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Vehicle routing problem with cross docking: A simulated annealing approach

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Abstract

Cross docking is a valuable logistics strategy given that it provides less inventory holding costs, less transportation costs and fast customer deliveries. Cross docking should also be considered in strategic planning since it provides competitive advantage by reducing firm costs. An efficient vehicle routing may even increase the benefits of the cross docking. This study presents a vehicle routing problem in a cross docking setting with heterogeneous vehicles having different capacities. All the routes begin and end at the cross dock and all the pickup and delivery sites are visited by only one vehicle. The aim of this study is to find the routes that minimize total transportation costs and the fixed costs of the vehicles. A simulated annealing algorithm is proposed to solve the problem. The proposed simulated annealing heuristic presents reasonable solutions in terms of computational time, best cost values and the convergence pattern on the best cost.

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Keywords: Logistics strategy, cross docking, vehicle routing problem, heterogenous vehicles, simulated annealing

1. Introduction

Supply chain and logistics management in contemporary markets is a vital function of operations management since consumers want to access diversified and quality goods in quick and easy ways. To efficiently deliver goods to customers it is insufficient to minimize costs for each supply chain member separately. Upper stream and downstream members of the supply chain should be considered as integrated in cost minimization since minimizing system wide

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cost will improve supply chain performance as a whole and provide better delivery performance to customers (Simchi-Levi, Kaminsky, & Simchi-Levi, 2007). Cross docking is one of the methods that establish integration between upper stream and downstream members of the supply chain.

Cross docking can be generally defined as the transfer of goods and materials from an inbound carrier to an outbound carrier while materials and goods do not actually enter into the warehouse or stored in a predetermined depot (Kulwiec, 2004). With cross docking policy, inventory holding role of a traditional warehouse is eliminated and at the same time products are still subject to consolidation meaning classification according to demand patterns and loading to delivery vehicles (Wen, Larsen, Clausen, Cordeau, & Laporte, 2008). Cross docking center should not be regarded as a storage point since products are stored for a short duration only for the consolidation process. Right after the consolidation, products will be transmitted to their corresponding customers according to product destinations (Moghadam, Ghomi, & Karimi, 2014).

Cross docking has various benefits for especially large scale supply chains working with massive amounts of products. Significant inventory savings due to no storage compose an important part of cross docking benefits. There is no routing to stationary storage areas and rerouting back to dock areas. Without the storage unit, inventory holding costs and inventory handling costs are severely reduced. In addition to benefits to the supply chain firms, crossdocking provides enhanced customer service by speeding up customer deliveries (Kulwiec, 2004).

Advantages of cross docking may even be enhanced by an efficient vehicle routing (Hasani-Goodarzi & Tavakkoli-Moghaddam, 2012). The vehicle routing problem (VRP) plays an essential role in the field of supply chain management and logistics. The costs related to operating vehicles used for transfer of goods to customers constitute an important part of total supply chain costs (Barbarosoglu & Ozgur, 1999). In VRP there are differentially located customers that have diverse demands for a product. They are served by some identical vehicles with a limited capacity from one depot. The aim of VRP is to determine a set of vehicle routes that brings minimum total cost in a single period given that (i) each route starts and ends at a depot; (ii) each customer is served by only one vehicle; and (iii) the total demand on each route does not exceed the vehicle capacity. (Lahyani, Khemakhem, & Semet, 2015).

Strategic management literature has not given much attention on supply chain management and benefits of supply chain management on strategic management is not well explored (Gonzalez-Loureiro, Dabic and Kiessling, 2015). Logistics management should be considered as a part of strategic management since it provides competitive advantage to the companies by focusing on low cost delivery performance, a key success factor in most of the industries. To make costs lower and gain competitive advantage distribution decisions should be considered in the strategic planning. Although, there are some arguments stating replenishment decisions such as transportation patterns are not at the strategic level and should not be discussed in the strategic planning, taking transportation costs out of consideration can indicate sub-optimality (Max Shen & Qi, 2007). A successful logistics strategy not only includes integration with other departments such as marketing and production, it also should be linked to overall corporate strategy (Meade & Sarkis, 1998). Sum, Teo and Ng (2001), showed that for strategic companies logistics plays a key role in strategic planning process. In their study they investigated how different departments influence strategic planning of the firms. Their findings showed logistics have a larger influence on strategic planning than marketing and production (Sum, Teo, & Ng, 2001).

In strategic planning, logistics strategies should be well-thought-out while deciding overall strategies of the firms. Logistics strategies are beneficial to the firms in terms of achieving overall corporate strategies, since one of the most important features of logistics strategies should be finding the ways of minimizing total cost in the distribution phase. Minimizing distribution costs can be achieved by determining best vehicle routing while serving to the customer. Cross docking is a technique that provides low inventory and transportation cost in the supply chain. In this aspect VRP with cross docking (VRPCD) can be considered as a vital logistics strategy during strategic planning of the organization and should take more attention from the strategic management point of view.

In the supply chain literature VRP has been intensively studied for the last decades in various contexts. First study of a VRPCD is conducted by Lee, Jung, and Lee (2006). They studied VRP in an environment including a number of pickup nodes and a number of delivery nodes connected by a cross dock. Shipments are conducted by homogenous vehicles chosen from a set. Routes of the vehicles start and end at the cross dock and all the vehicles return to the cross dock simultaneously. The objective is to minimize total cost including distribution costs and fixed costs of the vehicles. They used a tabu search algorithm to find the minimum total cost. Wen, Larsen, Clausen, Cordeau, & Laporte (2007) studied VRPCD in a setting where the vehicles after pickup do not have to come to the cross dock simultaneously.