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Inventory lot-sizing with supplier selection using hybrid intelligent algorithm

Mohammad Reza Sadeghi Moghadam [a], Amir Afsar [b], Babak Sohrabi [c,*]

[a] Department of Industrial Management, Faculty of Management, University of Tehran, Tehran, Iran
[b] Department of Industrial Management, Faculty of Management, Qom University, Qom, Iran
[c] Department of Information Technology Management, Faculty of Management, University of Tehran, Tehran, Iran

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Abstract

In supply chain management (SCM), multi-product and multi-period models are usually used to select the suppliers. In the real world of SCM, however, there are normally several echelons which need to be integrated into inventory management. This paper presents a hybrid intelligent algorithm, based on the push SCM, which uses a fuzzy neural network and a genetic algorithm to forecast the rate of demand, determine the material planning and select the optimal supplier. We test the proposed algorithm in a case study conducted in Iran.

Keywords: Hybrid intelligent algorithm; Inventory lot-sizing; Fuzzy neural network (FNN); Genetic algorithm (GA); Principle component analysis (PCA)

1. Introduction

The multi-period inventory lot-sizing scenario with a single product was introduced by Wagner and Whitin in [1], where a dynamic programming solution algorithm was proposed to obtain feasible solutions to the problem. Soon afterwards, Basnet and Leung [2] developed the multi-period inventory lot-sizing scenario which involves multiple products and suppliers. The model used in these former research works is formed by a single level indicating the type, amount, suppliers and purchasing time of the products. This model, however, is not able to consider the planning of the supply sector of the firm. In addition, the models used in previous works assumed that the rate of production demand is constant. While in practice a mechanism to forecast the rate of such demand is required.

In this paper, we introduce a new model for the multi-period inventory lot-sizing problem with supplier selection. We also propose a hybrid intelligent algorithm which is able to plan and control the inventory at different levels depending on the accurate forecasting of different demand rates. Our algorithm is based on a fuzzy neural network (FNN) and a genetic algorithm (GA): the forecasting of the periodical demand rates is done by means of the FNN, and the result of the FNN which are then passed to a GA in order to optimize the planning and inventory controlling models based on which the proper suppliers are selected.

The rest of the paper is organized as follows: Section 2 provides a literature review on the current inventory lot-sizing. Our hybrid intelligent algorithm is proposed in Section 3. Section 4 presents the experimental results using real data obtained in one of the biggest supply chain of sewing machines manufacturing in Iran. Finally, Section 5 closes the paper giving some concluding remarks.

2. Literature review

Bahl et al. [3] provided a comprehensive review of inventory lot-sizing literature. They classified the models in four categories: (1) single-level unconstrained resources, (2) single-level constrained resources, (3) multiple-level constrained resources, and (4) multiple-level unconstrained resources. Levels here refer to the different ones in a bill of material structure (where there is a question of requirements dependency) and constrained resources indicate production capacity limitations [2]. The scenario discussed in this paper belongs to the fourth category. Multi-echelon inventory systems along with multiple supply modes can be classified into two models first of which includes some features of multi-supplier

* Corresponding author.
E-mail address: bsohrabi@ut.ac.ir (B. Sohrabi).

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single stage ones and the second allows trans-shipments between inventory stocking points [4]. Minner et al. [5] considered a periodic review of two echelon systems where as an alternative to rationing a depot shortage, outstanding orders can be speeded up with a certain probability. The maximum extension of multi-echelon system was discussed as the break quantity rule by Dekker et al. [6], i.e., the quantity that if a customer order size is larger than the break quantity, the request is satisfied directly from the warehouse and otherwise shipped by the associated retailer. The objective is to find appropriate order-up-to-levels and the break quantity in order to minimize system operating costs. In so called no-delay multi-echelon inventory models, safety stocks are provided at every stocking point to cover against reasonable demand variability where extraordinary large orders are excluded from the analysis by assuming some kinds of operating flexibility. This modeling approach implicitly assumes the presence of two supply alternatives, a regular one for demands not exceeding a predetermined level of variability and an emergency mode to deal with excessive variations [7].

With the advent of supply chain management, much attention is now devoted to supplier selection. Rosenthal et al. [8] studied a purchasing problem where one needs to select among suppliers who offer discounts selling a ‘‘bundle’’ of multiply products. Then a mixed integer programming formulation was presented. Chaudhry et al. [9] considered vendor selection under quality, delivery and capacity constraints and price-break regimes. Ganeshan [10] presented a model to determine lot sizes that involve multiple suppliers including multiple retailers, and consequent demand on a warehouse. Kasilingam and Lee [11] incorporated the fixed cost of establishing a vendor in a single-period model that includes demand uncertainties and quality considerations in the selection of vendors. Also vein, Jayaraman et al. [12] proposed a supplier selection model that considers quality (in terms of proportion of defectives supplied by a supplier), production capacity (constraining the order placed on a supplier), lead-time, and storage capacity limits. This is also a single period model that attaches a fixed cost to deal with a supplier. They formulated a mixed integer linear programming model to solve the problem. Basnet and Leung [2] presented a multi-period inventory lot-sizing scenario where there were multiple products and suppliers. They considered a situation where the demand of multiple discrete products is known over a planning horizon. The model determines the type, amount, supplier and purchasing time of products. They presented an enumerative search algorithm and a heuristic algorithm to address the problem. Their model is one of the most useful ones for supply selection in a single stage category presented in literature.

None of the above mentioned, however, attempted to use multi-periods and multi-echelons model beside the supply selection. Therefore, inventory lot-sizing with supplier selection using hybrid intelligent algorithm takes advantages both from Basnet and Leung model (including multiple products in multiple periods with supplier selection according to holding, transition and purchasing cost) and the multi-echelon in which each level supplies the required products of the next level. Solving the model, a hybrid intelligent algorithm based on FNN and GA is designed.

3. Proposed hybrid intelligent algorithm

Demand forecasting is the foundation of the push system in supply chain management. Therefore, it is undoubtfully important to use a suitable method for forecasting the product demand. First, the PCA is used to reduce the large dimensionality of data set. Now as the outcome of the first part, demand forecasting is used as the input of the next one that is modeling where GA uses the forecasted demand to determine the required inventory in each echelon. Then the supplier is selected in the final echelon. Fig. 1 shows the processes involved in the hybrid intelligent algorithm.

3.1. Fuzzy neural network

Artificial neural networks (FNN) appear to be particularly suitable to forecast the demand of time series, as they can learn highly nonlinear models, hold effective learning algorithms, handle noisy data, and use inputs of different kinds [13]. ANNs have been designed to mimic the characteristics of the biological neurons in the human brain and nervous system [14]. An ANN creates a model of neurons and the connections between them, and trains it to associate output neurons with input neurons. The network ‘‘learns’’ by adjusting the interconnections (called weights) between layers. When the network is adequately trained, it is able to generate relevant output for a set of input data. One of the valuable properties of neural networks is that of generalization whereby a trained neural network becomes able to provide a correct matching in the form of output data for a set of previously unseen input data.

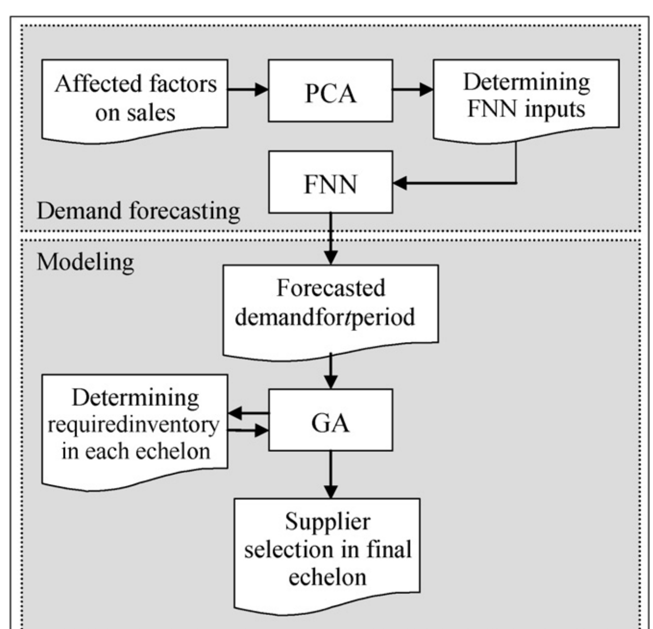

Fig. 1. Processes involved in hybrid intelligent algorithm for inventory lot-sizing.