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Costs and opportunities of moving picking activities upstream in distribution networks: A case study from the beverage industry

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ABSTRACT

The work addresses the reconfiguration of distribution networks where order picking activities have a significant impact on the system performance. In particular, the effects of moving picking activities upstream in the network are investigated taking into consideration an actual case study from the beverage industry.

The paper presents a comparison of the main cost factors characterizing two different configurations: the "downstream picking configuration" (AS-IS Configuration), with picking activities executed at intermediate facilities, and the "upstream picking configuration" (TO-BE Configuration), where picking activities are performed upstream in the network at a central distribution center.

The actual desirability of the shift to the "upstream picking configuration" is shown, and considerations about the opportunity of automating picking operations are given.

1. Introduction

The paper deals with a multi-echelon inventory/distribution network where order picking activities have a significant impact on the system performance. As an example, this situation is typical in the food and beverage industry, where multi-item pallets are delivered to the customers (e.g. catering businesses) with high frequency and low volumes per delivery.

The reader may refer to Tompkins et al. (2003) and Koster et al. (2007) for interesting discussions about picking activities. Traditionally, picking activities are labor-intensive activities, manually executed as closer as possible to the final customers. Thus, it is necessary to set up intermediate facilities where picking activities are performed just before delivery (picking located "downstream" in the distribution network). Note that, in order to execute the picking tasks, these intermediate facilities require to hold stocks of products. Hence, in such a supply chain configuration, the duplication of stock along the distribution network is a consequence of the product flow complexity and the need for manual picking activities.

Conversely, this paper deals with the effects that can be observed along the supply chain by moving picking activities "upstream". In recent years, a growing interest has emerged on the significance of centralizing logistic activities and shortening supply chain (e.g., Hwang and Rau, 2006; Ryan, 2003; Hammel and Kopczak, 1993). Nevertheless, most of the works in the literature discuss the distribution network design problem by focusing on factors such as the characteristics of product demand, the number of product sources, the product variety and the response time (see, Chopra, 2003). In contrast, the innovative contribution of this paper lies in analyzing the impact of picking activities and their location on costs and performances of distribution networks. Note that, especially in a context where the product variety is high and there are many small customers rather distant from production facilities, moving picking activities "upstream" is not a trivial task. The cost structure of the whole distribution network is expected to change along with the role and function of some supply chain actors. As a consequence, a cost-benefit analysis is required in order to assess the actual desirability of the new configuration of the distribution network. This is especially true in industrial sectors, such as the beverage industry, where product customization takes place at the very beginning of the distribution network so that it is not possible to make the supply chain more agile by postponing the point of product differentiation.

The proposed work, done in collaboration with a distribution company operating in the beverage industry and located in Europe, aims to assess advantages and disadvantages of moving picking activities "upstream", i.e. of centralizing picking at a central distribution center located closed to the production plant.

In the case study, such an opportunity is effectively accessible to the company thanks to the new advancements in logistics automation technology and, specifically, the recent availability of automated picking systems. In contrast, the centralization at a single facility of picking activities that are manually executed

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would lead to hard-to-overcome concerns about space availability, coordination between picking and material handling tasks and, in particular, the complex management of intensive material flows that must comply with the picking order requirements. Hence, another interesting aspect arising from the proposed case study is the adoption of not only information and communication tools (discussed in works such as, Gunasekaran and Ngai, 2004; Byrne and Heavey, 2006; Swafford et al., 2008) but also a new technology for automating a traditionally labor-intensive process such as order picking.

Given the aforesaid motivations, the study investigates costs and benefits related to the following two configurations:

- The "downstream picking configuration" with picking activities located at intermediate facilities, referred here as AS-IS Configuration.
- The "upstream picking configuration" with picking systems located at the central distribution center (automated picking systems are installed in this case study), referred here as TO-BE Configuration.

In both the configurations, three levels can be recognized in the distribution network as follows:

- Level 1: central distribution center (CDC).
- Level 2: intermediate actors playing different roles and involving different resources in the two configurations.
- Level 3: final customers served according to delivery routes.

Similarly, two product flows can be distinguished along the distribution network in both the configurations:

- The product flow from Level 1 (i.e. the CDC) to Level 2, denoted as $PF_{1,2}$.
- The product flow from Level 2 to Level 3 (customers), denoted as $PF_{2,3}$.

In the AS-IS Configuration, i.e. the "downstream picking configuration" (see Fig. 1), Level 2 of the distribution network is composed of a certain number of intermediate distribution centers (DCs). Stocks are held at both Level 1 and Level 2. The product flow $PF_{1,2}$ from the CDC to the DCs mainly consists of full single-item pallets shipped using high-capacity trucks. At the DCs order picking activities are manually performed so as to obtain multi-item pallets. The multi-item pallets constituting $PF_{2,3}$ are delivered to the customers by means of low-capacity vehicles according to predefined schedules and vehicle routes. Note that in the AS-IS Configuration the CDC is generally prevented from understanding the final customer demand, causing information distortions and amplifications of demand variability, i.e. the so-called "bullwhip effect" (see, Lee et al., 1997; Chen et al., 2000; Sucky, 2009).

On the other hand, the TO-BE Configuration involves a direct product flow (consisting of multi-item pallets) from Level 1 to Level 3. Therefore, stock duplication is avoided (stocks are held at the CDC only) and the CDC is allowed to access the actual customer demand. In order to avoid excessive increases in transportation costs, Level 2 is not suppressed but modified as follows: no DCs are maintained in the system but some cross-docking points (CDPs) are introduced (see, Waller et al., 2006, about the impact of cross-docking on supply chains). The CDPs are simply equipped areas for transferring pallets from trucks to smaller vehicles, more suitable to cover delivery routes.

The remainder of the paper is organized as follows. Section 2 describes the AS-IS Configuration and provides interesting data from the case study under discussion. In Section 3 the TO-BE Configuration is discussed. In Section 4 a comparison between the AS-IS Configuration and the TO-BE Configuration is carried out. The main differential operative costs are computed and some quali-quantitative considerations along with some final remarks are pointed out. Finally, the main conclusions of the study are presented in Section 5.

2. AS-IS Configuration

The AS-IS Configuration in the distribution network under study is the "downstream picking configuration". In this case study, Level 2 is composed of 240 DCs that can be classified into two groups as follows:

- High Volume DCs (or HV DCs): 13 DCs able to handle more than 10,000 (boxes/day).
- Low Volume DCs (or LV DCs): the remaining 227 DCs of smaller dimensions.

As explained in the previous section, the DCs hold stocks of products and carry out picking activities in order to arrange the final multi-item pallets. The multi-item pallets are delivered to the customers according to delivery routes starting/ending at the DCs. Each delivery route is assigned to exactly one DC that may cover a number of other routes depending on its own fleet of vehicles. It may be convenient to introduce the following notation:

- $\mathcal{R}_j^H$ is the set of delivery routes starting/ending at HV DC j.
- $\mathcal{R}_j^L$ is the set of delivery routes starting/ending at LV DC j.

Some significant aspects about the AS-IS Configuration of the three-level distribution network under study are analyzed in the following. Quantitative data regarding the AS-IS Configuration are provided and discussed in Section 4.

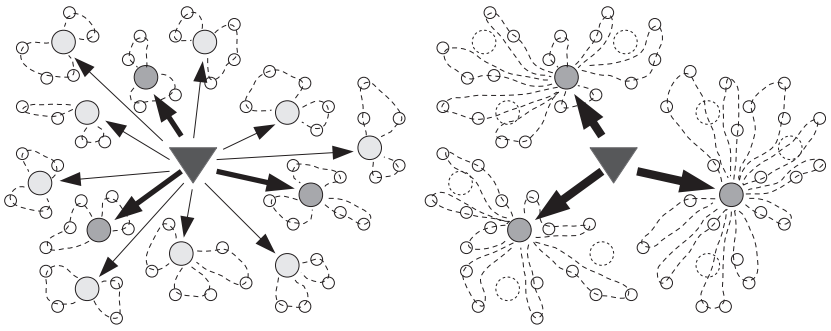

Fig. 1. Different distribution network configurations.