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Cost-effective pallet management strategies

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ABSTRACT

The existing industry strategies for managing pallets, (single-use expendable pallets, buy/sell programs, and leased pallet pooling programs), are analyzed and compared using push and pull inventory control policies. A two-stage integrated framework is developed that combines cost relationship models with data gathered in industry with multi-echelon inventory performance measures. For the base case, the single-use expendable pallet approach presents the least cost of all strategies, but the leased pallet pooling programs outperform the buy/sell programs in terms of total cost. The intervals where each strategy is most attractive are shown with respect to pallet cost, salvage cost, dwell fees, effective issue fees, retention rates, and transportation costs.

1. Introduction

Pallets play a central role in the handling and transportation of products through all echelons in the supply chain. Pallets are used to support unit loads of raw materials that get sent from suppliers to manufacturers; in turn, manufacturers send finished products on pallets to distributors; and finally, distributors fill requested orders to retailers on pallets. As the structural foundation of a unit load, pallets provide for efficient and standardized material handling and logistics throughout the world. With an estimated 80% of United States (U.S.) trade carried on pallets (Raballand and Aldaz-Carroll, 2007), pallets are undoubtedly the most commonly used unit load platform in the world. Approximately 450–500 million new pallets are manufactured annually and join the approximately 2 billion pallets that are in circulation in the U.S. (Buehlmann et al., 2009). In the European Union, some 280 million pallets are in circulation every year.

The pallet industry is vast, complex, and geographically dispersed. In the U.S., the wood pallet and container industry is composed of 2666 establishments and accounts for $7 billion dollars (estimated receipts) in 2012 (The United States Census Bureau, 2012; Rupert, 2015). There are three common industry strategies for managing pallets. In describing these systems, we provide the theoretical term with the industry term in parenthesis.

1. Open-loop system with no salvage value (single-use expendable pallet system): This case involves a single-use expendable pallet in which the chain of custody of the pallet transfers with the load. Rather than returning to the distributor or manufacturer, the pallet is expendable and is disposed (likely to a landfill). The pallets are whitewood or limited-use pallets that are chosen due to their use of inexpensive wood, which results in a low purchase price of a pallet.

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2. Open-loop system with salvage value (buy/sell program): In existing buy/sell programs, pallets are sold to the customers, transported with the product throughout the supply chain. After use the pallets are repurchased by a local pallet program or recycling facility. After inspection, the local pallet program either resells, refurbishes, or disposes of the pallets.
3. Closed-loop rental system (leased pallet pooling program): In leased pallet pooling programs, customers contract the use of pallets from a pallet pooling provider (essentially renting them). These programs offer a variety of leasing agreements to customers and place a predetermined number of pallets at user requested locations in the supply chain. After use, pallets are collected at a downstream location in the supply chain (e.g. at a retailer) and then repositioned to a point upstream in the supply chain (e.g., at the manufacturing echelon, or a consolidation DC). The reverse logistics associated with this operation (i.e. backhaul of pallets and pre-position of pallets), as well as the refurbishing activities gain significant importance. Leased pallet pooling programs rely on a network of return depots that collect empty pallets from many operations and perform inspection, sortation, repair, and backhauling. The return depots can be operated either by the pallet pooling provider or by locally contracted pallet recyclers.

This work develops an integrated two-stage framework that is used to understand the trade-offs pallet users face when selecting a pallet management strategy. Our analysis is conducted with respect to a single user/company who operates a multi-echelon supply chain. For example, many retail and grocery companies, like Sam's Club, Costco, Walmart, Publix, own and operate distribution centers and retail stores, and are thus responsible for the pallets at both the distributor and the retailer. Our work provides new knowledge into the trade-offs of the choice of a pallet supply chain management strategy by comparing strategies based on the total pallet costs. Total pallet costs incorporate both the multi-echelon nature of pallet management, as well as varying cost structure associated with purchasing, holding, ordering, and transporting pallets. To analyze the cost trade-offs we develop queuing network models for both open and closed-loop pallet supply chains operating under two variants of inventory control policy: push and pull. These models provide inputs to the cost analysis model for the pallet management selection problem.

This paper is organized as follows. The literature on pallet management strategies and related areas are reviewed in Section 2. The contributions of our work are articulated in Section 3, which includes development of a two-stage framework. The first stage are cost relationship models, which are presented in Section 4. The second stage includes multi-echelon inventory performance estimates, which we analyze through the stochastic open-loop and the closed-loop models presented in Section 5. Through numerical experiments and cost model sensitivity analysis, in Section 6 cost intervals where each strategy is most attractive are presented with respect to pallet costs, salvage costs, dwell fees, effective issue fees, retention rates, and transportation costs. The conclusions and directions for future research from this study are included in Section 7.

2. Literature review

Pallet supply chains differ from the traditional product supply chains in several dimensions. For instance, the traditional product supply chains have a predictable forward and reverse material flow among its actors such as: suppliers, manufacturer, distributor, wholesaler, retailer, end customer, recycler (if applicable) (Savaskan et al., 2004; Atasu et al., 2008, 2013). However, such a predictable flow is absent from the pallet flows, where the pallet can move from any actor in the supply chain to a repair facility and sent back (after repair) to another actor. Product supply chains exhibit cyclic flow patterns, whereas pallet supply chains exhibit network flow patterns. Further, pooled pallets are typically used for a large number of cycles compared to a traditional product. In addition, the recovery/disposal of pallets are closed to 100% especially in pallet pooling programs unlike products where the product usage is dependent on consumer usage and behavior.

Most of the literature with respect to pallet management is focused on pallet loading issues (Ram, 1992), regional differences of pallet systems (Guzman-Siller et al., 2010; Jin et al., 2008), specific military applications and systems (Harris and Worrell, 2008; Peterson, 2005), repair-replacement models (Tornese et al., 2016; Lanzenauer et al., 1978), or pallet end-of-life scenarios (Carrano et al., 2014; Buehlmann et al., 2009; Gasol et al., 2008; Corbiere-Nicollier et al., 2001). We focus our review on the limited archival literature available on pallet supply chain management and logistics. This work can be categorized into deterministic and stochastic pallet management models, depending on the certainty of pallet flows and demands at each point of the chain. We also briefly comment on selected literature on empty container supply chain management that has similarities to pallet logistics models.

Deterministic management models: These works treat demand for pallets deterministically and assume that the number of pallets that flow from each echelon is known with certainty. Kroon and Vrijens (1995) analyze the design of a return logistics system for returnable packaging (of which pallets are an example) that facilitates the transportation of returnable packaging from recipient to sender. They develop a mixed-integer programming model to determine how many units of returnable packaging should be available in the system; how many depots and where the depots should be located; how should the distribution, collection, and relocation of returnable packaging be organized; and what should be the fee structure. Duhaime et al. (2001) develop a minimum-cost flow model to plan the distribution of empty returnable containers in the Canada postal network to determine if the pool of containers was sufficient to meet demand and whether the containers were located at the correct locations in the network. Comparison of their model with historical data confirms that the company has adequate containers to meet demand; however, the company needs to improve the management of its return containers. Bilbao et al. (2011) provide a framework for choosing the pallet management strategy and the material with which