

# Study on the Application of SVM in Supplier Primary Election

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## Abstract

*Supplier selection is one of the most important things in supply chain management, the process of choosing a suitable supplier will effect enterprise's production and quality directly. This article puts forward a two-stage model of supplier selection based on analysis the problem of supplier management. It plots out the process as primary election stage and well-chosen stage, and builds up seven criteria to evaluate suppliers in primary election phase. Then, this context uses support vector machine to select suppliers and pays attention to two kinds of error — treat candidate supplier as non-candidate supplier and treat non-candidate supplier as candidate supplier. At last, a numerical simulation is used to explain selection of kernel function and sample training; the result reveals that this new method is practical and realistic and could reduce selection time.*

## 1. Introduction

With the development of information technology and world's flat, an enterprise's competition status finally is decided by three aspects: its status towards the main customers, its sustaining and unique superiority with its direct or indirect competitors; its localization of its main supplier and supply chain strategy. Hence, choosing suitable suppliers is a strategy problem for an enterprise.

But in the forming process which relates with the supplier, two essential factors play the crucial role. First is the cost, in order to seek the most competitive supply origin, majority enterprises do not hesitate to abandon traditional national raw material origin strategy, they adopt global raw material origin policy, the distance and quantity of suppliers are all increasing. The second essential factor is the excellent customer service; each enterprise seeks superior supplier who can support its logistic and JIT planning by no means the price.

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Under such situation, intensifying supplier relationship management, choosing appropriate supplier, constructing long-term cooperation partner relationship, guaranteeing supply chain's integration and coordination and enhancing enterprises competitive ability have become the focal point<sup>[1]</sup>.

## 2. Analyze the problem of supplier selection

In traditional purchase pattern, the typical procedure depends on price; each other obtains the income through the price competition. This purchase pattern emphasizes on how to trade with suppliers, takes suppliers' price comparison, chooses the lowest price as collaborator and holds short-term contract relationship with suppliers, which is disadvantageous to bilateral information communication and cooperation. However, under the supply chain environment, purchase management pays more attention to suppliers' quality rather than quantity. Enterprises select outstanding suppliers from various inspections and establish strategy partnership. Therefore, more and more people concern the issue of how to choose superior supplier as candidates from multitudinous supplier warehouse.

The method of supplier selection has developed three phases: qualitative analysis, qualitative associate with quantitative analysis and quantitative analysis. The quantitative methods at present are as follows:

(1) Linear weight model. In this method, the size of weight denotes grade. The bigger the size is, the more important the weight is. Typical methods in this model are AHP and ANP<sup>[2]</sup>.

(2) Case-based-reasoning method. It is one kind of artificial intelligence methods. It combines new information with former resemble cases<sup>[3]</sup>.

(3) Data envelopment analysis method (DEA). It is an analytical procedure developed by Charnes et al. DEA<sup>[4]</sup> is a mathematical programming technique that

calculates the relative efficiencies of multiple decision-making units based on multiple inputs and outputs.

(4) Total cost model. Total cost means all the cost related to supplier evaluation and selection in purchase lifecycle.

(5) Mathematical programming model. In order to describe decision problems, this model asks decision makers to construct object function and maximize or minimize object equation by changing variable's number<sup>[5]</sup>.

All of above methods can obtain certain effect under specific application environment, but the superiority will be substitute by complicated process when the data and information are very large. Take analytic hierarchy process (AHP) model for example, when the quantity of suppliers is large such as twenty, experts will make mistake easily, especially the logic error. As a result, it could not pass the consistency test and increase the complicacy of model application.

In modern globalization purchase society, one enterprise has dozens of suppliers for its multi-item purchase is extremely common. According to this situation, we divide supplier selection process into two stages, one is supplier's primary election stage and another one is supplier well-chosen stage.

(1) Supplier primary election stage. Determine the candidate suppliers from the mass suppliers. The goal of primary election stage is selecting right candidate suppliers which can establish long-term strategy partnership. It pays attention to suppliers' information of corporation and competition. These candidate suppliers should have good development potential, better financial condition and certain supply ability. This stage will takes a long time.

(2) Supplier well-chosen stage. In this stage, according to the concrete purchase duty, purchase target and evaluation criterion. Managers use certain quantitative method to choose final suppliers from these candidate suppliers. This selection depends on product's characteristic.

It can be seen that the number of suppliers is huge in supplier primary election stage and the process will take a long time to choose candidate suppliers. Therefore, it needs a better method to distinguish the candidate suppliers and non-candidate suppliers.

### 3. Theory of support vector machine

Supplier's primary election determines whether this supplier could be recognized as candidate supplier or not. In fact, this is a classification problem. Suppliers are candidate suppliers who conform to the classification condition, while others are non-candidate

suppliers. The support vector machine has its unique superiority in classification, especially binary classifier.

The support vector machine is one kind of new machine learning algorithm which develops in the statistical learning theory<sup>[6]</sup>. Its major characteristic is structural risk minimization principle. It also enhances the capability of learning generalization performance. In addition, the SVM will be equivalent to solving a linear constrained quadratic programming problem so that the solution of SVM is always unique and globally optimal.

Nowadays, SVM was introduced to a lot of applications, such as financial time-series forecasting, credit scoring<sup>[7]</sup>, and bankrupt prediction<sup>[8]</sup>.

The principles of SVM are as follows:

Suppose: binary classifications sample  $(x_1, y_1), \dots, (x_i, y_i)$ ,  $x \in R^d$ ,  $i$  is the number of sample,  $d$  is input dimension, hyperplane  $(wx) + b = 0$  separates this binary classification sample:

$$\begin{cases} (wx_i) + b \geq 0 & y_i = +1 \\ (wx_i) + b < 0 & y_i = -1 \end{cases} \quad (1)$$

If the sample is divided no error and the distance between these two classifications is maximization, this hyperplane is so-called optimal separating hyperplane. The solution of optimal separating hyperplane may be regarded as quadratic programming problem,

$$\begin{aligned} \min \phi(w) &= \frac{1}{2} \|w\|^2 \\ \text{s.t } y_i(x_i w + b) &\geq 1 \\ i &= 1, \dots, n \end{aligned} \quad (2)$$

The optimization problem could transform into simple dual problem.

$$\begin{aligned} \max Q(\alpha) &= \sum_{i=1}^n \alpha_i - \frac{1}{2} \sum_{i,j=1}^n \alpha_i \alpha_j y_i y_j (x_i \cdot x_j) \\ \text{s.t } \sum_{i=1}^n \alpha_i y_i &= 0 \\ \alpha_i &\geq 0, i = 1, \dots, n \end{aligned} \quad (3)$$

$\alpha_i$  is Lagrange multiplier according to each sample. At the same time, the optimal solution should satisfy the condition:

$$\alpha_i (y_i (wx_i + b) - 1) = 0, i = 1, \dots, n \quad (4)$$

If  $\alpha_i^*$  is the optimal solution, then  $w_i^* = \sum_{\text{support vector } i} \alpha_i^* y_i x_i$ . According to  $i$  which satisfies  $\alpha_i \neq 0$  and formula (4), the optimal classification function will be given as :

$$f(x) = \text{sgn}(w^* x + b) \quad (5)$$

In general cases where the data is not linearly separated, SVM uses nonlinear machines to find a hyperplane that minimizes the number of errors on the training set, it is called kernel function  $K(x_i, x_j)$ . Then transform the formula (3) into:

$$\max \sum_{i=1}^n \alpha_i - \frac{1}{2} \sum_{i,j=1}^n \alpha_i \alpha_j y_i y_j K(x_i, x_j) \quad (6)$$

$$\text{s.t. } \sum_{i=1}^n \alpha_i y_i = 0$$

$$0 \leq \alpha_i \leq C, i = 1, \dots, n$$

The classification function becomes

$$f(x) = \text{sgn} \left( \sum_{i=1}^n \alpha_i^* y_i K(x_i, x_j) + b \right) \quad (7)$$

Each kernel function brings different support vector machine.

Now, we use a numerical simulation to analyses the application of SVM in supplier primary election.

## 4. The application of SVM in supplier primary election

### 4.1. Establish evaluation criteria

In the above context, supplier primary election stage is different from well-chosen stage; each of them has different object and emphases. As a result, these two stages use different evaluation criteria.

As we mentioned before, primary election stage pays attention to suppliers' outstanding achievement, supply capability and their viability. For the sake of finding long-term partners, this stage has seven factors, such as technology level, service network, designed capacity, property debt, human resource, supply capacity, credit rank and so on.

On the other hand, well-chosen stage emphasizes particularly on current purchase, it focuses on product's characteristic, so its evaluation criteria are cost, quality, delivery on time and so on. These criteria are in the figure.1.

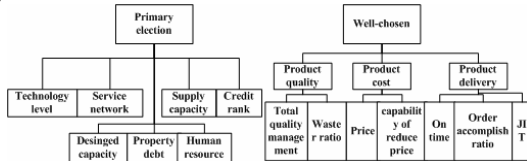


Figure.1 Evaluation criteria in supplier primary election and well-chosen stage

### 4.2. Implement process

(1) Data preparative. According to the evaluation criteria of supplier primary election in step4.1, enterprises should collect each supplier's correlation information and data which from year finance report, history trade and information supported by suppliers.

(2) Data processing. Because of different dimension of each evaluation criteria, these data should do normalization. Some qualitative criteria such as credit standing grade could use 9-score to normalize them. This article uses a manufacture firm's fifty suppliers'

history data as training sample. After normalization, construct a two-dimension data set, shown in table1, former 45 groups are training sets and latter 5 groups are testing sets.

Table.1 Suppliers' history data

The number of supplier	Technology level	Service network	Designed capacity	Property Debt	Human resource	Supply capacity	Credit rank	Candidate(+1) or not(-1)?
1	0.775	0.425	0.425	0.45	0.375	0.55	0.275	+1
2	0.75	0.425	0.575	0.375	0.375	0.7	0.475	+1
.....	.....	.....	.....	.....	.....	.....	.....	.....
48	0.425	0.525	0.7	0.475	0.525	0.675	0.55	-1
49	0.7	0.6	0.675	0.475	0.65	0.55	0.6	+1
50	0.85	0.75	0.625	0.75	0.625	0.85	0.525	+1

(3) Data training. In this context, we use SVM software "WINSVM" to solve problems and analyze results. We apply three kinds of kernel function:

A: linear kernel function:  $K(x_i, x_j) = x_i \cdot x_j$

B: polynomial kernel function:  $K(x_i, x_j) = ((x_i \cdot x_j) + 1)^d$

C: radial basic function:  $K(x_i, x_j) = \exp(-\|x_j - x_i\|^2 / \sigma^2)$

These kernel functions train sample, according to the results, we choose the excellent function as the optimal classification model.

During the process of classification, it appears two kinds of error, one is treating candidate supplier as non-candidate supplier, the other one is treating non-candidate supplier as candidate supplier. This article studies on how to select candidate supplier, therefore, a good classification model should reduce the occurrence of treating non-candidate supplier as candidate supplier. The reason is that the first kind of error could be repaired by certain measure, for example, manager artificial select lost candidate supplier. However, it is difficult to find the supplier who is wrong judged under the second kind of situation.

(4) Forecasting classification. Input some new suppliers' data; use the optimal classification model to classify, confirm candidate suppliers.

All the steps are shown in figure 2.

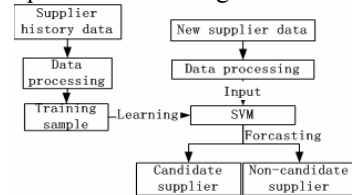


Figure.2 classification steps with SVM

### 4.3. Result analysis

After using three kinds of kernel function to train sample, the result shows that the effect of linear kernel function is not ideal. It means that supplier primary election is not a linear divisible problem. We should use non-linear kernel function.

The result of polynomial kernel reveals that the higher degree is, the worse training accuracy and testing accuracy are, which means the performance of

high degree's polynomial kernel is worse than the performance of low degree's polynomial kernel, see figure 3. Look into wrong classification data, in training set, the number of treating non-candidate supplier as candidate supplier is increase with degree, while in testing set, almost all of the non-candidates are judged as candidates. The polynomial kernel is not ideal in supplier primary election application effect.

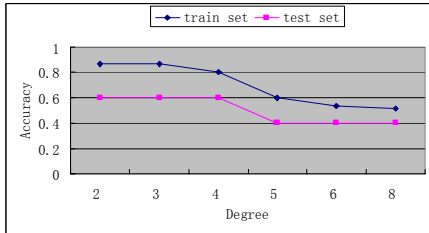


Figure.3 The accuracy of Polynomial with different degree

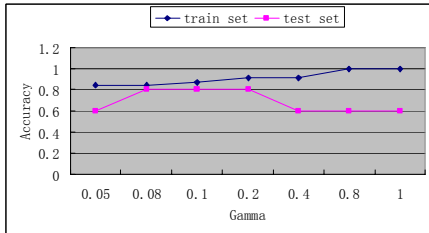


Figure.4 The accuracy of RBF with different gamma

At last, radial basic function trains sample, the accuracy changes with the diversification of gamma value. See figure 4. The classification result shows that the error is treating candidate supplier as non-candidate supplier. At last, we choose radial basic function, set gamma as 0.08, and optimal classification model is:

$$f(x) = \text{sgn}\left(\sum_{i=1}^n \alpha_i^* y_i K(x_i, x) - 0.149\right)$$

The accuracy of training set is 84% and testing set is 80%, and the distance of these two classifications is largest. It is good for selecting candidate supplier.

Using SVM to do supplier primary election, the primary task is choosing a suitable kernel function and building up an excellent classification primary model. It will reduce the process of supplier primary election decision and enhance the precision.

## 5. Conclusions

In purchase domain, massive literatures concentrate to discuss supplier selection. The reason is that suppliers are the most important external agency for enterprise's operation system. Suppliers are key essential of enterprises to guarantee product quality, price, delivery on time and service<sup>[9]</sup>. This article analyzes the suppliers selection process, divides supplier selection stage into two stages——primary election and well-chosen. Different stage has different evaluation criteria to select suppliers. It also researches

the application of SVM in supplier primary election stage.

However, each enterprise uses different criteria to evaluate its suppliers. The windage which appears in SVM responds to different sample data and different criteria. In practice, enterprises build up criteria and choose different kernel function according to their different situation. Besides, combining database management and information system is useful for manager to collect suppliers' information and history data. Unifying these aspects, SVM applied in supplier primary election is practical and realistic.

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