



Analysis and prediction of food donation behavior for a domestic hunger relief organization



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ABSTRACT

Non-profit hunger relief organizations strive to counteract the negative effects of food insecurity by providing food and services to individuals in need. These organizations rely on the goodwill of donors, that provide cash or in-kind food donations, to help them meet their objectives. Food donations vary considerably over time in terms of their quantity and frequency, thus presenting a challenge as organizations strive to satisfy the needs of the population being served. Using data from a domestic hunger relief organization, we analyze the uncertainty associated with in-kind food donations. A comprehensive numerical study is performed to quantify the extent of uncertainty in terms of the donor, product, and supply chain structure. In addition, several predictive models are developed to estimate the quantity of in-kind donations. Based on our numerical study, we show the relationship between forecast accuracy, donation behavior, and data uncertainty. Additionally, implications on operational efficiency and service delivery are discussed.

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1. Introduction

Food insecurity occurs when individuals have limited access to safe and nutritious food for an active, healthy life (Coleman-Jensen et al., 2013; Campbell, 1991). This condition is ubiquitous, affecting populations worldwide. The International Federation of Red Cross and Red Crescent Societies classify food insecurity as a complex, man-made hazard stemming from issues such as chronic poverty or the sudden loss of economic income due to health or recession (Complex/manmade hazards, 2015). Even mild forms of food insecurity produce hunger, malnutrition, and adverse health outcomes associated with undernourishment (Wunderlich and Norwood, 2006).

The complexity and scale of food insecurity require a variety of interventions to effectively alleviate its associated hunger and health issues. In the USA, food assistance is provided through federally funded programs such as the Supplemental Nutritional Assistance Program (United States Department, 2010) or a network of public and private organizations (e.g., soup kitchens, food pantries, food banks) working in local communities to meet the needs of the food insecure population (Ohls et al., 2002). Our focus is on domestic food relief interventions with a particular emphasis on the role food banks serve in the fight against food insecurity.

Food banks operate as wholesalers of surplus food. They solicit and stock bulk donations from community, government, and private sources; effectively store and warehouse goods; and distribute donations to local charitable agencies (Ohls et al., 2002). This donation-driven environment complicates the classic supply chain dilemma to match supply with demand. For example, supply uncertainty exists because the frequency, amount, and quality of donated items are not known in advance. Demand uncertainty occurs because estimates of food need are driven by complex factors related to poverty and unemployment.

Donation-driven environments are considerably different from commercial supply chains which typically prize greater speed and/or cost effectiveness to generate increased profits. While food bank supply chains desire to quickly move items to individuals in need in a cost effective and efficient manner, the overarching goal is not profit driven. As non-profit organizations, food banks seek to maximize relief while simultaneously minimizing donation waste.

The intent of this paper is multifold. The foremost aim is to analyze a specific food bank supply chain with a particular emphasis on forecasting supply-side inputs. A number of studies in the public policy and health literature examine food bank usage and the challenges associated with limited and unpredictable supply (Campbell et al., 2011; Paynter et al., 2011; Tarasuk and Eakin, 2003), nutritional related initiatives (Handforth et al., 2013; Hoisington et al., 2011), and the impact of corporate donations on food bank operations (Tarasuk and Eakin, 2005). However, to the best of our knowledge, the application of statistical analysis

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techniques to manage supply uncertainty has not been addressed. We fill this gap by explicitly studying the nature of in-kind supply uncertainty and demonstrating that time-series forecasting techniques can provide reasonable estimates for in-kind donations. Our results generate forecast accuracy within 10% for specific instances.

Our study has particular merit because it is important for non-profit organizations to leverage knowledge and technology to renew and reinvent their operational effectiveness. Food banks armed with better predictive information on supply donation behavior can refine in-kind donation strategies and make informed downstream distribution decisions, which in combination increases the potential of the supply chain to meet organizational objectives.

The remainder of this paper is outlined as follows. Section 2 summarizes the related literature. Section 3 outlines our approach to analyze and estimate the behavior of food donations. The results of the descriptive and predictive models of donation behavior are discussed in Section 4. We also illustrate how the predictive models can be used to inform decision making on supply acquisition. Section 5 provides some concluding remarks about the implication of our results on operational efficiency and service delivery.

2. Related literature

2.1. Classification of food bank supply chain

Supply chains that support food distribution for hunger relief are generally run by non-profit organizations, such as food banks. Several disciplines have studied food banks including public policy and health, economics, and operations and engineering management. Interestingly, different disciplines use different terminology to describe non-traditional, non-commercial supply chains. In the open literature terms such as non-profit supply chain (McLachlin et al., 2009), humanitarian supply chain (Mohan et al., 2013), and social welfare chains (Adivar et al., 2010) are all observed. There are many commonalities amongst these terms in relation to their objectives and customers. For example, all of the terms encompass the notion that net earnings are not distributed to individuals (Berenguer, 2016). Thus, as McLachlin et al. (2009) indicate, the focus is not on profit, however funding (federal, state, or donations) are of fundamental importance.

A more fine-grained examination of the objectives of non-profit supply chains show some important distinctions specifically in relation to humanitarian versus social welfare supply chains. For example, humanitarian supply chains support disaster relief activities, such as the provision of food, water, and shelter (Beamon and Balcik, 2008). Disasters can be sudden-onset, (i.e., hurricane, political crisis, or job loss) or slow onset (i.e., famine or poverty) (Van Wassenhove, 2006). The objective of disaster relief agencies is typically focused on providing short-term immediate assistance. In some cases long-term continuous aid is provided to support a more complete recovery.

In contrast, Adivar et al. (2010) introduce the term social welfare chain to capture supply chain activities that support social programs targeted for slow onset disasters such as homelessness, unemployment, poverty and crime. Clearly, social welfare and humanitarian relief chains have the same core goal of satisfying the needs of people affected by slow onset disasters. However, according to Adivar et al., the two chains differ based on the event that caused the humanitarian crisis and the length of assistance. More specifically, social welfare chains embrace the goal of not just reduction but prevention of a social issue and operate continuously through social development and improvement

programs. Such programs rely heavily on monetary donations and government funding and less on in-kind donations (Adivar et al., 2010).

Our objective is not to provide a comprehensive analysis to refine and bring consensus to definitions used in the open literature related to non-traditional, non-commercial supply chains, instead we offer justification for our linkage to the humanitarian supply chain literature stream. Food bank supply chains fit the characterization of humanitarian supply chains in that they respond to the disaster of food insecurity which can occur suddenly (i.e., job loss) or slowly (i.e., poverty). In the sections to follow, we review relevant humanitarian supply chain literature that addresses both sudden and slow onset disasters that have promise to inform food bank operations. We refer the reader to Beamon and Balcik (2008) and Van Wassenhove (2006) for a more comprehensive analysis of the distinguishing characteristics between commercial and humanitarian supply chains.

2.2. Donation management in sudden onset environments

In the humanitarian supply chain literature, several studies document the donation challenge. Research has mostly focused on the pros and cons of in-kind donations or the actual usage of in-kind donations to provide relief to vulnerable populations.

2.2.1. Monetary donations

A number of papers examine the benefit of receiving cash rather than in-kind donations. Özpolat et al. (2015) design a donation calculator to enlighten potential donors about the cost of shipping an item from the USA to an overseas location versus purchasing an equivalent item locally using monetary donations. Ülkü et al. (2015) develop a model to determine the likelihood a donor will give cash rather than an in-kind donation. The objective is to maximize the expected amount of donated cash while considering donor trust in the organization and their belief that the donation will make a positive difference. Certainly monetary donations offer much needed flexibility in terms of what is acquired and when to better meet the needs of those individuals requiring relief. Nevertheless, monetary donations still present similar challenges as in-kind donations regarding securing adequate and predictable amounts to generate relief for those in need.

2.2.2. In-kind donations

Several studies document the negative effect of in-kind donations. Donated items are frequently unusable, or culturally inappropriate (Russell, 2005). Management of these donations requires moving volunteers from more critical tasks to that of sorting and inspecting low priority donations (Van Wassenhove, 2006; Holguín-Veras et al., 2007). Furthermore, these donations may fail to reach desired recipients and many items are eventually discarded (Holguín-Veras et al., 2012).

The aforementioned challenges are rooted in the lack of advanced knowledge about the type, quantity, quality, and timing of in-kind donations. This challenge has largely been treated as a known input in the humanitarian supply chain literature. Much of the work within this literature stream focuses on strategies to effectively use donations further downstream, such as routing and distribution decisions (Leiras et al., 2014; Hoyos et al., 2015). Nevertheless, managing the flow of in-kind donations is critical to humanitarian supply chains.

2.3. Donation management in slow onset environments

The summary of donations management literature in slow onset environments is limited to the focus of this paper, which is hunger relief. As shown below, the bulk of the research

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