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The benefit of advance load information for truckload carriers

Hossein Zolfagharinia, Michael Haughton *

School of Business & Economics, Wilfrid Laurier University, Waterloo, Ontario N2L 3C5, Canada

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ABSTRACT

This paper models and measures the profit improvement trucking companies can achieve by collaborating with their clients to obtain advance load information (ALI). The main approach is to formulate a comprehensive and flexible mixed integer mathematical model and implement it in a dynamic rolling horizon context. The findings illustrate that access to the second and the third day ALI can improve the profit by averages of 22% and 6%, respectively. We also found that the impact of ALI depends on radius of service and trip length but is statistically independent of load density and fleet size.

1. Introduction and literature review

Asset repositioning is one of the important issues in truckload transportation (Crainic, 2000; Wieberneit, 2008). A recent estimate that 18% of trucks move empty every day translates to more than 165 billion dollars annually in the US market (Ergun et al., 2007a). This is a natural result of imbalance between supply and demand at different cities. To correct for this issue, strategies such as collaborative transportation (CT) are used to ensure that trucks (containers) are repositioned in a way that efficiently fulfills future demand.

In CT, logistics participants (i.e., shippers/consignees and carriers) collaborate with each other to improve the performance of transportation planning. Examples of collaborative transportation networks are Nistevo (www.nistevo.com) and Transplace (www.transplace.com). They are non-asset based companies that provide modular software under common web-based network to create connectivity and encourage collaboration. These fairly young companies (Nestivo founded in 1997; Transplace founded in 2000) focus on finding new opportunities that cannot be achieved within the internal company scope. One of the best examples is empty repositioning of trucks. The shipper does not have any information on how its shipment requests might impact the empty repositioning of trucks. However, carriers implicitly charge shippers for this cost component. This issue can be resolved by connecting shippers and carriers to their partners through visibility of orders. For example, two members of Nistivo network could save 19% over the cost of one-way rates and their shippers experience a more routine schedule and lower empty repositioning cost (Lynch, 2001).

In general, CT helps to reduce total transportation costs, increase trucks utilization and lower driver turnover (Ergun et al., 2007b). Collaboration could be among transportation clients (e.g., Ergun et al., 2007a), among carriers (e.g., Özener et al., 2011), or between client(s) and carrier(s) (e.g., Tjokroamidjojo et al., 2006) or all the above scenarios. Collaboration between a carrier and its clients is the focus of this study. One of the least costly methods when freight transportation service clients and carriers collaborate with each other is to communicate timely load information (from clients to carriers) and pickup and delivery plans (from carriers to clients). The benefit of information sharing has been extensively examined in several

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* Corresponding author. Tel.: +1 (519) 884 0710x6205.
E-mail address: mhaughton@wlu.ca (M. Haughton).

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contexts such as inventory management or production planning. See, for example, Bourland et al. (1996), Lewis and Talalayevsky (1997), Gavirneni et al. (1999), Frohlich and Westbrook (2001), Patterson et al. (2003), Helper et al. (2010), and Zolfagharinia and Haughton (2012). However, such attempts in the transportation field remain limited. These studies include the works by Mitrović-Minić et al. (2004), Jaillet and Wagner (2006), Tjokroamidjojo et al. (2006), Angelelli et al. (2009), and Özener et al. (2011).

We distinguish between less than truckload (e.g., Mitrović-Minić et al., 2004; Angelelli et al., 2009) and full truckload literature. Mitrović-Minić et al. (2004) developed a double-horizon heuristic algorithm for the same-day dynamic pick-up delivery problems with time windows. The heuristic solved the problem with short-term (minimizing total distance) and long-term goals (efficiently serving future requests). The benefit of advance load information was found to be positive but smaller for larger instances. Jaillet and Wagner (2006) addressed the benefit of advance information for two variations of the traveling salesman problem. By defining the notion of disclosure dates for incoming requests, they analytically showed how advance load information helps to improve competitive ratios. Angelelli et al. (2009) examined different short terms strategies for dynamic multiple-period routing problems where requests can be postponed for the next day. They also analyzed the impact of the short-term strategies on the long term objective. The obtained results suggested that 2-day look-ahead policy was definitely superior to 1-day look-ahead policy. Since the problem under consideration in this paper is a full truckload one, the rest of the review only focuses on relevant full truckload studies.

A recent work which addressed the benefit of information sharing is by Özener et al. (2011). The focus of their study was to answer this question: how does information sharing help carriers to collaborate with each other? Since each carrier has the full information about its demand and cost structure, different lane exchange mechanisms were proposed with and without information sharing. The obtained results showed that information sharing with side payments helped carriers significantly to improve their performances.

One of the relevant studies to the current work is by Tjokroamidjojo et al. (2006). They studied the dynamic load assignment problem (DLAP) in a full truckload industry. They modified the model developed by Keskinocak and Tayur (1998) in the aircraft scheduling problem. Comparing their work with traditional DLAP (e.g., White, 1972; Powell, 1996), the model has a tour building capability. The ultimate goal of their study was to evaluate the benefit of advance load information (ALI) in the dynamic load assignment problem. Tjokroamidjojo et al. (2006) modeled the problem's time dimension implicitly by using a preprocessing approach. Their optimization-based computational analyses illustrated that ALI does not help the carrier to reduce its costs if the truck dispatching decision is fixed as soon as load information is realized.

The closest typical problems to DLAP are full truckload dynamic pickup and delivery problems. They are also called dynamic stacker crane problems (Berbeglia et al., 2010). Dynamic pickup and delivery problems with full truckload (DPDFL) have received much less attention in comparison to the static version. However, the input data are often revealed through time when a client requests transportation services. Thus, it is crucial to assign drivers (or equivalently trucks) to requests (i.e., loads) on a real time basis. The studies by White and Bomberault (1969) and White (1972) are probably the first attempts show how the load assignment problem can be handled in a dynamic setting in which each node represents a region with demands at the particular point of time. The problem is reduced to a simple transshipment problem if future forecast is known.

The more realistic model appeared in the work by Powell (1986) since it considered two types of vehicle movement between regions. The model does not let trucks move between regions unless there is an actual demand for them. Thus, if the realized demand in a particular lane is less than the number of assigned trucks, extra trucks are held at their current locations for future demands. Powell (1987) extended his previous work by presenting the network flow problem. Similar to the previous works each node represents a region at a particular time. Two types of arcs were considered in the model, one represents deterministic information and the other for stochastic ones. Following the same approach, Powell et al. (1988) proposed a model called LOADMAP which combines the real-time load assignment with sophisticated future forecast to maximize the truckload profit and service level. Running the model four times a day could help company to increase its annual profit by 2.5 million US dollars.

In another work, Powell (1996) proposed a stochastic DLAP formulation. He showed that when some stochastic information about future demand is available, the proposed model outperforms the deterministic one, which is updated as new information arrives. The model was evaluated under three conditions: fleet size density, demand uncertainty and ALI. Not surprisingly, the stochastic model is superior with more fleet density, higher uncertainty but not with more advance load information.

Yang et al. (1998) proposed a mixed integer programming with rolling horizon framework for DPDFL in which requests arise continuously. A model was designed for a static case and rerun at each decision epoch. The proposed mathematical model was compared with three simple heuristics. Obtained results with only four vehicles showed that the optimal myopic method produces high-quality solution but, by being computationally inefficient, it was slower than the heuristics. They unified re-sequencing, reassigning, and diversion in their proposed model to minimize empty travel costs, delay costs, and lost revenue as a result of job rejection.

Powell et al. (2000) took a comprehensive simulation-based approach for tackling DLAP. The approach was to design an offline algorithm for the static version and put it into practice for a dynamic problem when demands were gradually realized as the time elapses and there was no information on future demand. They questioned the practical value of optimal myopic solutions in comparison to a greedy solution over a long run given that there was no guarantee of user compliance with the model's solution. User non-compliance often exists in practice, since the model cannot capture all available system