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Continuous Optimization

Soft-sensing of level of satisfaction in TOC product-mix decision heuristic using robust fuzzy-LP

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Abstract

Product-mix decision through theory of constraints (TOC) should take into account considerations like the decision-maker's (DM) level of satisfaction in order to make product-mix decision a robust one. Sensitivity of the decision made, needs to be focused for a bottle-neck-free, optimal product-mix solution of TOC problem. A membership function (MF) has been suitably designed in the present work, first in finding out the degree of imprecision in the product-mix decision, and thereafter to sense the level of satisfaction of the DM. Inefficiency of traditional linear programming (LP) in handling multiple-bottleneck problem through TOC has been discussed through an illustrative example. Comparison of traditional LP over fully fuzzified-LP (FLP) model has also been addressed to elucidate the advantages of FLP in TOC. Key objective of this work is to guide DMs in finding out the optimal product-mix with higher degree of satisfaction with lesser degree of fuzziness under tripartite fuzzy environment.

Keywords: Fuzzy linear programming; TOC; Product-mix decision; Fuzziness patterns; Level of satisfaction; Soft-sensing

1. Introduction

This paper outlines an alternative approach to linear programming (LP) solution of TOC product-mix, i.e., a fuzzy linear programming (FLP) approach, suitable for improving solutions obtained from TOC, and compares the solutions obtained by Hsu and Chung [13] and Onwubolu and Mutingi [21]. The article first provides the summary of the past research work made on improving the TOC product-mix solutions. Secondly, it narrates the salient features of FLP to incorporate level of satisfaction and to sense its nature and degree of fuzziness hidden in product-mix decision. A complex problem from a prior

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published research work is then analyzed comparing the conventional TOC product-mix decision with that of FLP solution. Finally, the article concludes with a summary indicating the scope for future work.

2. Prior research works

The available literature on TOC product-mix decision is as broad as it is diverse. Literature contains several proposals on how to revise the TOC product-mix decisions to identify the optimal product-mix under conditions where the original TOC heuristic failed.

Goldratt [10,11] demonstrated a technique that could be applied to predict the behaviour of a heated crystalline atom to optimize the numerous variables related to a work schedule. The application of this methodology in physics generated a new arena in manufacturing science what is today known as TOC. In 1990 Umble and Srikanth [28] presented a detailed look at the concept. In the early 1990 Goldratt [11] improved his concept of TOC by the management philosophy on improvement based on identifying the constraints to increasing profits. It was shown that product-mix decision-problem under TOC could be mathematically tackled as a linear programming (LP) model [10,11]. Luebbe and Finch [18] compared the TOC and LP using the five-step improvement process in TOC. They categorized the TOC as a manufacturing philosophy and LP as a specific mathematical optimization technique. It was stated that the algorithm could optimize the product-mix as ILP [18]. Further, it was revealed that the algorithm was inefficient in handling two types of problems. The first type included problems associated with adding new product alternatives to an existing production line [16]. The second type included problems concerning more than one bottleneck in which the algorithm could not reach the feasible optimum solution. Later on the concept of the dominant bottleneck was proposed as a remedy for finding our feasible optimum solution. Lee and Plenert [16] illustrated two examples of product-mix decision problem and concluded that TOC solution was inferior to the optimum solution and had the possibility of being infeasible when multiple constrained resources in a plant existed. Hsu and Chung [13] presented a dominance rule-based algorithm that classified non-critically constrained resources into three levels for solving the TOC product-mix problem when multiple constrained resources existed. Fredendall and Lea [8] revised the TOC product-mix heuristic to identify the optimal product-mix under conditions where the original TOC heuristic failed. Methods to identify a product-mix which maximizes profit have been studied extensively. One method, known as integer linear programming (ILP), is often used to optimize the product-mix. But it requires a high level of expertise to formulate and may take hours to solve. Researches reveal that TOC heuristic is simpler to use than an ILP [18]. But some researchers identified conditions under which TOC could create a non-optimal product-mix [16,23]. Extensive studies have been carried out to identify product-mix that maximizes profit by Buxey [6].

Balakrishnan and Cheng [2] clarified some of Luebbe and Finch [18] results. Specifically, by modifying their example [18], Balakrishnan and Cheng [2] showed that some of their [18] conclusions were not generalizable. Further it is shown that using LP is preferable to the $ return/constraint unit method in helping increase throughput and the reasons for this are discussed. Balakrishnan and Cheng [2] reported that LP was a useful tool in the TOC analysis. Finch and Luebbe's [9] response on Balakrishnan and Cheng [2] was that the issue of LP was a technique and TOC was a focusing process consisting of many different techniques. Finch and Luebbe's [9] argued that Balakrishnan and Cheng [2] did not compared LP with TOC. They [9] commented that Balakrishnan and Cheng [2] was a comparison of LP with one of many techniques sometimes incorporated in TOC.

Many researchers proposed variations of Goldratt's [10,11] product-mix problem. Lee and Plenert [16] demonstrated that TOC was inefficient when new product was introduced. Their observation was that the solution from TOC during introduction of new product produced a non-optimal product-mix. Plenert [23] discussed an example having multiple constrained resources to show that the TOC heuristic did not provide an optimal