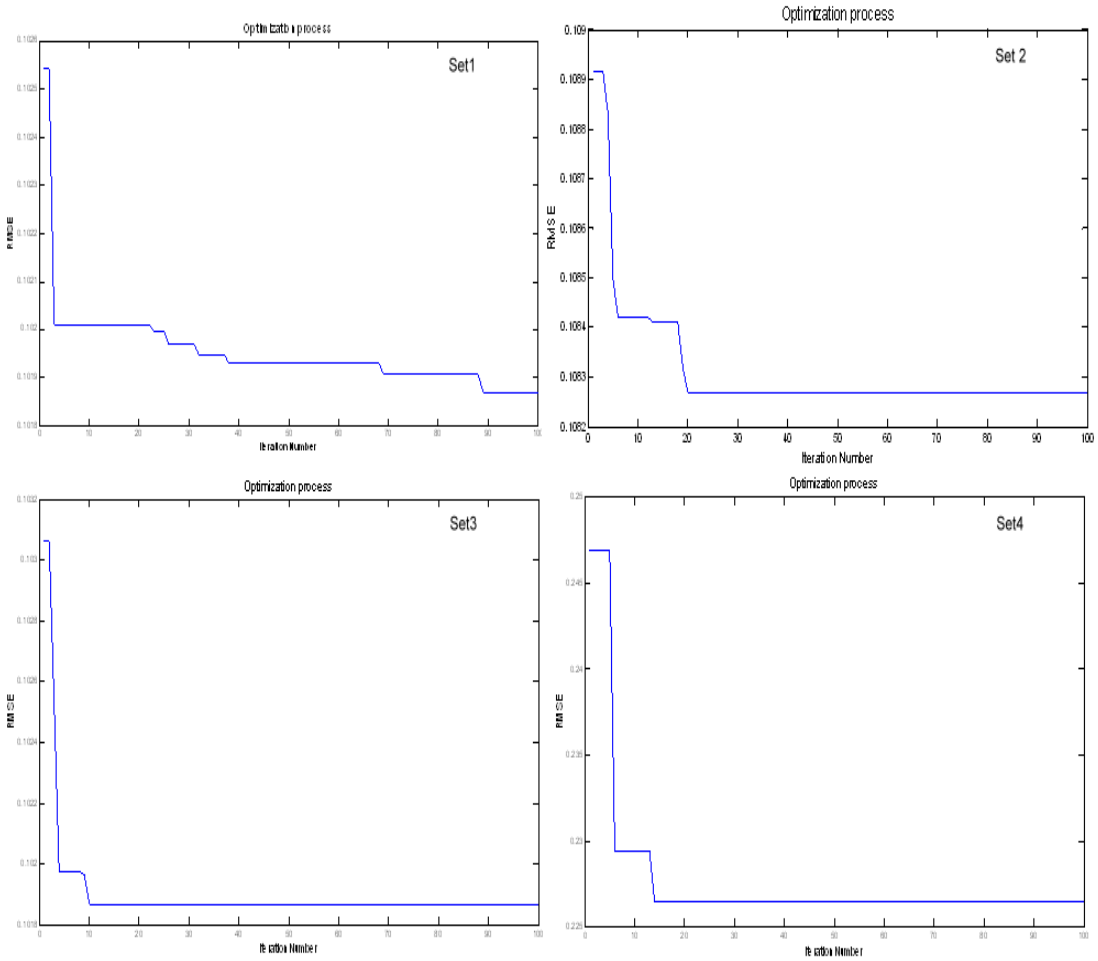


**Figure 7:** RMSE convergence trend chart using FOA to adjust SVR parameter in the training stage

**Table 2**: ROC curve analysis output result

| Set | Model | Sen | Spe | Auc | Gini | Set | Sen | Spe | Auc | Gini |
|---|---|---|---|---|---|---|---|---|---|---|
| **Set1** | FOASVR | 0.937 | 0.937 | 0.937 | 0.874 | **Set2** | 0.926 | 0.949 | 0.937 | 0.874 |
| | AFSASVR | 0.886 | 0.903 | 0.894 | 0.788 | | 0.891 | 0.931 | 0.911 | 0.822 |
| | SVR | 0.777 | 0.829 | 0.803 | 0.606 | | 0.800 | 0.851 | 0.826 | 0.652 |
| | ZSCORE | 0.657 | 0.743 | 0.700 | 0.400 | | 0.674 | 0.766 | 0.720 | 0.440 |
| **Set3** | FOASVR | 0.949 | 0.960 | 0.954 | 0.908 | **Set4** | 0.926 | 0.960 | 0.943 | 0.886 |
| | AFSASVR | 0.897 | 0.926 | 0.911 | 0.822 | | 0.903 | 0.914 | 0.909 | 0.818 |
| | SVR | 0.806 | 0.874 | 0.840 | 0.680 | | 0.846 | 0.897 | 0.871 | 0.742 |
| | ZSCORE | 0.737 | 0.823 | 0.780 | 0.560 | | 0.674 | 0.777 | 0.726 | 0.452 |

rankings in business operation and management performance, this research further performed ranking on business operation and management performance, meanwhile, dichotomy method was used to divide the enterprise into good performance and bad performance one. Then the error of the prediction value of the

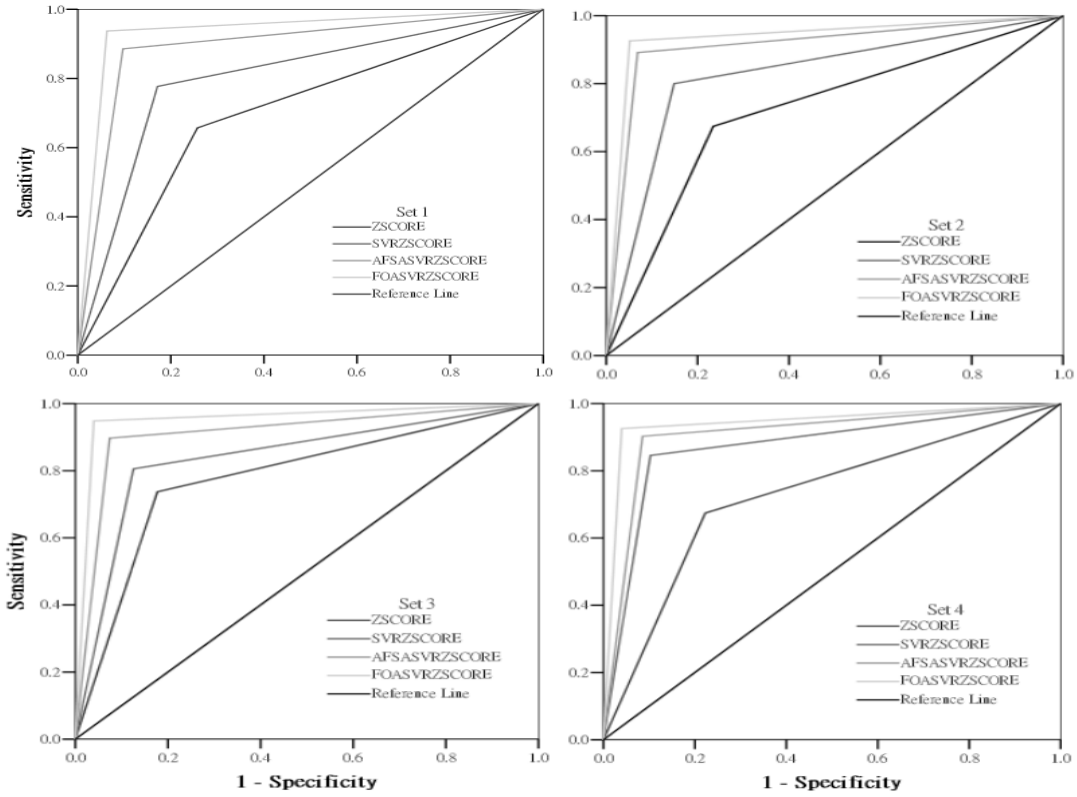


**Figure 8:** ROC curve of the classification prediction result of four business operation performance models in electronic industry

ZSCORE model is calculated to be used as dependent variable, then five variables of the ZSCORE model are associated to become sample data, then three models of FOASVR, AFSASVR and SVR are constructed respectively to predict the error value of the ZSCORE model so as to enhance the prediction capability of the ZSCORE model. From the analysis result, it is pointed out that the prediction capability of the ZSCORE model is worst, which might be a result due to different time background, and other model has to be relied on to predict the error item part, or the coefficient item or accounting item need to be re-defined before the prediction capability of ZSCORE model can be predicted. In addition, from the analysis result, it is clear that the prediction capability of the Fruit Fly Optimization Algorithm optimized Support Vector Regression model hybridized ZSCORE model is the best, the next are Artificial Fish Swarm Algorithm optimized Support Vector Regression model hybridized ZSCORE model, Support Vector Regression model hybridized ZSCORE model. Therefore, it is clear that the parameter C value and e value of general Support Vector Regression model will indeed affect the prediction accuracy of Support Vector Regression model, and the feature value is good to be used as reference by the related research personnel.

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