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Determining the ordering policies of inventory items in class B using If–Then rules base

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ABSTRACT

Multiple criteria ABC inventory classification is one of the most common techniques of planning and controlling of inventory. In this type of classification, other criteria in addition to the criterion of annual dollar usage are taken into account, and then items, based on their priority, are divided into 3 classes with different ordering policies (OPs). In this paper, multiple criteria ABC inventory classification is first performed using the Hadi-Vencheh model (2010). Then suitable OPs are determined for items of classes A and C and Finally, we apply the Zafiropoulos and Dialynas (2005) approach to extract fuzzy rules from the policies of these two classes for determining the policies of items class B. To show applicability of the proposed model, it is then implemented in a soft-drink manufacturing factory.

1. Introduction

One of the most important factors affecting the cost of the goods manufactured is determining the suitable policies to order raw materials stock in the warehouse. The duty of the inventory managers is to select a suitable alternative of these policies in such a way that the items required be available to the needed quantity in due time. Each of the different OPs will impose different costs by determining the special quantity of items, lead time, etc. The tight OPs such as fixed order size (FOS), although may impose the high inspection costs, the probability facing stock-out will be reduced. Conversely, the inexact OPs as twin bin (TB), despite the lower inspection costs, will have the higher stock-out probability. Therefore, an able inventory manager should adopt best alternative to determine an efficient policy, based on the priority each item. To achieve such a target, the classifying items inside the groups with different priorities should first be acted and then, suitable policies should be adopted for each group (Chen, Li, Kilgour, & Hipel, 2008). ABC classification is one of the most common techniques of classification, dividing items into 3 classes, namely, A (very important), B (moderately) and C (least important), based on Pareto principle. Traditional ABC (TABC) only uses the criterion of annual dollar usage, but many papers have mentioned that in addition to this criteria, other criteria as ordering cost, criticality of part, lead time, commonality, obsolescence, repairability, number of requests, scarcity, durability, perishability, reparability, demand distribution, stockability (Cakir & Canbolat, 2008; Chen et al., 2008; Flores & Whybark, 1986, 1987; Guvenir & Erel, 1998; Hadi-Vencheh, 2010; Ng, 2007; Partovi & Anandarajan, 2002; Ramanathan, 2006) are also needed for classification. Many approaches have been proposed for multiple criteria ABC inventory classification, including the bi-criteria matrix approach (Flores & Whybark, 1986, 1987), a case-based distance model (Chen et al., 2008), a artificial neural network approach (Partovi & Anandarajan, 2002), a weighted linear optimization model (Ramanathan, 2006), a cluster analysis method (Cohen & Ernst, 1988), a genetic algorithm approach (Guvenir & Erel, 1998), AHP (FAHP) method (Cakir & Canbolat, 2008; Partovi & Burton, 1993; Partovi & Hopton, 1994). But the available papers on the determination of type of policies of class B are few, and most of them have failed to present a certain suitable policy for the items this class, which is between the classes A and C. However, Silver, Pyke, and Peterson (1998) have suggested several policies on this class, and some articles as Cakir and Canbolat (2008) on the items in class B has introduced both FOS and fixed order interval (FOI). But inventory managers are still confused in adopting policies on this class, since either no discussion has been held over determining the certain OPs of class B, or this issue has been discussed with ambiguity. In this paper, the certain suitable ordering systems for the items of classes A and C are first presented, and then fuzzy rules are extracted for such policies using the Zafiropoulos and Dialynas approach (2005) and Khanlari, Mohammadi, and Sohrabi (2008). Next, by means of these rules, the suitable policies are presented for the items of class B as well.

Framework of this article is as follows. Section 2 summarizes concepts of fuzzy sets theory, fuzzy number and fuzzy linguistic

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variable. In Section 3, the suggested model for multiple criteria ABC inventory classification as well as for determining OPs of the items in class B is offered. An illustrative case study is presented to implement the proposed model in Section 4 and finally, in Section 5, conclusion and limitations are offered.

2. Fuzzy sets theory, fuzzy numbers and fuzzy linguistic variables

Fuzzy sets theory is quite similar to man's behavior when facing uncertainties to express inaccurate words, such as "approximately", "very", "nearly", etc. as well as for consistency with subjective judgments of different people due to various interpretations from a subject. Fuzzy sets theory is the most significant tool to face these conditions, an important duty that classic sets in crisp quantitative values form do not able decision making with respect to these cases. Zadeh (1965) introduces fuzzy sets theory for the first time. In order to elaborate on the said matter, consider the discussion in this paper, in which the OPs of items in class B are determined using fuzzification of criteria for extracting fuzzy rules. To achieve these ends, fuzzy set, fuzzy numbers and linguistic variables should first be introduced (Chen, 2000; Kaufmann & Gupta, 1991; Zadeh, 1965; Zimmermann, 1987, 1991).

Definition 2.1. A fuzzy set $\widetilde{A}$ in a universe of discourse X is defined by a membership function (MF) $\mu_{\widetilde{A}}(x)$ which associates $\forall x \in X$ a real number in the interval [0,1]. $\mu_{\widetilde{A}}(x)$ express membership degree (MD) of x in $\widetilde{A}$.

Definition 2.2. The α-cut of fuzzy set $\widetilde{A}$ is a crisp set $\widetilde{A}_\alpha = \{x|\mu_{\widetilde{A}}(x) \geqslant \alpha\}$. The support $\widetilde{A}$ is the crisp set $Supp(\widetilde{A}) = \{x|\mu_{\widetilde{A}}(x) \geqslant 0\}$. $\widetilde{A}$ is normal if and only if $Supp_{x \in X}\mu_{\widetilde{A}}(x) = 1$.

Definition 2.3. A fuzzy subset $\widetilde{A}$ of universe set X is convex if and only if $\mu_{\widetilde{A}}(\lambda x + (1-\lambda)y) \geqslant \min(\mu_{\widetilde{A}}(x), \mu_{\widetilde{A}}(y)),\ \forall x, y \in X,\ \lambda \in [0,1]$, where min denotes the minimum operator.

Definition 2.4. $\widetilde{A}$ is a fuzzy number if and only if $\widetilde{A}$ is normal and convex fuzzy set of X.

Definition 2.5. A triangular fuzzy number $\widetilde{A}$ is defined with piecewise linear MF $\mu_{\widetilde{A}}(x)$ as follows:

$$\mu_{\widetilde{A}}(x) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \leqslant x \leqslant a_2 \\ \frac{a_3-x}{a_3-a_2}, & a_2 \leqslant x \leqslant a_3 \\ 0, & \text{otherwise} \end{cases}$$

And as a triplet (a_1, a_2, a_3) is indicated, where a_1, a_3 the lower and upper bounds respectively, and a_2 is the most likely value of $\widetilde{A}$.

Definition 2.6. A positive trapezoidal fuzzy number $\widetilde{C}$ can be defined as (a_1, a_2, a_3, a_4) and its MF is defined as

$$\mu_{\widetilde{C}}(x) = \begin{cases} 0, & x \leqslant a_1 \\ \frac{x-a_1}{a_2-a_1}, & a_1 \leqslant x \leqslant a_2 \\ 1, & a_2 \leqslant x \leqslant a_3 \\ \frac{a_4-x}{a_4-a_3}, & a_3 \leqslant x \leqslant a_4 \\ 0, & x \geqslant a_4 \end{cases}$$

Fuzzy variables are highly suitable for expressing of decision makers' subjective judgments on the issues which have both qualitative and quantitative variables. These variables apply fuzzy numbers for prioritizing and ranking. In this paper, these variables are used to extract fuzzy rules, and as a consequence, determination of the suitable OPs of class B.

3. Determining the OPs for the items in class B

3.1. The Hadi-Vencheh (2010) multiple criteria ABC inventory classification approach

Before determination of the policies for items, those should first be classified by an appropriate model. In this paper, we apply the Hadi-Vencheh model (2010), hereafter HV-model, for multiple criteria ABC inventory classification. Since, it is simple and easy to understand. Let there are R items in the warehouse. Also, let x_{rc} and w_c denote the measurement of performance in a 0–1 scale of rth item under cth criterion and weight of the cth criterion, respectively. The score of each item $r(r = 1,\ldots,R)$ is obtained by HV-model (2009) as follow:

$$S_r = \max \quad \sum_{c=1}^{C} w_c x_{rc} \tag{1}$$

$$\text{s.t.} \quad \sum_{c=1}^{C} w_c^2 = 1 \tag{2}$$

$$w_c - w_{c+1} \geqslant 0, \quad c = 1,2,\ldots,(C-1) \tag{3}$$

$$w_c \geqslant 0, \quad c = 1,2,\ldots,C \tag{4}$$

The above model is a nonlinear program, which determines the most favourable weights within the feasible region

$$\gamma = \left\{ \mathrm{w}|\mathrm{w} = (w_1,\ldots,w_C), w_1 \geqslant w_2 \geqslant \cdots \geqslant w_C \geqslant 0, \sum_{c=1}^{C} w_c^2 = 1 \right\}$$

Although, the descending order of criteria is based on subjective judgments, the weights and score of each item obtain by the above model endogenously. In general, we can obtain the score each item by following stages:

1. Transform the measures x_{rc} using transformation $\frac{x_{rc} - \min_{r=1,2,\ldots,R}\{x_{rc}\}}{\max_{r=1,2,\ldots,R}\{x_{rc}\} - \min_{r=1,2,\ldots,R}\{x_{rc}\}}$ into a 0–1 scale.
2. Solve the model for each item r by a nonlinear optimizer.
3. Sort the scores S_r's in the descending order.
4. Group the items based on ABC analysis.

3.2. Determining suitable OPs for the items in class A and C

Once a suitable class was specified for each item, suitable policies should be determined for each of the classes. The items placed in the class A require tight control of inventory, high level of inspection, exact prediction and distribution of demand, detailed investigation of stocking records, safety stock by taking high level of safety into consideration, exact time of ordering, exact number of orders, reducing lead time, etc. Thus, for the items in this class, often, exact OPs have been proposed, such as FOS policy, just in time (JIT), barcode system (BS), automated record system, etc. Items in class C do not need to tight control, high inspection levels, high safety stock and determining economic order quantity. Therefore, those require the simplest type of data collection and control. To this end, for the items in this class, FOI, TB and visual review (VR) policies are adopted more (Cakir & Canbolat, 2008; Partovi & Anandarajan, 2002). For the items in class B, which is indeed between these two classes, problem is ambiguous, since both OPs of class A and OPs of class C can be employed. Here using fuzzy rules the suitable policies for items in this class is given.