A case based reasoning approach on supplier selection in petroleum enterprises

Kai Zhao [a,b,1], Xin Yu [c,*]

[a] College of Economics and Management, Heilongjiang Bayi Agricultural University, Daqing, China
[b] Department of Management and Law of Daqing Oilfield Co. Ltd., Petrochina, Daqing, China
[c] Department of Environmental Engineering, University of Science and Technology Beijing, Beijing, China

ARTICLE INFO

ABSTRACT

Petroleum is an important strategic material which is connected with the vitals and safety of the national economy, and the supplier selections are related to the safety of petroleum production and supply. However, the traditional approaches for supplier selections are limited in subjective evaluation of weights, inaccurate assessing rules, and inefficient decision-making. Although most of the current methods are widely applied in corporation management, a more efficient approach needs to be proposed for supplier selection of oil enterprise.

This paper summarizes the particular characteristics of the supply chain of Chinese petroleum enterprises, analyzes the limitations of the traditional methods of supplier selection, and brought forward the method based on case reasoning system (CBR) for petroleum enterprises. The method based on data mining techniques which solves three key problems of CBR, includes calculating the weights of the attributes with information entropy in case warehouse organizing process objectively, evaluating the similarities with *k*-prototype clustering between the original and target cases in case retrieving process exactly, and extracting the potential rules with back propagation neural networks from conclusions in maintenance and revising process efficiently. It demonstrates the advantages, practicability and validity of this method via case study finally.

1. Introduction

Petroleum is the most widely used energy which cannot be regenerated, and also an important strategic material that is connected to the vitals and safety of the national economy. In recent years, the supply-need contradiction of China's energy is pricking up as Chinese economy develops rapidly. Meanwhile the strategic repertory system for oil is faulty, so China has not enough ability to deal with the oil risks. It is forecasted that in 5–15 years, the price of oil will remain in a high standard because of the factors such as the dollar depreciation, the oil production reducing, and the expectation of OPEC raising, etc.

In the existing system, the oil produced by the Chinese petroleum enterprises is purchased and sold by the government only, thus some of the oil enterprises do not have "marketing" (Zhao, 2007), therefore the suppliers of the oil enterprises take a more important role. It is quite obvious that the suppliers as the most important partners, impact the enterprises very deeply on reducing production costs, increasing the efficiency, and realizing the continuance development with their qualification, rate of technicians, high quality rate, quality of product, supply, and R&D.

Nowadays, the globalization and informationization boosted the establishment of the dynamic alliance of enterprises, and make the competitions of single enterprise into competitions of supply chains. And this changes the traditional management to the supply chain management (Ma, Lin, & Chen, 2000). Under the situation of global trade and agile supply chain, supplier selection is a very important decision for an enterprise. So how to evaluate and select the suppliers is significant for the healthy growth of an enterprise.

Because of the traditional score method for selecting suppliers is weak for dealing with the uncertain information, and the results are hard to explain, so it is difficult to adapt the new competition.

This paper will utilize the case based reasoning system which imitates human thinking abilities, combines with data mining methods to select eigenvectors with high importance, confirm the weight of attributes impersonally, evaluate the similarities of the target case and the original case accurately, and meanwhile distilling the potential rules from the selection results, thus improves the accuracy and efficiency of the decision-making of the petroleum enterprise' supplier selection.

* Corresponding author. Address: Room 1803, No. 10 building, Anyuanbeili, Chao Yang District, Beijing, 100029, PR China. Tel.: +86 10 6232 6016; fax: +86 013261820380.
E-mail addresses: zhaokai@petrochina.com.cn (K. Zhao), rollyu@126.com (X. Yu).
[1] Tel.: +86 0459 5970771; fax: +86 013945999989.

2. The main methods of supplier selections

2.1. Linear weighting models

It is a method which solves single resource problems. Its fundamental is to distribute a weight to each rule, the bigger the weight, the more important. The integral of the supplier is the summation of the score of each rule and the product of the score and the weight of the supplier, and who gets the highest integral will be the best supplier.

Analytical hierarchy process (AHP) (Satty & Alexander, 1981) is the most widely used method of the linear weighting models. This method is simple, practical, and effective. It is used in the supplier selection (Lee, Ha, & Kim, 2001) and the evaluation of PRI (De Boer, Vander Wegen, & Telgen, 1998) etc.

The disadvantage of AHP is that it depends on the expertise, there are more subjective factors in it, and it is easy to have the variance of the judge matrix. In addition, sometimes there will be some blurry and inexact factors in the use of it, and makes warp of the decision result.

2.2. Total cost approaches (TCA)

It is a common method to solve single purchase project problems. The basic idea of it is to account the cost of purchase, includes the sales price, purchase expenses, transportation expenses of the supplier which can satisfy the needs. Comparing with the different purchase costs of the suppliers, the supplier which has the lower cost will be selected.

Timmerman brought out the method of Cost Ratio (Timmerman, 1986) which accounts the total costs of quality, transportation, and service that related with the cost to select the suppliers. This method accounts the ratio of the cost of each rule in the total costs to select the suppliers finally.

Fillip Roodhooft and Joseph Konings put forward the method of Activity Based Costing (ABC) (Roodhooft & Konings, 1996) to select suppliers in 1996. Monczka and Trecha (1988) propose that this method selects the suppliers via analyzing the direct and indirect costs in the purchasing activities of the enterprise.

Degraeve and some others compared 13 supplier selection models described in the literature before 2000 with Total Cost of Ownership, and calculated the purchase costs of the models with the real data of roller purchase of Belgium steel company. The conclusion is: mathematical programming method is better than evaluation method, and the multi-project model is better than single project model (Degraeve, Labro, & Roodhooft, 2000).

Because TCA needs to collect information and cost data of the suppliers in detail before making the purchase decision, the quantity of the information is huge, and the calculation is complex, so it is hard to be successful for those supplier selection problems which have not enough information of the suppliers.

2.3. Mathematical programming method

It is a very important method to solve the optimization problems of single and multi-resource, includes single/multi objective, linear/nonlinear programming, and mixed integral programming, etc.

Because mathematical programming method can be easily described, and there are good software for it, so it is widely used in the descriptions and methods of supplier selection problems. Gaballa (1974) used linear programming method in the problems of supplier selection first. Besides, Pan (1989) analyzed the orders to increase the stability of the supply, and built up the linear programming model, made cost as its target, and price, quality and service as its restrict.

Non-linear programming models are seldom used to select suppliers. Benton created a non-linear programming model for supplier selection with multi-project, multi-supplier, multi-customer, limited resource, abated quantity, took minimized total purchase costs, storage costs and order costs as its target, took storage capability and capital as its restrict, and solved it with Lagrangian relaxation approach (Benton, 1992). Ghldsypour and O'Brien (2001) brought out a mixed integral non-linear programming model with multi-resource problems under limited supply capabilities to select suppliers and confirm the purchasing amount, the target function is minimizing the costs of purchasing, storage, transportation and order, and took quality and supply capabilities as its restrict.

The single target model is hard to solve the multi-rule problems of supplier selections due to its minimizing cost goal. The multi-target linear programming model can solve the problems of rule conflicts in the supplier selection process, hereinto, Weber and Current (1993) used multi-target linear programming model to select suppliers, took price, quality, delivery as its target, and capability of the supplier, demand, policy, capital, and the amount of suppliers as its restrict. Buffa and Jackson also established a multi-target linear programming model which considered quality, price, service and delivery synthetically (Buffa & Jackson, 1983).

There are not enough academic and historical data sustention due to the complexity and non-confirmation of the society, production, and the economic systems, resulted in that it's hard to abstract clear mathematical models and accurate mathematical methods to solve those problems, meanwhile, it is hard to get the accurate analytic solutions when the problem is big and complex.

In summary, the traditional supplier methods are based on static analyzing methods which to mark the suppliers, that is the supplier who gets the highest mark will be selected. These methods have some common disadvantages as follows:

(1) The decision-making flow in existence methods lacks of dynamic state and learning ability, the restrict is fixed, and the adaptability of it is weak, so they cannot deal with the uncertain information of the suppliers effectively.
(2) The decision-making standard of the selection methods in existence is with strong subjectivity, no matter the settings of the index, or the distribution of the weight, more of less come from the preference of the decision-makers' subjectivity.
(3) The results of the supplier selection are commonly presented as marks or grades, which are not easy to understand, it also cannot present the performance of the suppliers, so it is hard to supervise the suppliers to improve.
(4) Because the results of the suppliers' selections cannot be explained, it is hard to find the latent rules and models from them, so the result of the decision-making lacks of predictability.

To sum up, people brought forward many models and methods theoretically aimed at the limitations of the supplier selection, but most of them can not be used in practice. Therefore, there are two extremities, on one hand, there are many theoretic models, on the other hand, enterprise seldom uses them. So it is necessary to establish models and methods which are maneuverable to shorten the distance of the theories and the practice, and to improve the management.

3. The CBR system of petroleum enterprise supplier selection based on data mining

Case based reasoning is an integrate representation of human being's three thoughts – intuition, logic, creativity. In 1982, Schank