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RFID's Impact on Out of Stocks: A Sales Velocity Analysis

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Abstract

In a previous paper (Hardgrave, Waller, and Miller, 2005), we reported the preliminary results of a major study that examined the influence of RFID on out of stocks (OOS). This initial paper provided some preliminary surface-level analysis of the findings. Overall, as previously reported, when looking across all Wal-Mart store formats for a large group of RFID tagged items (4554 items), the results were positive and encouraging. However, the previous paper did not control for various influences on out of stocks or provide a statistically robust indication of the true difference made by RFID.

In this paper, we further examine the influence of RFID on out of stocks. Specifically, we examine the RFID effect by sales velocity (i.e., number of units sold per day). As suspected, the influence on RFID varies by the units sold per day. These new findings control for other major variables such case pack size and shelf quantity to further isolate the RFID effect. Overall, we found that for products selling between 0.1 and 15 units per day, RFID reduced out of stocks by 30 percent. This point estimate provides a robust indication of RFID's ability to reduce out of stocks.

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Introduction

Out of stocks is a major problem for retailers, suppliers, and consumers. Nationally, the average out of stock rate is about 8% (Corsten and Gruen, 2003) which means that about 1 out of every 12 items on a consumer's shopping list is not on the shelf. The result: lost sales and unhappy customers. Although retailers have tried to improve out of stocks for years, the 8% rate has remained relatively stable (Corsten and Gruen, 2003).

In June 2003, Wal-Mart asked its top 100 suppliers to begin using RFID on pallets and cases going to a select group of distribution centers and stores. One of the anticipated benefits of RFID was a reduction in out of stocks. In February 2005, to empirically test this assumption, we began the largest out of stocks study ever conducted. The study included thousands of products in 24 stores of various Wal-Mart formats over a 6-month period. The initial results, released late 2005 (see Hardgrave, Waller, and Miller, 2005), were both positive and extremely encouraging. In the test stores (those that were RFID-enabled), out of stocks dropped 26% during the study period. This constitutes an improvement in out of stocks that was 63% better than the improvement experienced in control stores (those that did not have RFID). The initial results, while good, were a broad oversimplification of RFID's impact on out of stocks. The current analysis, as presented in this paper, takes a much closer look at the effects of RFID on out of stock and, in doing so, helps isolate the RFID effect. In this instance, we examine the RFID effect by sales velocity (i.e., number of units sold per day). As suspected, the influence on RFID varies by the units sold per day. As discussed in this paper, the new analysis provides a much more robust indication of RFID's ability to reduce out of stocks.

Out of Stocks – Causes and Consumer Responses

Why does an out of stock occur? There are hundreds of reasons why a product may suffer an out of stock, such as an inaccurate forecasting and ordering system, an impending hurricane causes a run on local stores, a new product sells many more units than anticipated, the product is sitting in the backroom, and the product was received but is damaged, among others. In general, the causes of OOS have been placed into six categories: store forecasting, store ordering, shelf replenishment, distribution center issues, retail headquarters or manufacturer issues, and other (Corsten and Gruen, 2003). Table 1 contains the weighting for each of these causes. These causes may vary due to events (such as a hurricane), by category (some products may stockout more due to shelf replenishment problems than store ordering, for example), by sales velocity (e.g., slow moving items may stock out more due to store forecasting), and by global region (e.g., in Europe, 38% of OOS are due to shelf replenishment issues).

As explained later, RFID, as currently used by Wal-Mart, addresses one of the root causes of OOS: shelf replenishment issues (i.e., product in the store but not on the shelf).

OOS Cause (U.S. average)	**%**
Store forecasting	18%
Store ordering	33%
Shelf replenishment (in the store, but not on the shelf)	22%
Distribution center	11%
Retail HQ or manufacturer cause	13%
Other	3%

Table 1: OOS Causes in the U.S.
(source: Corsten and Gruen, 2003)

How does a consumer react when a product is out of stock? Generally, a consumer reacts in one of five ways (see Table 2): decides she does need the product (do not purchase); decides she does not need the product immediately (delays the purchase); buys the same brand, but a different size, style, flavor, color, etc. (substitute – same brand); buys the same product, but a different brand (substitute – different brand); goes to another store to buy the desired product. Although these 5 reactions are common, the exact reaction will vary by region (for example, Europeans are much less brand loyal than Americans and are more likely to substitute a different brand) and by product category (for example, consumers are very brand loyal to diapers compared to paper towels and are, thus, more likely to go to another store to buy the diapers they want rather than switch to a different brand). See Corsten and Gruen (2003) for more information about consumer buying behavior by region and category.

Consumer response (U.S. average)	**%**	**Directly affects**
Do not purchase	11%	Retailer & supplier
Delay purchase	16%	Neither in the long term
Substitute – same brand	21%	Direct affect hard to determine since purchase was made
Substitute – different brand	22%	Supplier
Buy at another store	31%	Retailer

Table 2: Consumer Responses to OOS Occurrences (U.S.)
(source: Corsten and Gruen, 2003)

As shown in Table 2, an out of stock occurrence does not directly translate into a lost sale in all cases due to consumer buying behavior (i.e., sometimes, a consumer will switch to a different brand which is a loss to the supplier; sometimes, a consumer will go to another store to buy the product which is a loss to the retailer). When looking at direct affects, retailers absorb about 42% of the impact of an out of stock (11% + 31%) while suppliers absorb about 33% (11% + 22%). This means that for a store averaging 8% out of stock, the estimated potential lost sales for the retailer are 3.4% (8% x 42%) and 2.6% for the suppliers (8% x 33%)[1]. In other words, if a retailer could eliminate all out of stocks, they would potentially see a sales lift of 3.4% and their suppliers would potentially see a 2.6% lift. Although this may not seem like much, the implications are high: for example, a $1 billion supplier may see as much as $26 million in increased sales; a $100 billon retailer may experience as much as $3.4 billion in increased sales

[1] Note: this does not include the hard-to-determine effects of switching sizes, the accumulative effects of several out of stocks (i.e., the point at which a consumer decides to leave the entire shopping cart and go to another store – and never comes back!), and the risk of losing brand loyalty if a consumer substitutes a different brand.

annually. Thus, reducing out of stocks by even a small amount can translate into real dollars quickly.

Wal-Mart's Approach to Using RFID to Reduce OOS: Automatic Picklists

In a Wal-Mart store without RFID, picklists (i.e., lists of items that need to be taken from the backroom to the sales floor) are created by visually inspecting the shelves for out of stock, or nearly out of stock, items and then using a handheld scanner to add those items to a list. Only items that show inventory on hand can be added to the list. Picklists can also be created by using a handheld device to scan barcodes on cases of product stored in the backroom (known as a 'reverse picklist'). The system then identifies, via an indication of existing store level inventory, whether or not the case will fit on the shelf. If it can fit on the shelf, the associate 'picks' the case (i.e., places it on a cart) and takes it to the sales floor to be put on the shelf (many cases are picked before going to the sales floor). Both methods of creating picklists are laborious and rely upon the accuracy of the inventory count to suggest availability in the backroom (for example, in some cases, the product is not available in the backroom – rather, it is located somewhere else on the sales floor).

With RFID, stores will know what cases have been delivered to the store, taken to the sales floor, or stocked in the backroom. Combined with point-of-sale data, a much more accurate view of inventory – both on the shelf and in the backroom – can be provided[2]. As product is sold, picklists can be generated based upon a knowledge of items on the shelf (from point-of-sale data) and RFID-generated information of product in the backroom (i.e., cases received but not yet taken to the sales floor). In essence, the

[2] RFID is currently used at the case level only; individual items are not tagged. RFID information, combined with point-of-sale data currently available, will provide much more accurate inventory counts.

picklist process is changed from reactive (i.e., looking at the shelf or backroom to determine what needs to go to the shelf) to proactive (i.e., creating the list in real-time based on sales). This new 'automatic picklist' initiated by Wal-Mart is enabled by the data provided by an RFID technology environment and is currently the principal driver in reducing out of stocks. Note, however, that the process for the store associate stocking the shelf is no different – they receive a list of items (i.e., the picklist) to be picked and then proceed to find and stock these items. To them, the process is the same – in the background, though, the manner in which the items were added to the picklist has greatly improved. In this way the use of RFID-generated picklists helps address one of the causes of out of stocks (as discussed in the previous section): store replenishment (product in the backroom but not on the shelf).

Research Methodology

Scope

To investigate the impact of RFID, a group of test stores were chosen at random from among the 104 RFID-enabled stores at the time. In total, 12 test stores were selected: 6 Supercenters, 3 Neighborhood Markets, and 3 Division I (i.e., traditional Wal-Mart) stores. All stores were in the Dallas, Texas area. Twelve control stores were then chosen based on geographic location, size of stores (square footage), and annual sales. These stores (6 Supercenters, 3 Neighborhood Markets, and 3 Division I stores) were located in Texas and southern Oklahoma.

Scanning Out of Stocks

From February 14, 2005 to September 12, 2005 (29 full weeks[3]), the test and

[3] The analyses use Wal-Mart weeks (Saturday-Friday) as the time reference; thus 29 full weeks in the study

control stores were scanned daily. A national merchandising group was contracted to perform the scanning. An 'out of stock' was defined as any empty shelf space. Almost all sections of the stores were scanned for out of stocks, with the exception of some areas such as bakery goods, variable weight produce and meat, fresh flowers, books and magazines, live animals, fabrics, tires, firearms, plants, tobacco, and jewelry.

The daily scanning of a particular store started at approximately the same time each day and the scanners followed the same route each day. Thus, the same areas were scanned at approximately the same time each day in each store. This was done to eliminate any fluctuations in OOS due to the time of day. Stores were generally scanned between the hours of 2:00pm and 10:00pm. All items out of stock were scanned regardless of being tagged or not.

At the beginning of the study (February 14), 4554 unique products contained RFID tags. This set of products, from almost all departments across the various Wal-Mart store formats, was used as the 'test' suite throughout the duration of the study. Although tagged products continued to increase and move through Wal-Mart's supply chain, it was necessary to hold the number of items constant for evaluation during the entire duration of the study. This same set of items was examined across both the test and control stores.

<u>Treatment</u>

Test stores were equipped with RFID technology (readers/antennae) at various backroom locations: receiving doors, sales floor doors, box crusher, etc. Control stores had no RFID technology. Out of stocks at each test and control store were scanned for almost two months before RFID applications were enabled in the test stores (to establish a baseline). In this case, the RFID application was the automatic picklist.

Results

To investigate the effect of RFID by sales velocity, we calculated the pre-test versus post-test improvement in the number of stockouts for each item in each store using the first seven weeks of the study as the pre-test period and the last seven weeks of the study as the post-test period. These improvement numbers were separated into two categories: test store items and control store items. Using linear regression, we measured the difference between the test store items and the control store items while controlling for (accounting for) the following variables: case pack days of supply; shelf space days of supply; on hand days of supply; relative size of the case to the shelf; and a store performance indicator. The results are shown in Table 3.

For products selling less than 0.1 units per day (i.e., 1 unit every 10 days), RFID made no difference. These are extremely slow moving items and do not experience out of stock occurrences frequently; thus, RFID (vis-à-vis, automatic picklist) had little, if any, opportunity to help. For the various sales velocity categories from 0.1 to 7 units per day, out of stock reductions ranged from 20% to 32%. When products are selling between 7 and 15 units per day, RFID reduced out of stocks by 62%. These items are fast movers and would be expected to stock out frequently. RFID (automatic picklist) helps this category the most by anticipating the stockout and placing the item on the picklist. For products selling more than 15 units per day, we did not detect a reduction in out of stock. However, there were very few items in this category – not enough to draw a conclusion statistically; thus, our results for this category are inconclusive. One could speculate that for very high velocity items such as these (for example, milk), replenishment is going to be almost continual and the associates are going to be paying very close attention to it. Other innovative uses of RFID, beyond the automatic picklist, may help address items in this category (again, no firm statistical conclusions can be reached as to whether or not RFID actually made a difference for this category).

For products selling[4] …	RFID reduced out of stocks by …
less than 0.1	no reduction
.1 to .2	32%
.2 to .3	32%
.3 to .5	20%
.5 to 1	36%
1 to 3	29%
3 to 7	32%
7 to 15	62%
more than 15	inconclusive
0.1 to 15	30%

Table 3: Out of Stock Reduction by Sales Velocity

Overall, for products selling 0.1 to 15 units per day, out of stocks were reduced by 30%. Recall from the earlier discussion (Table 1) that the shelf replenishment issues were responsible for about 22% of out of stocks (although, this is an average and the

[4] The sales velocity categories were determined by the number of items and stockouts and driven by the statistical analysis. In short, the categories were created to achieve homogeneous covariance matrices, as required by the statistical methods used in the analysis.

number can vary by company, store, category, etc.). The 30% reduction is an aggregate reduction across all Wal-Mart store formats (Neighborhood Market, Supercenter, traditional Wal-Mart store) for thousands of products. Thus, for products in the 0.1 to 15 units per day range, RFID greatly reduced the shelf replenishment issues leading to out of stocks.

Discussion

For this paper, we controlled for many variables known to affect out of stocks (such as case pack size) to better isolate the RFID effect. Furthermore, we looked at the effect by sales velocity. Overall, RFID did not improve those products selling less than 0.1 units per day. However, for all products selling between 0.1 and 15 units per day, RFID helped reduce out of stocks by 30%. These results have several implications.

First, insight into where RFID makes the most difference can help early adopters determine the proper tagging strategy. Procter & Gamble (P&G) has introduced an innovative 3-tier tagging strategy of advantaged products, testable products, and challenging products (Roberti, 2006). Advantaged products, for P&G, are those that have "high value, are fast moving, and often suffer from high-levels of shrinkage" (Roberti, 2006). Testable products are those where return on investment (ROI) may exist, but is harder to determine or will take longer to realize. Challenging products are difficult to tag (poor RF properties) or where ROI is difficult to achieve. The OOS reduction by sales velocity may help a company determine where the ROI resides (from purely an OOS perspective). As indicated by P&G, fast moving items may indeed be 'advantaged products' since the reduction in OOS was high for that group (62% reduction for products selling 7 to 15 units per day). Interestingly, in our study, we found that more than 90% of the 4554 items used in the analysis were in the sales velocity categories of 3 or less items. This suggests that, for the initial tagging effort, companies may not have maximized their ROI if they purposely chose to tag slower moving items. Given the choice, the current results would suggest that fast moving items would be a wiser choice (all other things, such as RF properties, being equal). It is hoped that companies can use the results herein to determine the best tagging strategy (based on P&G's 3-tier framework, for example) for their products.

Second, a 30% OOS reduction greatly reduces shelf replenishment as a source of OOS problems. Thus, retailers can begin to focus on other root causes of out of stocks, such as store ordering and store forecasting and how RFID may be used to attenuate these and other causes of out of stocks.

Third, although current use of RFID (automatic picklist) did not help those selling less than 0.1 units per day, it should not discourage RFID's potential for these products. For example, RFID could be used to help alert associates when products are delivered that may need to be taken directly to the sales floor. Also, the visibility provided (i.e., backroom) could improve the store ordering and forecasting for these items. For vendor managed products, RFID could provide insight into those stores that need immediate attention. Rather than sending merchandisers to stores at random, RFID could help direct personnel to stores that may be facing out of stock situations when product is in the backroom.

Lastly, recall the earlier discussion of the cost/revenue implications of OOS reduction. As indicated, retailers suffer about 3.4% (of the 8% OOS) loss of potential sales and suppliers about 2.6%. Given that RFID was able to reduce OOS by 30%, the potential impact of RFID (in sales uplift), at this point (for products selling in the range of 0.1 to 15 units), is about 1% for retailers (3.4% x 30%) and about 0.8% for suppliers (2.6% x 30%).

Keeping Wal-Mart's Initiative in Perspective

As discussed earlier, Wal-Mart used data provided from an RFID-enabled store and tagged cases to create an 'automatic picklist'. This was a relatively minor tweak of the existing process. So, let us put their change in perspective.

When using a new technology, such as RFID, companies may decide to introduce it as an 'incremental' technology or a 'radical' technology (see Figure 1). As an incremental technology, processes are changed only slightly; as a radical technology, existing processes are drastically changed or the technology is used as a process enabler (i.e., to create new processes). With RFID, companies can decide to use it either way (incremental or radical).

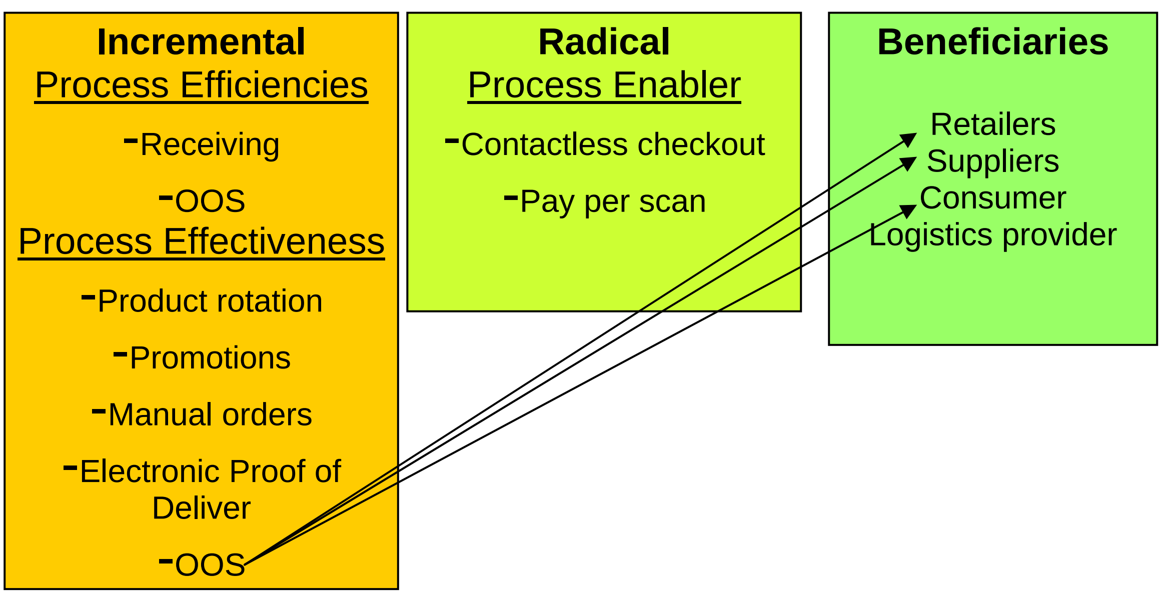

Figure 1: Wal-Mart's RFID Initiative in Perspective

Some examples are shown in Figure 1. First, as an incremental technology, RFID can be used to improve the efficiency and/or the effectiveness of existing processes. For example, early evidence suggests that RFID can reduce the amount of time to receive product at a warehouse (Katz, 2006). Instead of scanning each case of product individually with a barcode scanner, RFID tagged product can be read automatically at a dock door portal. Gillette reported a reduction from 20 seconds to 5 seconds in pallet receiving at their distribution center due to RFID (Katz, 2006). The process of receiving was not drastically changed (i.e., forklifts unloaded the product as before). The only change was eliminating the need to manually scan the product. Thus, the process became more efficient. Although not the focus of this study, the out of stocks process also became more efficient due to the use of the new automatic picklist as it eliminated the need to manually scan the shelves for out of stock situations (for those products that were RFID-enabled). RFID, in addition to making a process faster (i.e., efficient), can also improve the process. For example, RFID data can provide the visibility needed to know whether or not product is being rotated properly (using the first-in-first-out (FIFO) method, for example). This insight can, thus, help ensure proper rotation. Other examples include: (1) RFID has proven to be an effective tool for improving promotions (Collins, 2006; Murphy, 2005); (2) Wal-Mart has reduced the number of unnecessary manual orders by 10% (Sullivan, 2005); and (3) RFID can reduce the errors in receiving (in addition to increasing the speed of receiving as previously discussed) via the RFID-enabled process referred to as electronic proof-of-delivery (or ePod) (Electronic Proof of Delivery, 2006).

To date, most RFID efforts have been focused on its use as an incremental technology. However, it can be used as a radical or disruptive technology. For example, should RFID get to item level tagging, then the concept of ‘contactless checkout’ may become a reality. If it does, then the process of checkout will be radically changed. There has also been some discussion about RFID’s facilitation of pay-per-scan as a new method of inventory (whereby the retailer does not pay the supplier until the product is sold) (Sarma, 2006). Pay-per-scan would radically change existing inventory methods and the relationship between retailers and suppliers.

Now, put Wal-Mart’s RFID initiative (as it relates to OOS) in perspective: an incremental tool to improve the existing shelf replenishment process. Simply by using RFID reads on cases that have entered the backroom, Wal-Mart was able to modify their manual reactive picklist process such that it became proactive and automatic. With RFID, associates did not have to scan the shelves to determine out of stocks – the system did it for them – and with the assurance that the box will be in the backroom when they go to retrieve it. Wal-Mart put no extra emphasis on the process and did not change the way the associates did their job. An associate who only worked the picklist (i.e., did not create it) would not have noticed a change in the process – although they may have noticed the increased number of items and accuracy of the picklists! With this very minor improvement to the existing shelf replenishment process, Wal-Mart was able to reduce out of stocks by 30% for products selling between 0.1 and 15 units per day and, in doing so, provides benefits for the retailer, the suppliers, and consumers!

Conclusion

Our earlier work (Hardgrave, Waller, and Miller, 2005) provided initial insight into RFID’s effect on out of stocks across all products for all stores. As identified in

Table 1, there are many things that cause out of stocks and, in the previous paper, we did not try to control or account for these causes. In the current paper, we have taken a much closer look at the RFID effect and controlled for many variables known to affect out of stock (such as case pack size and shelf quantity). By investigating the out of stock reduction by sales velocity, we were able to gain new insight into the true RFID effect by number of units sold per day. The effect does vary by velocity category and, overall, for products selling between 0.1 and 15 units per day, RFID reduces out of stock by 30%.

This reduction came from simply using RFID data at the store level to incrementally make the shelf replenishment method more efficient. Will out of stocks ever be totally eliminated? Probably not, but RFID appears to substantially reduce OOS – something that has not happened in a very long time!

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