Target-Oriented Compromised Sales and Profit Approach for Production and Distribution Planning in a Supply Chain

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ABSTRACT

This paper aims to determine optimal aggregate production and distribution plans in a supply chain system that simultaneously achieve two business targets of total profit and total sales, with uncertain parameters, e.g., production rate during regular time and overtime, inventory holding costs for a manufacturer and distribution centers, and transportation cost. A fuzzy multi-objective linear programming (FMOLP) model is developed to represent the planning problem. The proposed method that minimizes maximum deviation from satisfaction targets of fuzzy profits and sales is more effective, compared with the method that maximizes minimum satisfaction of fuzzy profits and sale, to determine various compromised solutions, which are Pareto-optimal, and to allow a planner to select the most desirable solution based on his/her opinion. This paper has made a significant contribution since it is the first one that proposes the FMOLP approach to determine compromised solutions with two target-based objectives of simultaneously achieving total fuzzy profit targets and total sales target.

KEYWORDS

Compromised Solution, FMOLP, Fuzzy Multi-Objective Linear Programming, Supply Chain, Production and Distribution Planning, Profit and Sales, Seasonal Demand, Target-Oriented, Uncertainty

1. INTRODUCTION

Aggregate production and distribution planning in a supply chain (APDP-SC) problem involves determination of production quantities, workforce levels, inventory levels for a manufacturer and distribution centers, and transportation quantities among supply chain members under seasonal demands over a planning horizon of 6 to 12 months (Nam & Logendran, 1992; Djordjevica et al., 2019). Typically, APDP-SC is performed under seasonal demands and limited resources and it aims to best utilize the resources (Spitter et al., 2005).

Linear programming (LP) model is a popular technique to solve APDP-SC problem. It determines optimal production, inventory, and transportation quantities under limitations of materials, workforce,

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and inventory spaces. For single-objective problems, it may aim to achieve a maximum profit or minimum cost. For multiple-objective problems, it may determine compromised solutions between two or more conflicting objectives, e.g., minimizing cost and maximizing customer satisfaction. The LP model for multiple objective problems is called multiple objective linear programming (MOLP) model. It has two or more objective functions and parameters in the model are constant parameters (Tavakkoli et al., 2010; Horng & Yenradee, 2020). Practically, it is difficult to accurately determine the values of some parameters as constants since the parameters are uncertain (Akkawuttiwanich, & Yenradee, 2020). In order to handle this situation, MOLP model is extended to fuzzy multiple objective linear programming (FMOLP) model by changing constant parameters to fuzzy ones (Su, 2017; Azadeh et al., 2015; Rezakhani, 2012; Tansakul & Yenradee, 2020).

This research work is developed to satisfy real needs of small Thai industries with five characteristics as follows: First, many small Thai industries have limited production and distribution capacities, and investment budget. They cannot economically manage to completely satisfy demands of all customers. Thus, they accept to partially satisfy the demands, and the leftover demands are lost. Second, objectives of most available models are to minimize total related costs, or to maximize a total profit. These objectives are not practical in business. Real businesses are neither attempted to get the highest sales nor the highest profit. They want to achieve the sales target and the profit target simultaneously. They do not want to significantly achieve over the targets since the targets of the next year will be significantly increased too. Third, the total profit and total sales are not necessarily maximized at the same time because increasing sales volume may not always lead to an increase in profits. When a company increases its sales volume, it incurs additional costs to produce and market those products, which can include costs such as labor, materials, and advertising expenses. As a result, the marginal cost of each additional unit sold may be higher than the marginal revenue earned from selling that unit. In such cases, the company may be better off selling fewer units at a higher price, rather than increasing sales volume and incurring higher costs. At low production level, the profit and sales will grow together. But at high production level, to further increase sales, it may need excessive costly overtime and holding cost that may reduce the profit. In practice when sales and profit targets are high, achieving the sales and profit targets simultaneously may not be possible and compromised solutions are needed. Fourth, there are many compromised solutions and planning managers want to manipulate solutions. They want to generate a number of different solutions and personally select the one that they like most. Finally, some unit cost parameters are uncertain and should be represented by fuzzy numbers instead of constants. Therefore, the profit which is affected by the fuzzy unit cost parameters are also uncertain and should be represented by the fuzzy numbers.

To satisfy real needs with five characteristics, the APDP-SC model is developed to determine compromised solutions between achieving sales target and profit target where the demands can be partially satisfied. Some parameters, e.g., productivity rates under regular time and overtime, unit transportation cost, and unit inventory holding cost, are fuzzy numbers. Some techniques are developed to generate a number of different compromised solutions, and allow the planning managers to select the preferable compromised solution.

This paper considers a supply chain structure as shown in Figure 1. The supply chain has 2 stages of a manufacturer and distribution centers. The manufacturer makes two decisions of production and storage. The distribution centers make two decisions of storage and sales. Transportation decision from the manufacturer and distribution centers is also required. The manufacturer produces 2 product types.

This paper has specific objectives as follows:

1. To develop the FMOLP model for APDP-SC problem to simultaneously achieve sales and profit targets.
2. To propose some methods for defuzzification of fuzzy constraints and fuzzy objective function coefficients, and for determining compromised solutions for two target-oriented objectives of achieving sales and profit targets.

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