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The integration of association rule mining and artificial immune network for supplier selection and order quantity allocation

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ABSTRACT

This study firstly uses one of the association rule mining techniques, a TD-FP-growth algorithm, to select the important suppliers from the existing suppliers and determine the importance of each supplier. A hybrid artificial immune network (Opt-aiNet) and particle swarm optimization (PSO) (aiNet-PSO) is then proposed to allocate the order quantity for the key suppliers at minimum cost. In order to verify the proposed method, a case company's daily purchasing ledger is used, with emphasis on the consumer electronic product manufacturers. The computational results indicate that the TD-FP-growth algorithm can select the key suppliers using the historical data. The proposed hybrid method also provides a cheaper solution than a genetic algorithm, particle swam optimization, or an artificial immune system.

1. Introduction

With fierce global competition, most of the manufacturing functions in a supply chain have become more important. Many factors are regarded to be the causes of increased competition, such as a short product life cycle, rapid changes in consumer demands and competition from emerging countries. In particular, the purchasing of materials is a critical link between outsourcing and manufacturing. Therefore, an efficient purchasing process improves an enterprise's efficiency, reduces cost and increases profit.

Diversification of risk in the modern corporate environment leads manufacturers to source multiple suppliers of raw materials or parts. in the choice of a single main supplier or several suppliers results in most enterprises attempting to obtain the best product quality and maximizing the interest of supply chain partners, so the selection of suitable suppliers ensures high-quality products and effective management can reduce total costs. However, in this complex environment, supplier selection and order quantity allocation that minimizes cost are still two important issues for the manufacturing sector.

This study proposes an order quantity allocation model that uses a combination of association rule mining and hybrid evolution algorithms. A TD-FP-growth algorithm that has shown its capability in association rule mining is applied to select important suppliers from the existing suppliers and to determine the importance of each supplier. A hybrid artificial immune network (Opt-aiNet) and particle swarm optimization (PSO) (aiNet-PSO) is then proposed for the allocation of orders to key

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suppliers at minimum cost. In order to verify the proposed methods, a case company's daily purchasing ledger is used, with emphasis on consumer electronic product manufacturers.

The remainder of this paper is organized as follows. Section 2 provides an introduction to the related topics necessary for this research and the proposed model is presented in Section 3. Section 4 illustrates the results from the model evaluation using a case company. Concluding remarks are given in Section 5.

2. Literature survey

This section introduces supplier selection, order quantity allocation, order assignment and allocation methods, association rule mining, artificial immune systems and particle swarm optimization.

2.1. Supplier Selection

Suppliers are vendors who provide raw materials, components or services that an organization itself cannot make. In the current manufacturing environment the supplier is a vital part of a supply chain and a suitable supplier can offer the company the right quality products and the right quantity at a reasonable price and at the right time [1]. As an organization becomes more dependent on suppliers, it is important to find an appropriate method to evaluate supplier performance. The supplier selection problem requires the consideration of multiple objectives. Bhutta and Huq [2] proposed that supplier selection could be viewed as a multi-criteria decision-making problem.

Dickson [3] conducted a survey and presented 23 different criteria for an appropriate supplier performance evaluation. Hu [4] analyzed 24 papers published after 1991 and discovered that price, quality, production capacity and delivery remain the most important attributes for supplier evaluation techniques. In order to be more practical when selecting suppliers, Çelebi and Bayraktar [5] presented 37 criteria. These criteria were categorized into three dimensions, cost, quality, delivery and service.

Some supplier selection methods are detailed in literature, including artificial neural networks [6], data envelopment analysis (DEA) [7], analytic hierarchical processes (AHP) [8] and analytic network processes (ANP) [9].

2.2. Order quantity allocation

Order quantity allocation minimizes cost using an order quantity allocation model, after the most suitable suppliers are selected [1,10,11]. Kokangul and Susuz [12] suggested that order quantity allocation determines the total cost of purchase (TCP) and total value of purchase (TVP). Based on the study by Aissaoui et al. [13], order quantity with minimum cost suppliers dates back to a study from the 1950s, published by Stanley et al. [14]. Linear programming was first applied to supplier selection and order quantity allocation to find the minimum-cost allocation for defense procurement. Currently, many methods are used for order quantity allocation, such as mathematical programming, multi-attribute decision-making and soft computing algorithms, as follows.

2.2.1. Mathematical programming

Gaballa [15] used mixed integer programming for modeling decision problems. Stanley et al. [14], Austin and Hogan [16], Bender et al. [17] and Chaudhry et al. [18] also used mixed integer programming. Chaudhry et al. [18] used linear and mixed integral programming methods to determine the process of cost minimization. The linear programming model adds supplier process capability, quality, delivery time, outsourcing price and performance parameters. Jayaraman et al. [19] proposed mathematical programming to optimize selection criteria and the allocation problem. Gao and Tang [20] used raw materials and the products of objective functions and order quantity to determine an optimal purchasing strategy and multi-objective linear programming was used to construct a multi-objective function. Xu et al. [21] applied the dynamic method to study order quantities for various products, quantity and discount, and different factors were added to the objective function. Weber and Current [22] used mixed-integer planning algorithm to solve a multi-objective function and applied it to an actual case. Ng [23] suggested a weighted linear program for multi-criteria supplier selection and order quantity allocation. The order quantity is decided by the weights.

2.2.2. Multiple-criteria decision making

An analytic hierarchy process (AHP) method is widely used in the study of supplier selection and helps researchers set preferences for criteria indicators, order quantity parameters and supplier priority. Through operation, the criteria indictors and supplier ranking are aggregated. In using the analytic network process (ANP) method for supplier selection [9], Sarkis and Talluri [24] incorporated various objective attributes, such as strategy, production and other intangible and tangible criteria, into the evaluation model and used the dynamic evaluation of managers for supplier evaluation and order quantity estimation in a competitive environment. Xia and Wu [25] combined the AHP method with the mixed-integer planning method for order quantity allocation.