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Review Paper in Vehicle Routing Problem and Future Research Trend

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Abstract

The transportation industry is as an effective factor for the success or failure of any company because of its direct effect on the overall cost of products or services. However, this industry faces a major competition in the global and local markets. Thus, effective planning to produce the right product and achieve on-time delivery to meet customers' satisfaction is a main goal of all companies. Operation research is widely used as a technique to address transportation problems (TPs) and obtain optimal solutions for decision-making problems. This study aims to review TP, that is, vehicle routing problem, and the models used to address these problems. The future trend for studies on TP problems is also proposed.

INTRODUCTION

The transportation problem (TP) is an optimization problem with a linear objective function and linear constraints. The TP can be described using linear programming mathematical model. The cost efficiency and time effectiveness in product delivery became the main challenge to all corporations because of their direct effect on overall price and market demand. Transportation mode plays a central role in achieving competitive advantages through timely responsiveness and cost efficiency by controlling resources, locations, and transportation models. First, resources refer to things that need to be transferred from one location to another which takes in several forms, such as liquid, money, solid, and machines. Second, locations refer to the points of ports, recollection, notes, supplies, bus stations, railway stations, loading port, and airports. Third, the modes of the transportation are an important factor to meet transportation challenges. Timely availability and efficient movement of raw materials and finished goods can be met using optimal transportation models. The TP aims to identify the optimal shipping schedule to maximize profit and minimize the entire shipping cost while meeting supply limits and demands. TPs differ according to transportation types, which can be maritime, air, land, rail, space, pipeline and cable, and intermodal transportation systems. However, resource, location, and transportation modes are the main dimensions in determining the optimal transportation model. In this study, the focus is centered on land transportation because it has a direct effect on reducing costs in various economic sectors and improving the quality life of the citizens.

LITERATURE REVIEW

Land Transportation ProblemTPs

Optimizing TP of elements has strangely been important to numerous disciplines. Optimization refers to the development of selecting components deliberated to be the greatest from some substitutes that might be availed. For example, one has to solve problems with the purpose of maximizing or minimizing an actual purpose. This can be attained by selecting values of numbers or actual variables from a definite set of values. This phenomenon makes transportation an optimal delivery plan for a certain product. When product supply is obtainable from various sources, demand tends to be quantified for the product at every terminal, with obviously well-defined transportation price from the source to destination. Thus, the problem is in discovering the optimal delivery strategy that can minimize the total transportation price for product transportation from sources to terminals. The current literature presents numerous types of the land TPs. The main types of land TPs are convoy routing problem [1], bus terminal location problem [2], inventory routing problem [3], vehicle routing problems (VRP) with split deliveries [4], inventory routing problem with time windows [5], truck loading problem [6], and VRP [7]. However, VRP received a considerable attention as one of the most common problems in transportation [8].

Vehicle Routing Problem (VRP)

VRP is a combinatorial optimization and integer programming problem which asks, "What is the optimal set of routes for a fleet of vehicles to traverse in order to deliver to a given set of customers?" Several methods are used, and the classical VRP has been used extensively in trucking industry applications. After the development of VRP by [9], it grew speedily and had many variants. Five methods were also suggested by [10] to solve VRP: (a) exact method with some relaxed constraints, (b) improvement/exchange, (c) route first/cluster second, (d) savings/insertion, and (e) cluster first/route second.

Heuristic Method

A heuristic method is often named only a heuristic, that is, any method to problem solving, learning, or discovery that services a practical technique not certainly optimal or perfect, nonetheless adequate for the direct objectives [11]. Since the last of three decades, numerous heuristic approaches have been extensively employed in this field. They used a Bender's decomposition method to solve the problem. [12] used a heuristic method to solve a correlated descending time window problem in which the time windows of couples of customers are attuned for achieving a lower charge solution. [13] applied simple route structure heuristics to create immediate solutions to vehicle routing problem with time windows (VRPSTW). [14] demonstrated and solved the VRPSTW through objective programming methods. [15] measured multi-depot vehicle routing problem by time windows (MDVRPTW) and suggested six heuristic algorithms for transmission costumers to yards and then linked their outcomes. [16] have developed a sweeping algorithm for solving MDVRP. This algorithm has two phases comprising a task of customers to yards and solving some common VRPs. Each VRP is solved by a sweeping algorithm. [17] solved MDVRP with saving algorithm. The first step of their algorithm is conveying customers to yards, and second is solving common VRPs with saving algorithm. [18] suggested a mixture genetic algorithm to solve MDVRP. In their study, the original population is created by two methods which consist of neighborhood and randomization research (NS). The solutions of NS are superior and require fewer computational time than randomization. [19] measured the MDVRP by employing genetic algorithm. Their model states the restriction of time consumption when distributing the product to each consumer. Commonly, the goal of the MDVRP is to minimize the total distribution distance or time spent in attending all clienteles. Smaller distribution time results in advanced level of consumer satisfaction. The eventual objective of the MDVRP is to upsurge the efficiency of the distribution [20].

[21] offered an ant colony algorithm hybridized with supplement heuristics for the time-dependent truck routing problem with time windows. [22] offered a better LNS algorithm for actual-time truck routing problem with time windows. In a possible solution to a traditional VRPTW, the service time (distribution time) must be reduced in each customer's time window. This kind of time window is generally named a crisp or hard time window. In real-life TPs, the time windows may be desecrated out of several practical thoughts. Soothing the restraints of inflexible time windows can lead to well solutions with regard to the number of trucks, time, and distance. Occasionally, no possible solution can be obtained if all time window restraints should be met; a slight earliness or lateness to some clienteles is satisfactory to gain an executable distribution plan. Typically, customers demand a "narrower" time window than they want, whereas in the actual, a slight bit of nonconformity from the stated time window is satisfactory to them [23].

[24] suggested a multi-objective linear programming problem for MDVRP on the foundation of the vague time window. This multi-depot model is transformed to some single-depot routing problems by allowing the Euclidian distance between customers and yards through three stages, namely, allocating customers to delivery centers, solving the VRP with time VRPTW-α and solving the customer service level improvement problem. However, the frequency and multi-product MDVRPFTW model (together with multi-level or single-level instance) has not received a considerable attention; thus, it is recommended for future research [24].

TYPES OF TRUCKING BUSINESS

The trucking business is a crucial source of contemporary market and economy. It is a recurring profitable business, with its profits fluctuating with the national economy and fitness of industries, providing shipping facilities to clients. For example, two decades ago, this profitable company has constituted roughly 8% of the United States' gross domestic product (GDP) [25]. Numerous carriers comprise less-than-truckload (LTL), and full truckload (TL), for hire, exempt, private, common, dedicated contract, and contract (Figure 1).

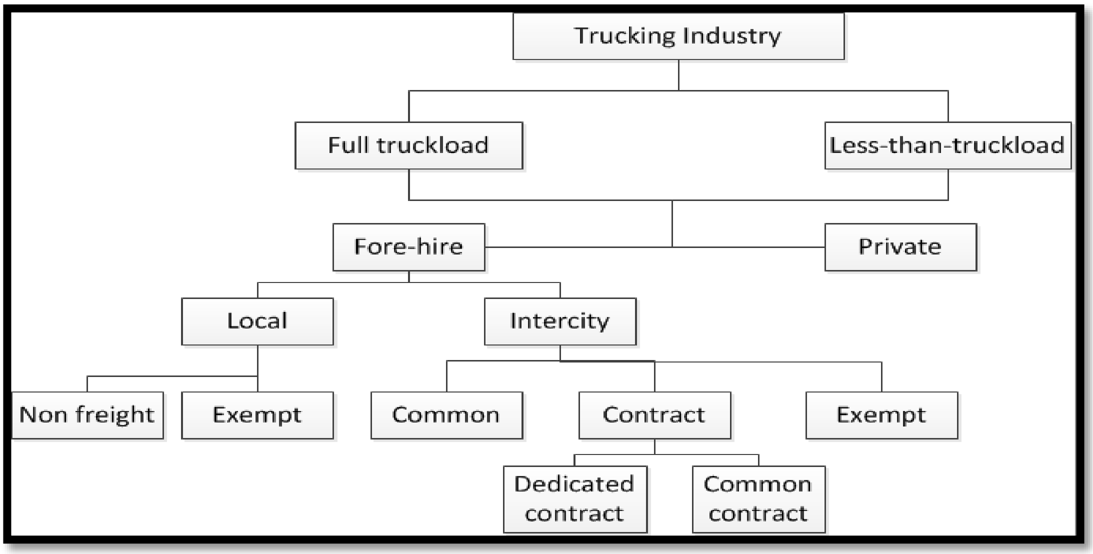

Figure 1: Kinds of Carriers in the Trucking Business

LESS-THAN-TRUCKLOAD CARRIERS AND FULL TRUCKLOADLTL AND TL CARRIERS

LTL and TL carriers are dominant types in the trucking market. In a LTL, shipments from different clients are conveyed together, while in a TL, the cargo from one client fills the entire truck [26]. Based on the LTL model, the cost of a small shipment is typically lesser because the clients merely pay for the list of products conveyed and for the transportation distance. Nevertheless, according to TL, a fixed cost rate is charged based on distance, irrespective of the capacity and weight carried [27]. Through combining lesser shipments and attaining greater capacities, TL charges are generally lower per pound than LTL charges. For-hire truckload is a cargo service to the broad community and charges a payment for the assumed service [27]. It can be more characterized as local and intercity workers. Local carriers pick up and deliver freight within a city's marketable zone. Intercity transporters function between exact marketable zones [28]. The two types of transporters often work in tandem. Private truckload is corporation owned and operates vehicles to carry its private goods [29]. It does not deliver goods as its main commercial, nonetheless has a private fleet, plus trailers, vehicles, drivers, and maintenance tools. It also delivers fast and extremely reliable transport. This type of transport is appropriate for long term with large-volume business because it provides stable transportation by dropping the ordinary operational cost [30]. In exempt carriers, an exempt transporter is exempt from economic rules. The category of product dragged controls exemption. Exempt possessions typically comprise natural or unmanufactured possessions (such as vegetables, fruits, wood chips, regular livestock, vesicular rock, normal crushed, to be used for embellished determinations) and other things of tiny or no value) or by the countryside transportation process (air carriage and empty shipping containers with intermodal load containers and farm property carriers) [25]. For common truckloads, a communal transporter delivers freight–transportation services to the broad public according to the market demand, at affordable charges, and deprived of discrimination and equally charge all customers. Examples of communal transporters are FedEx and UPS. For contract carriers, a contract transporter's main business is to deliver carriage services to exact transporters under specific contract-of-carriage [31]. For instance, a contract transporter that flies structures, transplant matters, or sensitive medicines has definite workers or equipment in such carriage situations.

In addition, a contract transporter has the ability to select a client or reject to carry cargo for payment [31]. For instance, one contract transporter can negotiate an advanced fee for a specific service by delivering some unique service. In dedicated contract truckloads, a dedicated contract transporter hires drivers and vehicles to transport under constant contracts. It runs as a private fleet for shippers, allowing them to evade the cost that is associated with hiring drivers, truck prices, and equipment maintenance [32], which includes different types of vehicles such as cars and bus [33]. LTL and TL are two key transportation models for the trucking business. LTL offers shipping services with lower truckload numbers, that is, 50–10,000 lb [25]. The LTL combines many smaller deliveries into TL numbers for express transportation and dis-collects TL deliveries at the destination for distribution in lesser quantities. On the contrary, TL delivers services to transporters who tender adequate volume to meet the lowest weights required for a TL shipment and truckload proportion [25]. Contract carriers or common carriers can be used by many corporations that own transportation fleets in certain circumstances, such as when numerous goods must be transported; however, there is no available vehicle in the request time. These subcontracted contract or communal transporters are named third-party logistics (3PL) firms, which offer a multifaceted supply chain's needed logistics services, such as loading, transhipment, and additional value-added facilities [34], [35]. The for-hire carriers can be considered 3PL as a flexible alternative method for private transporters that face a scarcity of vehicles and warehouses. However, possessing a private fleet is an intensive asset for firms with fluctuating demand, and their returns are seasonality complex. For instance, some shopping centers refill stocks related with a holiday or seasonal sales. Based on the 3PL contractor, the dedicated contract carrier delivers an optimal solution by offering a mixture of benefits of the contract and provides carriers, consequently allowing management of drivers and fleet. Many of them are very upkeep with inventory, warehousing, cross-docking, and management solutions that contribute to cost efficiency and effective time response. Thus, sharing transportation mode, such as truck transportation, can overcome these challenges by increasing transport capacity, reducing transportation rate, increasing driver earnings, and reducing emissions and pollution [36]. Even though dedicated contract carriers (DCCs) deliver economic and flexible solutions to transporters, they still encounter multiple challenges. Particularly in TL shipping, empty consecutive cost accounts for a great ratio of the traveling charge. Contracted carriers, customers, and even the customer's suppliers/customers can influence service performance and cost reduction outcomes by managing the performance in proactively, organizational changes within the provider firm, and designing and re-designing performance metrics and incentives [37]. Moreover, truck sharing has several challenges, such as capacity and daily shipping schedule; selecting a communal transporter is rarely considered based on a cost viewpoint [36]. This shows the problem of DCCs in fleet management. In a progressively severe market rivalry, the majority of the trucking firms compress costs to seize the market segment, and DCCs are not exempted. TL facility is extensively used in many businesses, such as temperature-controlled facility, dry food, just-in-time inventory preservation, and cross-dock. Notwithstanding, because of the fewer flexibility than LTL given that shipping facilities have particular characteristics, a TL facility can deliver quicker distribution and lower shipping costs. [24]

applied mathematical approaches and a simulated annealing heuristic algorithm to solve VRPTW under multiple depots; the time window in this work is fuzzy, similar to the soft window method.

CONCLUSION

Overall, the aforementioned studies discussed above and other studies by [38] and [39] merely deliberated a number of multiple depots' restraints, plus rules of working time, strict time windows, and fixed amounts of trucks. In addition, given that DCCs were not their research emphasis, TL utilization was not their objective. Thus, the new trend of future research is to not only to consider the actual approaches to solve real-life, delivery vehicle routing problems with multiple depots and strict time windows but to consider vehicle utilization. Moreover, numerous elements should be emphasized in future work, as identified as follows: (1) strict time window of customer, (2) driver scheduling, (3) multiple depots, (4) multi-trip, (5) carrier selection or outsourcing, (6) driver regulations, (7) pickup and delivery, and (8) fixed number of trucks.

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