SHIPMENT POLICIES FOR PERISHABLE INVENTORY

We study shipment policies of perishable inventory with fixed shelf life, which affect products’ age at the shipping location and at the receiving location. Aging of inventory has shown to increase product expiration, which is an important problem draining firms’ profits and burdening the environment (Akkas et al. 2017). At our research collaborator, the cost of product expiration is significant and is equivalent to 15% of annual profits. The consumer-packaged-goods industry disposes of 20% of its product waste at landfills, which is a substantial amount considering the fast-moving, high volume nature of consumer packaged goods (GMA 2008).

In practice, first-in-first-out shipment policies are believed to be essential to control the costs associated with product expiration. Using a dataset from an audit study that includes inventory data by age and position at a manufacturer’s distribution center, we show the extent of inventory aging and compliance to the first-in-first-out shipment policy in practice. Our data reveals that 8% of the SKUs have lost more than 50% of their shelf life while 31% of the SKUs have lost more than 25% of their shelf life by the time they are shipped to retail. Further, the inventory is rotated (for first-in-first-out shipments) only for the 46% of the products. We find that rotated inventory on average is older than “unrotated” inventory, which is unexpected. Further analysis shows that, most likely due to limited labor, the warehouse manager selectively rotates inventory, giving rotation preference to products with less number of inventory positions, which require less effort to rotate, and slower moving products, while ignoring other factors that impact the expiration cost such as shelf life and cost-of-goods-sold.

Given that the first-in-first-out shipment policy is much emphasized in practice for its importance to reduce expiration cost, yet not complied with extensively in practice, we ask the following questions:
• Is the first-in-first-out policy even optimal for the manufacturer?
• If not, can we find and characterize the optimal policy?
• Can we find alternative heuristics that are practically implementable and more beneficial for the manufacturer?

We investigate these questions using an infinite horizon dynamic programming model considering a two-echelon supply chain, in which a manufacturer fulfills a retailer’s orders for a perishable product. Both firms order inventory according to a periodic review order-up-to policy. The demand rate at the retailer is known by both parties. The manufacturer is responsible for the cost of outdates both at the retailer and at its own distribution center, which is common practice for consumer packaged goods manufacturers in North America (GMA 2008). We assume first-in-first out inventory depletion at the retailer. In addition, we assume that expiration at the retailer is more costly than expiration at the distribution center, which is the case in practice since inventory is handled in units at retail stores as opposed to cases or pallets at the distribution centers. The manufacturer seeks to maximize its net profits by deciding the age composition of inventory to be shipped to the retailer each period.

Interestingly, we find that the first-in-first-out shipment policy is not optimal for the manufacturer. We develop a number of heuristics as alternative policies. One of the policies is based on our empirical findings that managers consider demand rates. Another heuristic policy is based on our analysis of a one-period analytical model that captures the essence of the two-echelon perishable inventory shipment problem. Across the 1,920 scenarios tested, the first and the latter heuristic methods produce an optimality gap of 22.91% and 10.73%, respectively. Both policies outperform the first-in-first-out policy which has an optimality gap of 24.63%.

Regarding the expiration amount in the supply chain, the first-in-first-out policy outperforms the
other policies by producing the least amount of expiration across the two echelons. We also find that last-in-first-out (no rotation) is the worst shipment policy for the environment by generating the most amount of waste.

Our study connects multiple streams of literature. To the best of our knowledge, our research is the first to address shipment policies in a two-echelon setting in the perishable inventory management literature. We also contribute to the sustainable operations management literature by showing the environmental impact of shipment policies. Our empirical analysis explains the factors a manager considers when selectively deciding when to comply with a warehouse management process. As such, our paper adds to the literature that uses real-world data to explain behaviors in operations management. Furthermore, we build on the empirical research on inventory management by using a unique dataset that includes proprietary inventory data from the upstream supply chain and differentiates inventory by its age and position.

It is important for manufacturers to properly manage the shipment of aged inventory considering waste implications throughout the supply chain, since waste is a big problem in the consumer packaged goods industry impacting profits and the environment. Our research generates useful insights for practitioners for better management of perishable inventory, considering the impact on profits and waste.

References:


GMA, 2008. 