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Integrating a Weighted Additive Multiple Objective Linear Model with Possibilistic Linear Programming for Fuzzy Aggregate Production Planning Problems

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ABSTRACT

This study uses an integrated optimization method by applying a weighted additive multiple objective linear model with Possibilistic Linear Programming (PLP) to fuzzy Aggregate Production Planning (APP) problems under an uncertain environment. The uncertainty conditions include uncertainties of operating times and costs, customer demand, labor level, as well as machine capacity. The aim of this study is to minimize total costs of the plan that consist of the production cost and costs of changes in labor level. The proposed hybrid approach minimizes the most possible value of the imprecise total costs, maximizes the possibility of obtaining lower total costs, and minimizes the risk of obtaining higher total costs from PLP as multiple objectives for the fuzzy multiple objective linear model optimization. The outcome of the proposed approach shows that the solution is closer to the ideal solution obtained from Linear Programming than a typical solution obtained from PLP. There is also a higher overall satisfaction value.

KEYWORDS

Aggregate Production Planning, Fuzzy Multiple Objective Linear Model, Fuzzy Set Theory Linear Programming, Multiple Objective Linear Model, Possibilistic Linear Programming, Weighted Additive

INTRODUCTION

Aggregate Production Planning (APP) is a process by which a company determines suitable levels of capacity, production, subcontracting, inventory, stock outs, and pricing over a specified time horizon (3 to 18 months) (Wang and Liang 2004). It attempts towards the best utilization of resources by predicting on the historical data of production process such as production time, production volume, and value of products. Typically, firms can deal with customer requirements by: (1) changing workforce's size by hiring in the peak periods and lay off in the off-peak periods effects to production rate change, (2) introducing overtime or subcontracting to avoid union regulations of workforce and severe problem, and (3) planning backorders by delivering the produced products later. Most organizations generate this plan with imposed constraints of production process that yield the produced quantities of each product to meet customer requirements and minimize total associated costs. Basically, the costs that are related to aggregate production planning can be roughly classified into three groups: (1) production costs are the costs that are related to purchasing materials and overhead, (2) Costs that are associated

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with changes in production rate such as hiring, training, firing costs, and overtime compensation as well, (3) Costs that are related to inventory such as holding and ordering costs.

Referring the optimization of APP, it can be classified into two types in terms of objective function optimization. Firstly, it is a problem with a single objective. This problem can provide the best solution, which corresponds to the minimum or maximum value of a single objective function that lumps all different objectives into one. It is useful as a model that provides decision makers with insights into the nature of the problem, but usually cannot provide a set of alternative solutions that trade different objectives against each other. Karmarka and Rajaram (2012) studied aggregate production planning for process industries under oligopolistic competition. Their goal is to maximize the profit, so they formulated a competitive version of the traditional aggregate production planning model with capacity constraints. Their framework is very useful in incorporating the interactions with the raw material supplying sector where supplies are limited, where prices reflect these limitations. Hossain et al. (2016) studied Aggregate Production Planning (APP) of multiple products under demand uncertainty by considering wastage cost and incentives. Their goal is to minimize the total relevant costs by considering imprecise demand, production capacity, workforce, inventory control, wastage reduction, and proper incentive for the workforce.

Secondly, it is a problem that has more than one objective. Multi-objective optimization is used to interact among different objectives and give a set of compromised solutions, largely known as the trade-off non-dominated, non-inferior, or Pareto-optimal solutions. It is more likely to identify a wider range of these alternatives, and its model is more realistic. For instance, Gocken and Baykasoglu (2010) studied multi-objective aggregate production planning with fuzzy parameters. They proposed ranking methods of fuzzy numbers and tabu search for solving the fuzzy multi-objective aggregate production planning problem based on triangular fuzzy numbers. Tohidi and Razavyan (2012) studied an L1-norm method for generating all of efficient solutions of multi-objective integer linear programming problem. Their research considers the recession direction for a Multi-Objective Integer Linear Programming (MOILP) problem and presents necessary sufficient condition to have unbounded feasible region and infinite optimal values for objective function of MOILP problems. Their algorithm can also give a subset of efficient solutions that can be useful for designing interactive procedures for large, real life problems. Entezaminia et al. (2016) studied a multi-objective model for multi-product multi-site aggregate production planning in a green supply chain. Their study was designed to incorporate the profit and green principle in an aggregate production planning. They used Analytical Hierarchy Process (AHP) to indicate environmental impact of various production alternatives and also used LP-metrics method to consider two conflicting objectives; minimizing total losses and maximizing total environmental scores of products.

Generally, Linear Programming (LP) can be used as a mathematical tool for APP to create optimal aggregate production planning with both single and multi-objective problems. The developed linear programming model provides decision support to promote the planning process review, in order to reduce the current inventory costs and improve the customer service level. Gulsun et al. (2009) studied APP based on a multi-objective model, which includes multiple products and multiple planning periods. Their model includes two objectives: (1) minimizing cost (2) minimizing effects on the workforce motivation level caused by hiring/layoff decisions. They employed a Linear Physical Programming (LPP) approach that uses crisp numbers, but objective functions are piecewise linear, which denotes desirability degrees of decision makers. Takey and Mesquita (2006) studied aggregate planning for a large food manufacturer with high seasonal demand. They found that the best way to meet forecast demand was by adjusting the production, inventory, workforce levels and other resources level of aggregate production planning in a cost-effective manner, based on production strategies (chase, level, and compromise strategies). Li (2016) carried out linear programming models and methods of matrix games with payoffs of triangular fuzzy numbers. His book discusses the concepts of solutions of matrix games with payoffs under uncertain economic management by developing an efficient linear programming model.

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