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An efficient heuristic to obtain a better initial feasible solution to the transportation problem

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ABSTRACT

Transportation of products from sources to destinations with minimal total cost plays an important role in logistics and supply chain management. All algorithms start with an initial feasible solution in obtaining the minimal total cost solution to this problem. Generally, better is the initial feasible solution lesser is the number of iterations of obtaining the minimal total cost solution. Here, first we demonstrate a deficiency of a recently developed method in obtaining the minimal total cost solution to this problem. Then we develop a better polynomial time (O(N^3) (N, higher of the numbers of source and destination nodes)) heuristic solution technique to obtain a better initial feasible solution to the transportation problem. Because of the intractability of carrying out enormous calculations in this heuristic technique without a soft computing program, this technique is coded using C++ programming language. Comparative studies of this heuristic with the best available ones in the literature on results of some numerical problems are carried out to show better performance of the current one. Our heuristic is found to lead to the minimal total cost solution in most cases (88.89%) of the studied numerical problems.

1. Introduction

The transportation problem deals with transporting a homogeneous product from multi-source to multi-destination with the minimal total cost subject to satisfaction of the supply and the demand constrains. The network diagram of this problem is depicted in Fig. 1. It is a special case of Linear Programming Problem (LPP). The application of the transportation model can be extended to other areas of operation, including inventory control, employment scheduling, and personnel assignment (Taha [46]).

In order to proceed with a minimal total cost solution technique to the transportation problem, it is necessary to start with an initial feasible solution (IFS). Thus IFS acts as a foundation to a minimal total cost solution technique to this problem. In obtaining an IFS to the transportation problem many heuristics solution techniques have been presented in the literature. VAM - Vogel's Approximation Method (Reinfeld and Vogel [36]), GVAM – Goyal's version of VAM (Goyal [14]), TOM – Total opportunity-cost method (Kirca and Şatir [22]), Northwest Corner Method (Taha [46]), Minimum Cost Method (Taha [46]) are familiar ones. Besides, Sharma and Sharma [41] proposed a new solution procedure to solve the dual of the incapacitated transportation problem. Sharma and Prasad [40] presented a heuristic that obtained a very good starting solution to the transportation problem in $O(N^3)$ time. Mathirajan and Meenakshi [30] claimed that their proposed VAM-TOC approach provided a very efficient initial feasible solution. They supported their claim by highlighting the solutions to numerical problems where 20% of them led to the minimal total cost solution, and the rest of them led to the near minimal total cost solution. Because of the intractability of carrying out enormous calculations in northwest corner method, minimum cost method, row minimum cost method, column minimum cost method and VAM for finding an IFS to the transportation problem, they were implemented in C++ by Imam et al. [16] and Sen et al. [39]. Kulkarni and Datar [26] developed a heuristic based algorithm to attain an initial feasible solution in obtaining the minimal total cost solution to the modified unbalanced transportation problem. Vasko and Storozhyshina [48] examined the importance of processing the dummy column (row) in the VAM, the Greedy heuristic (Winston [49]), Northwest Corner method, the maximum demand method (Pargar et al., [33]) and Russell's method (Hillier and Lieberman [15]) for solving unbalanced transportation problem. Shimshak et al. [42] and Balakrishnan [5] proposed certain modifications to VAM for obtaining initial solutions to the unbalanced transportation problem. Schrenk et al. [38] analyzed degeneracy characterizations for two classical problems: the transportation paradox in linear transportation problems and the pure constant fixed charge (there is no variable cost and the fixed charge is the same on all routes) transportation

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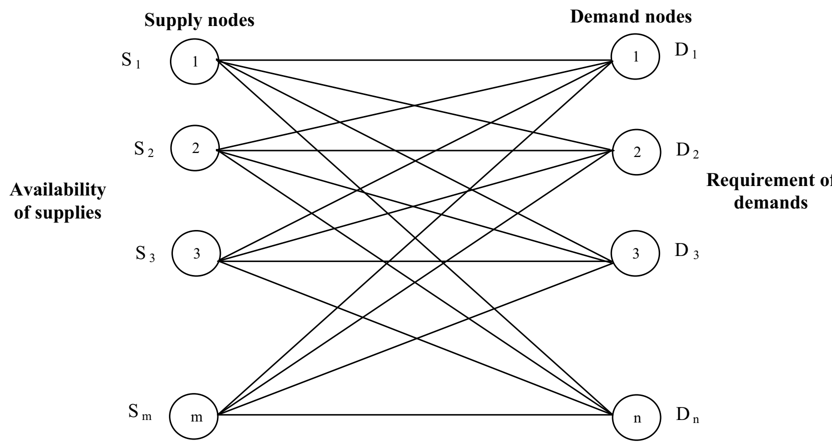

Fig. 1. Network diagram for the transportation problem.

problems. Juman et al. [20] performed a sensitivity analysis on VAM procedure to see the effect of balancing and unbalancing issues on the initial cost of VAM. Liu [27] studied the transportation problem with varying demands and supplies within their respective ranges. Following these variations the minimal total cost were also varied within an interval. So, he constructed a pair of mathematical programs where at least one of the supply or the demand was varying, to calculate the lower and the upper bounds of the total transportation cost. Juman and Hoque [21] demonstrated the failure of Liu [27]'s approach in providing the correct upper minimal total cost bound solution at all the time. Besides, Juman and Hoque [21] extended the Liu's [27] model to include the inventory costs during transportation and at destinations, as they are interrelated factors. Then they developed heuristic techniques to find the lower and the upper minimal total cost bounds to this extended model. Korukoğlu and Balli [24] proposed an improvement to the well-known VAM by taking the total opportunity cost into account. They claimed through computational experiments that this improved VAM provided more efficient initial feasible solution to a large scale transportation problem. VAM was also improved by using total opportunity and allocation costs by Singh et al. [43]. Deshmukh [11] proposed a new method called an innovative method (NMD) to provide an initial feasible solution to the transportation problem. However, among the existing heuristics in obtaining an IFS, VAM is one of the most efficient heuristics to the transportation problems as it facilitates a very good IFS (often an optimal solution). Moreover, very recently, a new approach called "Zero Suffix Method" (ZSM) was proposed by Sudhakar et al. [45] in obtaining a minimal total cost solution to the transportation problem. But, we demonstrate here that the ZSM does not provide the minimal total cost solution always. Instead, it has been found to provide a very good initial feasible solution. Hence, VAM and ZSM can be considered as the best available methods in obtaining an IFS in the literature. General understanding is that better is an IFS lesser is the number of iterations in obtaining the minimal total cost solution to the transportation problem. This notion has motivated us to develop a better method of obtaining an efficient IFS to the transportation problem, so that starting with the obtained IFS the minimal total cost solution to the problem can easily be obtained by a well-known technique.

Here we also survey some papers which are concerned with the development of the minimal total cost solution technique to the transportation problem. Various minimal total cost solution techniques to the transportation problem have been developed. Charnes and Cooper [8] developed the Stepping Stone Method, Dantzig [9] proposed the Modified Distribution Method, Srinivasan and Thompson [44] described two new primal basic methods – the cell and area cost operator algorithms for solving the transportation problem. Adlakha and Kowalski [1] proposed an alternative algorithm to reach to the minimal total cost solution. Pandian and Natarajan [31] presented a new method called "fuzzy zero point method" in obtaining the minimal total cost solution to the transportation problem where the transportation cost, supply and demand are trapezoidal fuzzy numbers. This zero point method was improved by Samuel [37] for solving both crisp and fuzzy based transportation problems. Ramadan and Ramadan [34] developed a hybrid two-stage algorithm (GA-RSM) to find the minimal total cost solution to this problem. The first stage uses genetic algorithm (GA) to find an improved initial basic solution and the second stage utilizes this solution as a starting point in the revised simplex method (RSM) to get the minimal total cost solution to the problem.

Further, we also, survey some variant of the transportation problems such as Solid Transportation Problems, Fixed charge transportation problems, Fuzzy transportation Problems, etc. Adlakha and Kowalski [2] presented a simple heuristic algorithm for the solution of small fixed-charge transportation problems (the extension of the transportation problem in which a fixed cost is incurred). Liu and Kao [28] studied a fuzzy transportation problem, in which the cost coefficients and the supplies and the demands are fuzzy numbers. They formulated a pair of mathematical programs to calculate the bounds of the fuzzy total transportation cost. Li et al. [29] proposed a neural network approach for multi-criteria solid transportation problem (a generalization of traditional transportation problem in which the different modes of transports called conveyances are available for shipment of products). Jimenez and Verdegay [18] studied both Interval solid transportation problem (ISTP is a generalization of the STP in which input data are expressed as intervals instead of point values) and the fuzzy solid transportation problem (FSTP is a generalization of the STP in which supplies, demands and conveyance capacities are trapezoidal fuzzy numbers). Jimenez and Verdegay [19] proposed a solution procedure for uncertain solid transportation problem (*a generalized transportation problem in which the conveyance are available and the inputs of the problems are not the point values*). Jimenez and Verdegay [17] proposed an evolutionary algorithm based solution approach for solving fuzzy solid transportation problems. Das et al. [10] discussed the limitation of Vogel's Approximation Method (VAM) and developed an improved algorithm after resolving this limitation for solving transportation problem. Pandian and Natarajan [32] proposed a new method for finding a minimal solution to bottleneck transportation problems (a special case of a transportation problem in which a time is associated with each shipping route). Ramadoss et al. [35] presented an innovative implementation of evolutionary heuristic algorithm to solve the assignment