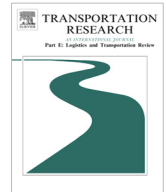




ELSEVIER

Contents lists available at ScienceDirect

Transportation Research Part E

journal homepage: www.elsevier.com/locate/tre

Dispatching policies for last-mile distribution with stochastic supply and demand



Robert A. Cook, Emmett J. Lodree*

Department of Information Systems, Statistics & Management Science, Culverhouse College of Commerce, University of Alabama, Tuscaloosa, AL 35487, USA

ARTICLE INFO

Article history:

Received 28 February 2017

Received in revised form 13 July 2017

Accepted 16 August 2017

Available online 7 September 2017

Keywords:

Humanitarian supply chain

Donations management

Dynamic programming

ABSTRACT

Relief distribution has received considerable attention in the disaster operations management literature. However, the majority of this literature assumes that supply is always available. In reality, a significant portion of the materials that flow through the humanitarian relief chain are donations, which represent an uncertain supply source in terms of both quantity and timing. This paper investigates a two-stage relief chain consisting of a single staging area (SA) where donations arrive over time in uncertain quantities, which are periodically distributed to random numbers of disaster survivors located at a point of distribution (POD). A single vehicle travels back and forth between the SA and POD transporting relief supplies during a finite horizon. The goal of this study is to identify dispatching policies for the vehicle with the sole purpose of minimizing unsatisfied demand at the POD. To this end, we examine the effectiveness of two common-sense heuristic policies relative to the optimal dispatching policy, the latter of which is determined via stochastic dynamic programming. Our findings indicate that although continuously dispatching the vehicle between the SA and POD is not an optimal policy, it is either optimal or close to optimal in most situations.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

Following any large-scale disaster, large quantities of food, water, clothing, and medical supplies are needed to avoid extreme suffering and loss of life. Especially at first, other considerations such as cost are insignificant compared to the consequences of having a need go unmet; all parts of the humanitarian supply chain must work efficiently from the initial collection of supplies to the final delivery to beneficiaries. While there are other important aspects of the disaster relief process, relief agencies estimate that logistics makes up about 80% of the total relief effort (Trunick, 2005).

Attention to disaster relief logistics greatly increased after the 2004 tsunami in the Indian Ocean. News networks broadcast the tragic story around the world, which in turn sparked an influx of financial and in-kind donations from sympathetic viewers. Truly, the outpouring of concern and support was one of the brightest moments in human history; unfortunately, the surge of in-kind donations posed very significant logistical problems. The Sri Lankan airport was overwhelmed by the amount of aid donated from around the world, and the existing warehouses were unable to hold the goods that made it in; ultimately the supply chain collapsed due to a combination of excess volume and/or damage (Thomas and Kopczak, 2005). Because of the urgency of the situation, the relief chain was designed and implemented before decision makers had sufficient information about the extent of the disaster. This uncertainty prevented them from using traditional

* Corresponding author.

E-mail addresses: racook1@crimson.ua.edu (R.A. Cook), ejlodree@cba.ua.edu (E.J. Lodree).

for-profit techniques, and instead they had to improvise ad hoc solutions as best they could. This was far from the first disaster in the world, but the visibility and severity of this event led logisticians around the globe to realize the need for specialized strategies for disaster relief logistics. Since then, many studies have contributed to our understanding of the unique characteristics of humanitarian supply chains, which are comprised of the following four functional stages (e.g. Vanajakumari et al., 2016):

1. *Major Distribution Centers* – Permanent distribution centers strategically located throughout the world, holding water and food before they are sent to Pre-Staging Areas. For example, the Federal Emergency Management Agency (FEMA) has 8 storage centers in the continental U.S. and 3 offshore locations: Guam, Hawaii, and Puerto Rico.
2. *Pre-Staging Areas* – Temporary locations to hold inventory in anticipation of a disaster. The facilities help aid agencies quickly move needed supplies to main Staging Areas. An example of this is moving supplies near Florida before hurricane season.
3. *Staging Areas (SAs)* – While major distribution centers and pre-staging areas are maintained independent of whether or not an active disaster is taking place, SAs are established once disaster events occur. Staging areas are temporary constructs chosen from a pre-determined set of locations such as schools, shopping mall parking lots, or faith-based organizations (e.g. churches). They are intended to reduce the lead time and cost of distributing aid to disaster survivors by bringing supplies closer to affected areas.
4. *Points of Distribution (PODs)* – Locations where aid is distributed to affected people. Like SAs, POD locations are selected after the disaster but identified before. Similar to SAs, promising locations for PODs are schools, parking lots, and churches, ideally situated close to affected areas, but can sometimes be as far as 600 miles away.

This study addresses the final stage of the humanitarian relief chain, last-mile distribution, which refers to the delivery of relief supplies from staging areas to local distribution centers (Knott, 1987). Specifically, this paper considers the impact of unsolicited donations on last-mile distribution in a humanitarian relief supply chain. The aforementioned logistical difficulties associated with the Sri Lankan airport give some sense of how unsolicited donations can affect relief distribution. Generally speaking, the most significant drawbacks associated with unsolicited donations can be attributed to *material convergence*, which refers to the influx of supplies and equipment in response to perceived needs during the aftermath of major disasters (Holguín-Veras et al., 2012). Based on interviews with practitioners, Holguín-Veras et al. (2012) found that the challenges of material convergence have more to do with the massive volume of donations than donation uncertainty; the presence of donated items in overwhelming quantities causes congestion at entry points into affected areas and at end sites where donated items reach their destination. Incoming donations have to be inspected and sorted before being distributed to beneficiaries, but because the majority of donated items are not needed, they eventually end up being destroyed. These and other issues related to material convergence unnecessarily add complexity to the disaster relief supply chain, which in turn causes delays in delivering relief supplies to the people who urgently need them. Although this paper addresses unsolicited donations in last-mile distribution, material convergence is not considered directly; in particular, this paper takes unsolicited donations into account by modeling supply at the Staging Area as an exogenous stochastic process. Thus our focus is managing donation uncertainty as opposed to handling the large amounts of donations specific to material convergence. On the other hand, the random donation arrivals considered in this study can be thought of as those that prior to being transported to the SA, have emerged out of material convergence after clearing inspection and sorting processes.

The specific relief chain examined in this study consists of a single staging area and a single point of distribution as shown in Fig. 1. The point of distribution is located close enough to the affected area that it is readily accessible to disaster survivors (i.e., beneficiaries), but far enough away so that their safety is not compromised. Donations and beneficiaries arrive periodically to the staging area and point of distribution respectively, both in uncertain quantities. A single vehicle of limited capacity is available to transport donations from the staging area to the point of distribution with the goal of minimizing unsatisfied demand.

The system in Fig. 1 represents a stylized version of a more complex relief logistics network observed in practice. In the real-world system, there are multiple SAs, PODs, and vehicles that are dispatched among them. The motivation for limiting the scope of this study to the simplified system shown in Fig. 1 is the possibility of being able to characterize the structure of optimal policies analytically, computationally, or both. The ability to express the form of an optimal policy, albeit in a stylized environment, can be very useful. For one, if we discover that optimal policies within the context of the stylized system are complicated and unstructured, then we know it would be highly unlikely for complex models that more closely resemble the real-world system to have optimal policies that are simple or structured. Another advantage is that if the stylized model leads to the identification of simple or structured optimal policies, then the resulting insights could be used to design effective solution procedures for more complex models in future studies.

It is also worth mentioning that the two-stage relief chain portrayed in Fig. 1 has an analogous counterpart in a for-profit supply chain context, namely shipment consolidation. Also known as inventory consolidation or temporal consolidation, shipment consolidation refers to holding small loads that arrive randomly at different times and transporting them in a single larger load (Lai et al., 2016). From this perspective, the humanitarian aid vehicle dispatching problem introduced in this paper is equivalent to a shipment consolidation problem with stochastic supply and demand. However similar to most humanitarian logistics papers that have their own commercial sector counterparts, our study can be distinguished from the shipment consolidation literature by its objective function. Specifically, the objective considered in this study is mini-

Download English Version:

<https://daneshyari.com/en/article/5110411>

Download Persian Version:

<https://daneshyari.com/article/5110411>

[Daneshyari.com](https://daneshyari.com)