



Effects of ticket-switching on inventory management: Actual vs. information system-based data



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ABSTRACT

Inventory inaccuracies in retail stores result from a combination of controllable and uncontrollable factors such as theft, damage, spoilage, misplacement, process errors, ticket-switching, among others. While most shrinkage types affect only one (type of) item, ticket-switching simultaneously affects the inventory of multiple items. Ticket-switching is the process of switching the identifier or ticket of an expensive item with that from a (relatively) cheap item with the explicit intent of purchasing the expensive item by paying the cheap item's price. Ticket-switching incidents distort inventory records in store information systems. Inventory management decisions based on such data from store information systems are therefore sub-optimal. We study the effects of ticket-switching on optimal order quantity of the involved items and the resulting profit. Under uniformly distributed demand and yield conditions, we find that ticket-switching increases (decreases) the optimal order quantity of the expensive (cheap) items. Surprisingly, results from our analysis indicate that profit on expensive (cheap) items is higher (lower) in the presence of ticket-switching behavior than otherwise.

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1. Introduction

Global Retail Theft Barometer surveyed 1187 retailers in 43 countries world-wide and found that retail shrinkage in 2011 cost the industry an estimated US\$ 119 billion, which is about 1.45% of overall sales. The highest proportion of shrinkage were reported by retail categories that include apparel, health/beauty and DIY. This should not be dismissed as an insignificant proportion based purely in terms of the absolute percentage, since even a 2 to 3% sales loss can amount to about 25% loss in profit in this industry with tight profit margins (e.g., [21]). Moreover, reduction due to shrinkage from 2% to 1% is tantamount to about 40% increase in sales (e.g., [1,5]).

The increased use of EAS (Electronic Article Surveillance) over the years has reduced the occurrence of shrinkage in retail store settings [6,9]. A general consequence of a shrinkage event is the loss or disappearance of items. While the source of shrinkage can take many forms such as damage, misplacement (e.g., [17]), process error, shop-lifting (e.g., [7]), spoilage (e.g., [18]), theft (e.g., [9]) and ticket-switching [25, 26], the loss per shrinkage incident depends on the number and type of items involved, the short-term demand for such items and their substitutes, the temporal aspect of that item (e.g., fashion apparel,

perishables), and the complexity of the item's replenishment process. Regardless, while a majority of shrinkage incidents affect only one (type of) item (e.g., a pair of jeans), some *simultaneously* involve multiple items per incident. Ticket-switching is one such type of shrinkage.

Ticket-switching is the process of switching the ticket or item identifier on an expensive item with that from a (relatively) cheap item with the explicit intention of 'purchasing' the expensive item but paying only the cheap item's price [14,25]. A ticket-switching incident manifests different impacts on actual in-store inventory and the retail store's inventory information system. From an actual inventory perspective, the store is out of the expensive item but receives a smaller (i.e., price of the cheap item) payment in return. From the store information system's perspective, the customer purchased a cheap item by paying its price. While this may not seem like a major loss for the store since the store only lost the price difference between the expensive and the cheap item, the overall loss to the store due to such incidents is indeed significant. This significance is a direct consequence of information disparity between actual inventory and that in the retail store information system. Since retail stores generally place replenishment orders based on remaining inventory from the perspective of their information systems, any disparity in such information could have deleterious consequences. For example, since ticket-switching of the expensive item is invisible to the store information system, this could ultimately result in the store bearing witness to stock-out situations (e.g., [16]) of the expensive item and excessive inventory and related inventory cost of the cheap

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item. When the cheap item is a perishable, excessive inventory of perishables that are invisible to the store information system has the potential to precipitate in unnecessary waste due to spoilage.

While there is no dearth of publicly available statistics related to shrinkage in general, it is difficult to determine specific percentage values for individual types of shrinkage. The availability of ticket-switching statistics is even rarer due to its very nature (of simultaneously affecting the actual and information system inventory levels of multiple items) and the existence of other types of shrinkage mechanisms. To add to this complexity of distinguishing different types of incidents that comprise overall shrinkage, ticket-switching events are vulnerable to misinterpretation as other types of shrinkage. For example, a ticket-switching incident can be misconstrued as the combination of a (price or identifier) tag detachment incident for the cheap item, loss (e.g., theft or misplacement) of an expensive item and sale of an imaginary cheap item. Regardless, theft accounts for the largest proportion of shrinkage in a majority of cases, and it is reasonable to assume that ticket-switching is significant even if it's a small fraction of the overall theft statistic.

Ticket-switching is not an unknown phenomenon in retail store environments. Retailers have been aware of its existence for a long time. Clearly, given a choice, retailers would prefer to prevent rather than to deal with the deleterious consequences of ticket-switching. While some retailers take additional and targeted precautions to guard specifically against ticket-switching and its variants (e.g., ensure that both the shoes and the shoe box do indeed belong together during check-out), resource constraints severely prevent complete elimination of ticket-switching incidents. For example, while it may seem relatively easy to identify ticket-switched items during check-out, several factors render this difficult. Some of these include (1) checking every scanned item with relevant information displayed on the screen drastically slows down the check-out process, (2) ticket-switched items may be difficult to differentiate (e.g., organic vs. conventional produce), (3) the lack of alertness of unconcerned check-out personnel possibly due to sheer laziness, and (4) complicity of the check-out person. The introduction of item-level RFID tags (e.g., [19]) could possibly reduce ticket-switching incidents as well as alleviate their consequences in terms of inventory management when store inventory are taken with high frequency. However, very few stores (e.g., Trasluz, American Apparel) currently have 100% store-wide item-level RFID tags in place, while several other retailers have only a few products (e.g., shoes at Macy's, Wrangler jeans at Wal-Mart, Levi's jeans at Kohl's) with item-level RFID tags. Nevertheless, complete store-wide item-level RFID tags may not necessarily eliminate ticket-switching incidents (e.g., [14]).

Given that ticket-switching is commonly known among retailers, what is surprising is the sheer lack of published research literature on ticket-switching and its related dynamics. We attempt to address this gap in extant literature. Specifically, we model ticket-switching with two items – one 'cheap' and the other 'expensive' – and the switching of the expensive item's ticket with that from the cheap item. Please note that *expensive* and *cheap* are relative terms whereby an expensive item in one ticket-switching incident could be a cheap item in another. For example, consider three items *A*, *B* and *C* that sell for \$1, \$50 and \$1000 respectively. While *B* is the expensive item for a ticket-switching incident involving items *A* and *B*, the same *B* is the cheap item when involved in a ticket-switching incident comprising items *B* and *C*. We do not concern ourselves with such relative differences since it's outside the scope of this paper. To our knowledge, this is among the few papers that consider ticket-switching and its effects on inventory management.

We study a few facets of the dynamics of ticket-switching incidents that are novel to existing research literature. Based on these, the contributions of this paper are three-fold: (a) we raise awareness for ticket-switching and its simultaneous effects on multiple items from an inventory management perspective, (b) we study optimal order quantity as well as retailer profit for both cheap and expensive items in the

presence and absence of ticket-switching behavior, and (c) we develop associated policy implications for retailers in the presence of ticket-switching behavior.

The remainder of the paper is organized as follows: we briefly discuss ticket-switching and some ticket-switching incidents in Section 2. In Section 3, we model ticket-switching behavior in a system with two items – one expensive and the other cheap – and evaluate optimal order quantities and profit functions from different perspectives. We conclude the paper in Section 4 with a brief discussion on findings and possible extensions to this study.

2. Ticket-switching

Ticket-switching, by definition, requires the existence of at least two items with their own price or identity tags that are used to look up the price of the item in an associated database. Moreover, since ticket-switching incidents occur without implicit or explicit awareness/consent of the retail store personnel, the retailing environment must be conducive to such acts. This necessitates the simultaneous existence of several different items and a reasonably positive probability for a customer to successfully instantiate and complete a ticket-switching event without the knowledge of the store personnel. It can, therefore, be safely assumed that the origin of ticket-switching incidents dates back to the use of price or identity tags, which could be a bar code or an RFID (Radio Frequency Identification) tag [23], in a retailing environment.

We believe that the origin of ticket-switching is relatively recent, perhaps as recent as the late nineteenth century, when price tags were introduced by John Wanamaker in retail store settings with the explicit purpose of replacing haggling with a fixed price for all customers. The relatively recent introduction of automated identification technology such as bar codes in retail settings about four decades ago, for efficient inventory-taking and check-out, most likely facilitated ticket-switching behavior. Unlike price tags in the form of stickers where the check-out personnel have an opportunity to verify the price sticker with the item, it is not common for check-out personnel to verify the item-description generated from the bar code scan with the actual item. Moreover, whereas the retail industry trend is moving toward more automation and fewer human touch points, manual verification of item-description with the actual item slows down the check-out process.

From a ticket-switching perspective, price stickers are the easiest, followed by bar codes and then RFID tags. Bar codes are currently the most commonly used price/item identification tag in retail environments, followed by price stickers and then by RFID tags. Item-level RFID tags are being used by a very small fraction of retail stores (e.g., Trasluz, American Apparel), primarily for inventory management purposes. It is relatively easy to ticket-switch bar codes as is evident from the few highly publicized incidents in the media. From the customer's perspective, a simple (sticker) price tag is the easiest to switch but difficult to check-out while an RFID tag is the most difficult to switch and easiest to check-out of the store. Since a price sticker is affixed or attached on the item, it is easy to switch, but the price-switched item has a positive probability of being discovered by knowledgeable check-out personnel. Ticket-switching is difficult to accomplish with RFID since (a) unlike printing a cheap item's bar code, it is difficult to copy/clone (e.g., [14]) the content of the cheap item's RFID tag and (b) the tag may be embedded in the item. Moreover, the customer cannot switch the RFID tag from an already-purchased cheap item since the system knows that that tagged item was already purchased from the store – i.e., can't buy the same (unique coded) item more than once. However, after successful ticket-switching, it is relatively easy to remove an RFID-tagged item from a store with automated check-out.

Since ticket-switching incidents are difficult to identify using the retail store inventory information system or the actual store inventory, such incidents are generally not specifically targeted for consideration to be addressed. Moreover, based on our limited experience in such

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