Transportation Research Part E 70 (2014) 205–224

Contents lists available at ScienceDirect

Transportation Research Part E

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

An integrative approach to determine store delivery patterns in grocery retailing

Michael G. Sternbeck *, Heinrich Kuhn [1]

Catholic University of Eichstaett-Ingolstadt, Supply Chain Management & Operations Research Group, Auf der Schanz 49, 85049 Ingolstadt, Germany

A R T I C L E I N F O

Article history:
Received 10 November 2013
Received in revised form 10 May 2014
Accepted 7 June 2014

Keywords:
Grocery retailing
Store delivery
Retail operations
Planning interdependencies

A B S T R A C T

This article focuses on the tactical problem of selecting delivery patterns according to which grocery stores are repetitively supplied with products from different order segments by retail-owned distribution centers. The research environment considered consists of logistics processes in DCs, transportation and instore logistics. We identify dependencies on the delivery patterns selected and specify the relevant costs. These costs are reflected in the objective function of a binary selection model. Implementing and applying the model to the real case of a major European retail company yields substantial cost savings potential of 5.3%, amounting to tens of millions of euros per annum.

1. Introduction

The bricks-and-mortar grocery retail environment is becoming increasingly competitive. On the one hand, consumers are demanding more freshness, greater shopping convenience and lower purchasing prices. On the other hand, persistent market consolidation is apparent, resulting in better sourcing conditions for retailers, and lower sales prices that are further intensifying competition in the grocery sector (McCarthy-Byrne and Mentzer, 2011). Moreover, the declining demographic trend in many European countries will increase pressure on current retail spaces. Retail operations efficiency plays an important role if companies are to survive under such conditions.

The changing logistics networks of grocery retail companies over the last few decades are a result of striving towards higher operational efficiency. While in the past manufacturers were generally responsible for supplying the individual stores, grocery retailers nowadays operate their own distribution centers (DCs), and channel the vast majority of product flows through the network via this route (Fernie et al., 2000, 2010; Kuhn and Sternbeck, 2013). Such a network configuration provides an opportunity for retailers to bundle products across many suppliers and to reduce truck arrivals at the store, while also ensuring more frequent product deliveries. After such radical changes in coordinating product flows between manufacturers and the point of sale, grocery retail companies are currently in the process of better adjusting their planning systems to realize efficiency gains without modifying the logistics networks at their core (Kuhn and Sternbeck, 2013).

One important mid-term planning question resulting from conducting store deliveries via retail DCs is how best to determine store delivery patterns, which is considered in this paper (Hübner et al., 2013). The delivery pattern of a store specifies the number of deliveries for each order segment from DCs, and the specific points in time when the deliveries are to be carried out.

* Corresponding author. Tel.: +49 841 937 21823; fax: +49 841 937 21955.
E-mail addresses: michael.sternbeck@ku.de (M.G. Sternbeck), heinrich.kuhn@ku.de (H. Kuhn).
[1] Tel.: +49 841 937 21823; fax: +49 841 937 21955.

http://dx.doi.org/10.1016/j.tre.2014.06.007
1366-5545/

Store delivery patterns affect corresponding store order sizes, which represent an important efficiency driver along the different retail logistics subsystems (DC, transportation and store). We therefore translate the impact of a specific delivery pattern selected for one store into corresponding order size effects. This is also necessary to consider different sales volumes per store, as a store with low sales may order less volume once a week than a high-sales store does every day.

Decisions on delivery patterns obviously affect transportation as the number of shipments and transportation lot sizes are determined by the delivery patterns selected (Schöneberg et al., 2010). However, processes in the DCs and stores are also heavily influenced, resulting in the need for an integrative planning approach (Kuhn and Sternbeck, 2013). In the DCs, picking performance is dependent on order size, as the picker's preparation and travel times are distributed across more product picks. Moreover, the delivery patterns of all stores assigned to a DC determine the picking capacity required, which is restricted and should be balanced to a certain degree in order to perform personnel shift planning. In the stores, shelf-filling and restocking processes are also dependent on order sizes affecting the volume that does not fit onto the shelf and has to be stored temporarily in the backroom, which represents major additional handling effort (DeHoratius and Ton, 2009; Raman et al., 2001b; Kuhn and Sternbeck, 2013). As the goods receiving areas in the stores may be constrained, such dedicated storage areas have to be reflected in the process of selecting delivery patterns as well.

In spite of these significant dependencies, retail research lacks an integrative approach to determining store delivery patterns that results in a company delivery plan including processes in the DCs, transportation, and the stores. The goal of this paper is therefore to develop a holistic cost minimization approach to determine store delivery patterns that integrates relevant dependencies along the internal retail supply chain and can be used by operations planners as a decision support system. Achieving this objective involves two main steps. First, costs that are relevant for the decision are identified and specified. Second, a binary selection model builds on this to select store-specific delivery patterns from a set defined ex ante that integrates precalculated costs and relevant capacity restrictions. The model is applied in a case example with data from a major European retailer to demonstrate that the suggested approach can deal with relevant problem sizes, and can lead to significant operational cost reductions.

The remainder of this paper is organized as follows. First we review relevant literature in Section 2. Section 3 further details the research setting by describing the retail logistics network structures assumed and specifying order segments and delivery patterns. We also elaborate on the processes considered in the three logistics subsystems store, transportation and DC. Building on this analysis, Section 4 elucidates the relevant interdependencies and delineates the cost components on which the decision model developed is based, and describes the model in detail. After this, Section 5 applies the model to a real industry case. Section 6 concludes the paper and identifies future research opportunities.

2. Related literature

This section mainly focuses on a review of retail-specific articles that provide solutions to the problem of periodically supplying stores from DCs and integrating retail-specific processes such as picking, transportation and instore logistics. We find that there are only few studies that apply an integrated planning approach, incorporating relevant interdependencies comprehensively along the internal retail supply chain.

Kuhn and Sternbeck (2013) and van Zelst et al. (2009) investigate operational cost distributions on the different logistics subsystems of grocery retailers. The authors find that instore handling represents the largest operational cost block of bricks-and-mortar grocery retail companies. Inventory holding costs, however, are significantly lower than warehousing, transportation and instore handling costs. Where the determination of delivery patterns is concerned, that is the reason why inventory models focusing purely on inventory carrying costs abstract from the major cost blocks in such a retail environment. In contrast, standard periodic vehicle routing problems do not integrate the large interdependencies in the DCs and in the stores, and therefore only focus on approximately a quarter of operational logistics costs along the retail supply network. This underlines the need for integrative approaches when deciding on periodic store delivery patterns.

Gaur and Fisher (2004) develop a decision support system for the Dutch retailer Albert Heijn. The authors solve a periodic inventory routing problem in order to determine delivery times for the stores and also the corresponding vehicle routes. A maximum time span between two successive deliveries is introduced to reflect small store backrooms (Gaur and Fisher, 2004). The result is used as input for truck assignment and workload balancing in the DCs such that DC loading and unloading capacities deviate only minimally from a DC capacity profile. The strength of this approach is that several grocery retail-specific requirements are included and relevant interdependencies are considered, such as DC capacity and delivery times. However, instore processes are not explicitly integrated.

Zhao et al. (2007) also study an inventory routing problem in a retail setting. A single warehouse serves stores that are geographically dispersed and assigned to regional clusters with a single stock keeping unit (SKU) characterized by constant store-specific demand rates. All stores in a cluster are supplied by the same delivery profile, and vehicle routing is derived. The authors consider fixed and variable transportation costs, inventory holding costs in stores and the DC, and fixed ordering costs in the DC. A similar model is provided by Anily and Federgruen (1990). However, the key focus of these papers is the transportation subsystem. DC picking and instore handling processes are not included in the decision making.

Cardós and García-Sabater (2006) design a decision support system to determine delivery schemes for stores focusing on inventory and transportation costs. The objective function minimizes relevant instore inventory costs and transportation costs that are dependent on the delivery profile selected per store. Transportation costs are determined by incorporating