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Working Paper

Bringing Research to Retail℠

Northwestern Retail Analytics Council

Quantifiable Benefits and Analytical Application of RFID Data

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Platt Retail Institute (PRI) is an international consulting and research firm that focuses on the use of technology to impact the customer experience. PRI develops marketing and technology deployment strategies, supported by analytics, to build brands and increase sales. PRI clients include retailers, media companies, financial institutions, hardware and software companies, educational institutions, and other businesses. In addition to its global consulting expertise, PRI also publishes the quarterly *Journal of Retail Analytics* and other pioneering industry research.

To learn more about Platt Retail Institute, please visit www.plattretailinstitute.org.

Northwestern | Retail Analytics COUNCIL

The Retail Analytics Council (RAC) is the leading organization focused on the study of consumer shopping behavior across retail platforms to provide an understanding of how these impact retailers, particularly as new technologies are introduced. Established in August 2014, RAC is an initiative between Medill's Integrated Marketing Communications department, Northwestern University, and the Platt Retail Institute. The RAC unites industry, faculty, students, and its Advisory Board members for the study and exchange of ideas.

To learn more about the Retail Analytics Council, please visit rac.medill.northwestern.edu.

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About Avery Dennison

Avery Dennison RFID is a global leader in Radio Frequency Identification (RFID) enabled solutions, and is the world's largest UHF (Ultra High Frequency) partner. With more than 800 patents and applications, and with global manufacturing capabilities that have produced more than 7 billion RFID tags and labels, Avery Dennison has an industry-leading solution development team that supports customers from business case development to complete solution roll-out. Based in Westborough, Massachusetts, Avery Dennison RBIS, the parent company of Avery Dennison RFID, responsibly serves the global marketplace with operations in 50 countries across six continents.

Avery Dennison has partnered with Macy's to develop custom inlay solutions for tagging multiple product categories. Beginning in 2012, Avery Dennison executed a program where key categories (dress shirts, suit separates, denim, and soft home) of Macy's private label brands were tagged with branded, integrated EPC tickets. In 2016, the program expanded to encompass 100 percent of Macy's private label ready-to-wear families of business. EPC data is centrally managed through the tandem of an Avery Dennison local software application and a cloud database, ensuring data integrity. Related activities include:

- Partnered with Macy's to develop custom inlay and media solutions to meet the demands for new category enablement.
- Assisting brands in complying with Macy's EPC requirements by developing RFID media and data management solutions for tagging merchandise at factories and logistics centers.
- Developed Global EPC data management and integrated online ordering solution to ensure accuracy and visibility with RFID source tagging
- Macy's also uses Avery Dennison RFID media for in-store applications including tag-ups, returns tagging, and shoe department display auditing.
- Avery Dennison is the sole, mandated source of RFID media for tagging Macy's private label apparel and footwear brands, representing a significant portion of Macy's product assortment.

To learn more about Avery Dennison, please visit www.averydennison.com/RFID.

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About Tyco Retail Solutions

Tyco Retail Solutions is a leading provider of integrated retail performance and security solutions, deployed at more than 80 percent of the world's top 200 retailers. Customers range from single-store boutiques to global retail enterprises. Operating in more than 70 countries worldwide, Tyco Retail Solutions provides retailers with real-time visibility to their inventory and assets to improve operations, optimize profitability, and create memorable shopper experiences.

Tyco Retail Solutions (TRS) has been a long-time partner of Macy's, providing products and services since 1970 under the Sensormatic brand. Beginning in 2008, Tyco advised Macy's on the testing and implementation of a large-scale RFID deployment program that helped drive sales growth through improved inventory accuracy in replenishment categories. Since that time, and with the support of a TRS focused professional services group, Tyco has played an instrumental role in helping create new value in areas such as display execution, omni-channel fulfillment, back-to-front replenishment, and smart infrastructure.

The foundation of the Macy's RFID program is Tyco Retail Solutions' TrueVUE inventory intelligence software suite, which provides an end-to-end solution from tag commissioning to back-end system integration. TrueVUE software empowers the entire RFID platform, and is specifically designed to support in-store processes through the capture of Electronic Product Code (EPC) data on mobile devices and fixed readers, which in turn feeds configurable reports and enables improved inventory accuracy, omni-channel fulfillment, display execution, and many other applications. In addition to providing software, the TRS professional services team works closely with Macy's on overall program, implementation and execution, and creating new end-to-end applications and use cases.

To learn more about Tyco Retail Solutions, please visit www.tycoretailsolutions.com.

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About Zebra Technologies

With the unparalleled visibility Zebra (NASDAQ: ZBRA) provides, enterprises become as smart and connected as the world we live in. Real-time information – gleaned from visionary solutions including hardware, software, and services – gives organizations the competitive edge they need to simplify operations, know more about their businesses and customers, and empower their mobile workers to succeed in today's data-centric world.

Macy's initial goal when first launching its RFID program was to maintain an accurate inventory of the items replenished in their stores on a regular basis. This was a big challenge, because its inventory integrity was degrading month over month, and the manpower and time necessary to count and reset it accurately via barcode scanning would not have been practical or sustainable. Macy's adoption of RFID addressed this challenge, and Macy's RFID-enabled processes have since expanded, becoming foundational to its successes in omni-channel, buy online–pick up in-store, and pick to the last unit. The growth of this program relied on technology that provided Macy's a better way to count with less labor, more often, and with fewer errors and greater efficiencies.

Zebra Technologies provided solution expertise, as well as the hardware infrastructure to help them along this journey. Macy's selected Zebra's MC3190-Z Mobile RFID Reader as its RFID tool of choice. This mobile computer provides a high efficiency RFID reader engine that allows them to count 30 times faster than with traditional barcodes and scanners. Because of the speed of RFID-enabled data capture, Macy's can count far more often than its once-yearly traditional store count, maintaining inventory accuracy throughout the year. The Zebra mobile computer also offers a patented omnidirectional antenna that has the advantage of longer read range, while eliminating any concern about tag alignment. A key enabler for omni-channel success is the locationing feature of the Zebra device that allows Macy's to search for – and pinpoint – items in the store and backroom with such accuracy that it reduces the number of pick declines and improves the overall customer experience. Zebra's MC3190-Z mobile RFID reader provides both RFID-reading and barcode-scanning capabilities in a single unit that Macy's leverages across many use cases and continues to grow with as its RFID program matures.

To learn more about Zebra Technologies, please visit www.zebra.com.

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About RFID Sherpas

For over a decade, RFID Sherpas has played a central role within the retail industry providing "vendor neutral" guidance and other traditional management consulting services to a global base of retailers and brands. Its founders have led RFID consulting practices at Kurt Salmon, Capgemini and VeriSign. The firm supports clients at all stages of their RFID and omni-channel journeys with a mix of strategy, operations and technology consulting – from investigation to pilots to full rollouts across their enterprises. RFID Sherpas helps executives navigate the maze of choices and negotiate effectively with the selected technology partners. The firm has designed, launched, and managed a wide range of international programs involving a variety of merchandise categories at all points of the price spectrum. Often this includes the initiation of source tagging programs in offshore locations.

In recent years, RFID Sherpas has focused increasingly on the data produced by sensor systems and the positive implications for business processes and customer interactions. Several leading retailers have adopted its proprietary Execution Management methodologies.

To learn more about RFID Sherpas, please visit www.rfidsherpas.com.

Working Paper Supporting Organizations

About the Council of Supply Chain Management Professionals

Since 1963, the Council of Supply Chain Management Professionals (CSCMP) has been the leading worldwide professional association dedicated to education, research, and the advancement of the supply chain management profession. With more than 8,500 members globally, representing business, government, and academia from 62 countries, CSCMP members are the leading practitioners and authorities in the fields of logistics and supply chain management.

To learn more about CSCMP, please visit www.cscmp.org.

About RAIN RFID Alliance

The RAIN RFID Alliance is an organization founded in April 2014 to promote awareness, increase education, and support the universal adoption of UHF RFID technology. RAIN members use the EPC Gen2 UHF RFID specification, incorporated into the ISO/IEC 18000-63 standard. Membership in the Alliance is open to all companies that are involved in the technology.

To learn more about Rain RFID, please visit www.RAINRFID.org

I. Executive Summary

Executive Summary of Findings Related to Macy's RFID Program

This Working Paper analyzes historical data provided by Macy's related to its RFID program. RFID technology provides unprecedented visibility into the location of retail merchandise and, therefore, provides benefits that may include reduced inventory requirements, enhanced omni-channel fulfillment, influence sales, improved customer satisfaction, reduced markdowns and labor costs, as well as improved supply chain coordination. Macy's has been a pioneer in deploying RFID at the item level within retail. Our research is focused on four Use Cases:

- Display Audit.
- Inventory Accuracy.
- Single Unit Fulfillment.
- Back to Front.

Based upon an analysis of the data provided by Macy's, the following conclusions can be drawn:

1. The use of RFID has substantially improved the rate of display compliance, which drove overall customer satisfaction as measured by a Net Promoter Score.
2. Inventory accuracy, as measured by Gross Unit Variance, showed significant improvement because of the ability to conduct more regular cycle counts of RFID tagged items.
3. Making single merchandise units visible and available for sale as part of Macy's omni-channel program was found to be very beneficial. Test stores significantly outperformed the control stores in terms of fulfillment requests, units picked, and units sold. The data also shows that the ability to locate and sell RFID enabled merchandise is higher than for non-RFID enabled merchandise.
4. The data supports the finding that items placed on display (i.e. the sales floor) sell at a higher rate than those that are not displayed.

While Macy's did not provide material on point, we believe that RFID generates a rich source of information that can combined with other store level data to generate valuable operating insights that can aid retailers in the following areas: (a) demand forecasting and merchandise trends, (b) dynamic pricing, (c) fitting room utilization and conversion, (d) in-store marketing, and (e) merchandise placement.

To our knowledge, this is the most extensive set of data made available on the quantifiable attributes associated with RFID within a retail store. We would like to thank Macy's for their ground-breaking work with item level RFID and their participation in this study.

II. Introduction

At the most elementary level, a retailer effectuates an arbitrage between a customer and merchandise. Therefore, gathering and parsing as much information as possible about customers, products, and their interactions can yield valuable business insights. Item-level RFID data is arguably the single-most-important merchandise-related information available to help a retailer further its intended role as a customer/product intermediary.

The purpose of this Working Paper is two-fold. The first objective is to present detailed findings related to the use of RFID. While many excellent studies have been published about RFID as a facilitator of supply chain management, we are not aware of any prior research that considers as extensive an amount of data being made available to an outside independent firm for analysis and publication by a retailer. As a result, this Working Paper provides findings that complement the existing literature by offering detailed insights into the quantifiable attributes associated with RFID.[1] The second objective is to demonstrate how RFID-generated data can be integrated with other information to provide additional retail business insights.

RFID technology has existed for some time. Historically, impediments to RFID adoption have been "high costs," and that RFID tags "generate more data than can be efficiently processed … [as] (m)ost retailers are not capable of transmitting, storing, and processing the data that would be available."[2] The maturing of the technology, along with the reduced cost associated with its implementation and the ability to process large amounts of information, has led to increased retail adoption.[3] In addition, an acknowledgement of the technology's many benefits, and the recognition by store-based retailers of the need to develop intelligent digital stores as part of establishing an integrated omni-channel customer experience, is fueling implementation.

RFID is a technology whereby merchandise information is imbedded into a tag that is captured by a reader that records this information.[4] This information, in turn, is captured from a distance by means of radio waves. The principal advantage of RFID tags versus traditional bar codes is that they can hold more information about the product (such as price, size, color, and location), thus enabling accurate, and in some cases real-time tracking. In addition, the time required to collect information is much faster and more accurate than traditional bar code scanning.

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[1] It was noted, in the past, for example, that "Industry reports and white papers are now filled with estimates and proclamations … there is a huge credibility gap of the value of RFID, and that a void exists in showing how the proclaimed values are arrived at, and how those values can be realized." Unlocking the Value of RFID," *Production and Operations Management*, 2007.

[2] "Retailing Management," 8th Edition, *McGraw-Hill Irwin*, 2012.

[3] A recent survey conducted by GS1 U.S. finds, for example, that an average of 47 percent of items received by apparel and general merchandise retailers have RFID tags, that 57 percent of retailers are currently implementing RFID, 19 percent plan to implement within a year, and 10 percent plan to implement within two years. Likewise, IDTechEx estimates that the global RFID market (for tags, interrogators, systems, services, networking, and software) will reach $13.9 billion in 2016, and grow at 17.0 percent CAGR through 2018.

[4] For purposes of this Working Paper, we will only be addressing passive RFID tags that are powered by a nearby transmitter and are applied at the individual SKU level. Compare this to active RFID tags, which have their own power source that allows for data collection and transmission.

This technology provides unprecedented visibility[5] into the location of retail merchandise and, therefore, provides benefits that may include reduced inventory requirements, enhanced omni-channel fulfillment, influence sales, improved customer satisfaction, reduced markdowns and labor costs, as well as improved supply chain coordination.[6]

Macy's RFID Use Cases

Department store chain Macy's has provided the primary data upon which our research relies. Our insights into the quantifiable attributes associated with RFID are presented in a series of four Macy's RFID Use Cases. A summary of the findings from each Use Case presented in this research follows:

Use Case #1: Display Audit

1. Display Compliance: The use of RFID has substantially improved the rate of display compliance. The rate of items not being displayed was found to be in the 4 to 6 percent range, versus a self-reported rate of 30 percent prior to the implementation of RFID.
2. Customer Satisfaction: Overall customer satisfaction, as well as the customers' ability to "find all items," improved at a faster rate for the Women's Shoe Department (WSD) than Macy's stores as a whole. This may be attributable, in part, to improved display compliance rates, as well as the fact that store associates are spending more time with customers and less time taking inventories.
3. Sales and Markdown Indications: Based on the limited data provided, a definitive link between the use of RFID and unit sales and markdowns in the WSD cannot be established. However, there is an indication that 1 percent more sales were made at full price, and 2.6 percent more sales were made at full price and after the first markdown during the post-RFID deployment period than for the comparable non-deployment period.

Use Case #2: Inventory Accuracy

1. Gross Unit Variance (GUV): The RFID-enabled brand was found to have lower year-end GUVs than both tested, non-RFID enabled brands. The tests further demonstrate that the GUV accumulates at a 4 to 5 percent monthly rate when monthly cycle counts of the RFID-enabled brand were not taken. When monthly cycle counts of the RFID-tested brand occurred, the GUV is maintained in a 2 to 4.5 percent range.
2. Markdown: While many other factors may be at work, the data tends to support the proposition that better inventory accuracy can lead to fewer markdowns because better buying decisions are being made.

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[5] "RFID for Better Supply-Chain Management through Enhanced Information Visibility," *Production and Operations Management*, 2007.

[6] "Unlocking the Value of RFID," *Production and Operations Management*, 2007.

Use Case #3: Single Unit Fulfillment

1. Making single merchandise units visible and available for sale via RFID was found to be beneficial. In a series of test and control studies, it was determined that the test stores significantly outperformed the control stores in terms of fulfillment requests, units picked, and units sold. A related finding is that this could also lead to transportation cost savings.
2. Testing over a five-month period also found that the ability to locate and sell RFID-enabled merchandise is 6.1 percent higher than for non-RFID enabled merchandise. Stated another way, the ability to fill orders of RFID-enabled merchandise is more efficient than that of non-enabled merchandise. Testing of the sale of congruent and non-congruent merchandise found that the RFID-tagged merchandise fill rates outperform the non-RFID-tagged merchandise by approximately 3 percent.

Use Case #4: Back to Front (BTF)

1. There is a strong correlation between sales and units picked. The data supports the finding that items placed on display sell at a higher rate than those that are not displayed.
2. The data also supports the conclusion that items picked and put on display that have not sold during the year sell at a higher rate than those that are not.
3. Sales by Merchandise Category: Sales of units put on display outperform those that are not found (i.e., not displayed) in all categories considered. In addition, the impact of BTF on sales among categories varies.

Integrated Analytical Applications

In this section, we illustrate additional applications that incorporate the use of RFID data, which is a rich source of retail information. The following applications are discussed, and models presented, that incorporate RFID data, in combination with other data sets, to produce additional retail intelligence. These are:

1. Demand forecasting and merchandise trends.
2. Dynamic pricing.
3. Fitting room utilization and conversion.
4. In-store marketing.
5. Merchandise placement.

Ascertaining the cost of implementing a technology such as RFID is relatively uncomplicated. The benefits of this technology, on the other hand, can be harder to quantify. To help understand the quantifiable benefits of RFID, we present here four separate Use Cases based on data supplied by Macy's. Each Use Case begins with background information, addresses the test objectives, and details the results.[7]

[7] Macy's provided all primary data relied upon for this research. Additional testing, that may have been desirable, was limited in certain instances because of a lack of applicable data.

III. Macy's RFID Use Cases

A. Use Case #1: Display Audit

The challenges associated with managing display compliance in the Women's Shoe Department (WSD) at Macy's is formidable. For example, during 2016, Macy's carried more than 250,000 SKUs of women's shoes. A typical Macy's Women's Shoe Department will carry 800 shoe styles (with a larger store carrying from 2,000 to 4,500 styles). With this volume of shoes, management estimated that some 30 percent of samples were missing from the sales floor on a consistent basis. This occurred for various reasons, including:

- The sample shoe was sold and not replaced with another sample of the same style.
- Sample shoes were re-boxed, rather than remaining on display, and returned to inventory.
- New arrivals, which are processed in the stockroom, never made it to the sales floor.
- The sample shoe was stolen from the sales floor.
- The stockroom and sales floor were not maintained in compliance with store operating procedures.
- Department staff had to manually scan bar codes to ensure that all shoe styles were displayed. This task took three to four hours per store, thus such assessments were generally limited to two times per week.

Macy's felt that by ensuring that all styles were in view of its customers (i.e., if display compliance was increased), that various benefits could be realized. These include:

- By ensuring more inventory is represented on the sales floor, sales could be positively impacted.
- Customer service and satisfaction could be positively impacted due to the presentation of all available styles on the sales floor.
- Markdowns could be reduced, as more inventory was being displayed and thus in view of customers wanting to make a purchase.
- Merchants rely on display compliance data to aid in buying and store allocation decisions.

The desire to reduce the rate of missing display styles, and to realize the noted benefits, were major considerations that impacted Macy's decision to pilot, and ultimately adopt, RFID systemwide in its WSD. The principal operating consideration was that with RFID, the incidence of department audits could be increased to five times versus two times per week (as was the case using bar code scanning),[8] and that the time involved would only take from 45 to 60 minutes versus three to four hours per occurrence (again with the use of bar code scanning), thus positively impacting display compliance.

Macy's began examining deploying RFID in the WSD in 2010. In 2011, it was piloted at three locations. These included stores in Columbia, MD, Bridgewater, NJ, and Arlington, VA. Satisfied with the test results, extensive deployment planning occurred during 2012, with systemwide deployment occurring in August 2012.

Three studies, as detailed below, were undertaken from the data that was made available by Macy's. Summary findings are as follows:

1. Display Compliance: The use of RFID has substantially improved the rate of display compliance. From the data provided, the rate of items not being displayed was found to be in the 4 to 6 percent range, versus a self-reported rate of 30 percent prior to the implementation of RFID.

[8] Bar code scans are processed at 300 units per hour, versus 5,000 units per hour using RFID scans.

2. Customer Satisfaction: Overall customer satisfaction, as well as the customers' ability to "find all items," improved at a faster rate for the WSD than Macy's stores. This may be attributed, in part, to improved display compliance rates, as well as the fact that store associates are spending more time with customers and less time taking inventories.
3. Sales and Markdown Indications: Based on the limited data provided, a definitive link between the use of RFID and unit sales and markdowns in the WSD cannot be established. This is because sales and markdowns can be impacted by many variables that could not be accounted for here. However, there is an indication that one percent more sales were made at full price, and 2.6 percent more sales were made at full price and after the first markdown during the post-RFID deployment period than for the comparable non-deployment period.

Display Compliance

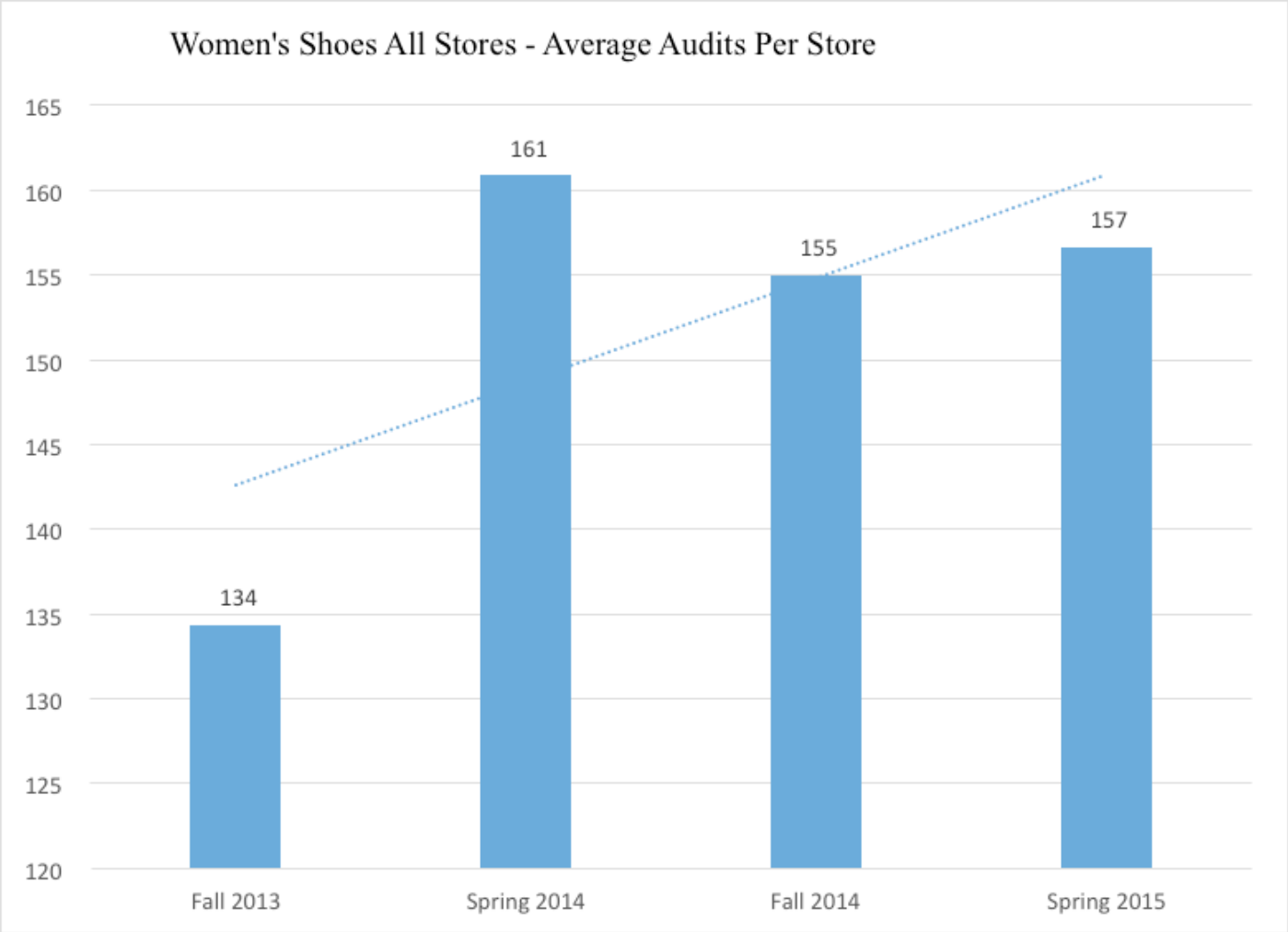
The test objective was to ascertain changes in display compliance from the date of RFID systemwide deployment.[9]

Historically, as noted above, physical audits were limited to approximately two per week or 48 per season, on average, prior to RFID deployment.

[9] The data presented here encompasses all Macy's stores beginning in the fall of 2013.

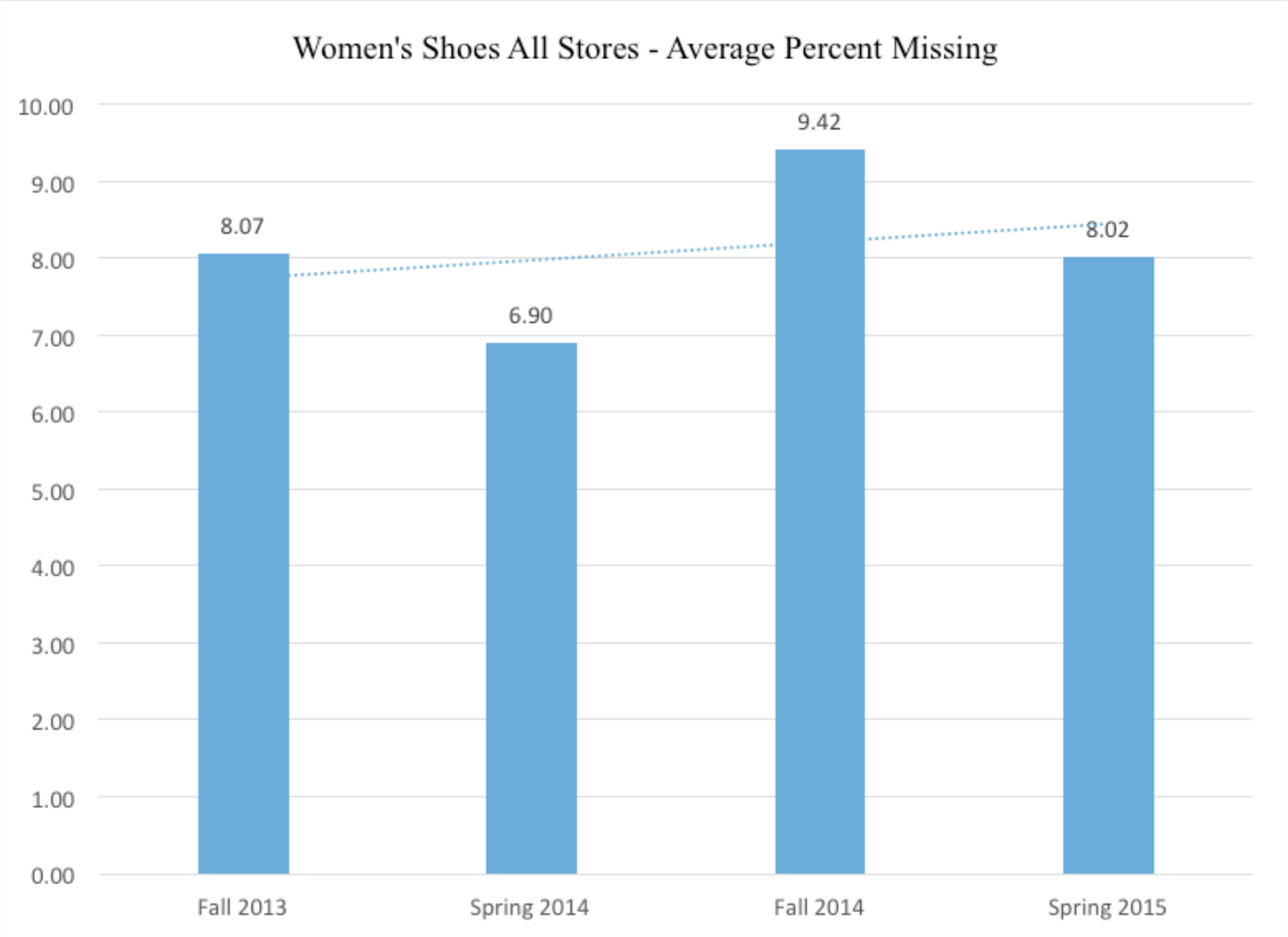
As UC #1-Chart 1 indicates, during the system wide deployment beginning in the fall of 2012, the audit rate increased to an average of 134 per store during the season. As deployment penetrated and became more operationalized, the audit rate continued to increase, and has remained relatively consistent. As a general statement, the more audits that are conducted, the higher the likelihood for improved compliance. However, beyond a certain level, the benefits of increased audits begin to diminish.

UC #1-Chart 1.



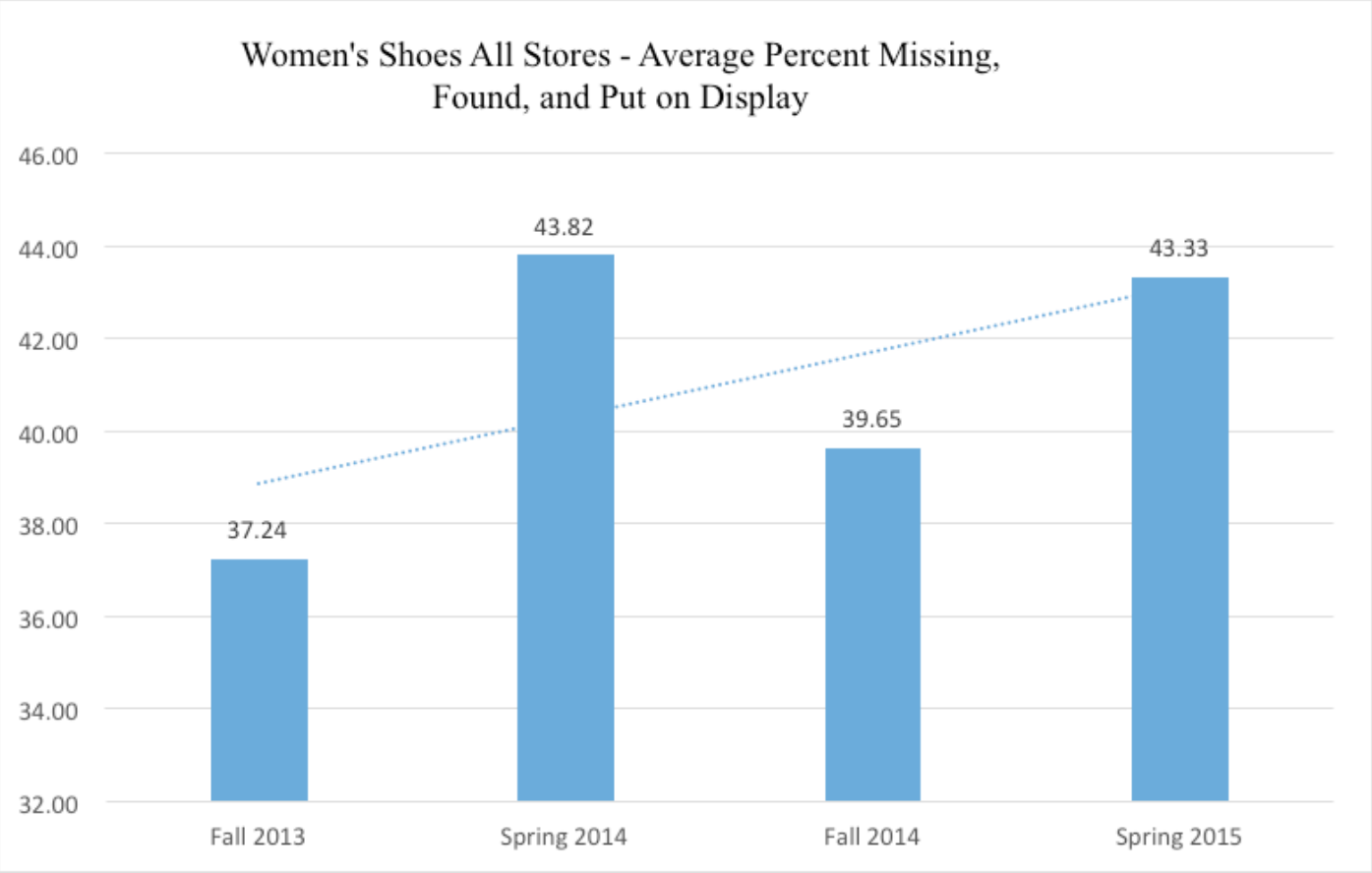
UC #1-Chart 2 illustrates that the average styles missing (those that are not being displayed) is generally in the 7 to 9 percent range following the initial compliance audit. This result is itself a vast improvement over the self-reported 30 percent missing rate prior to the RFID deployment. Keep in mind that further efforts are then undertaken, with reliance on the RFID technology, as discussed below in UC #1-Chart 3, to find and ticket (put on display) as many of the remaining missing items as possible to further improve the display rate.

UC #1-Chart 2.



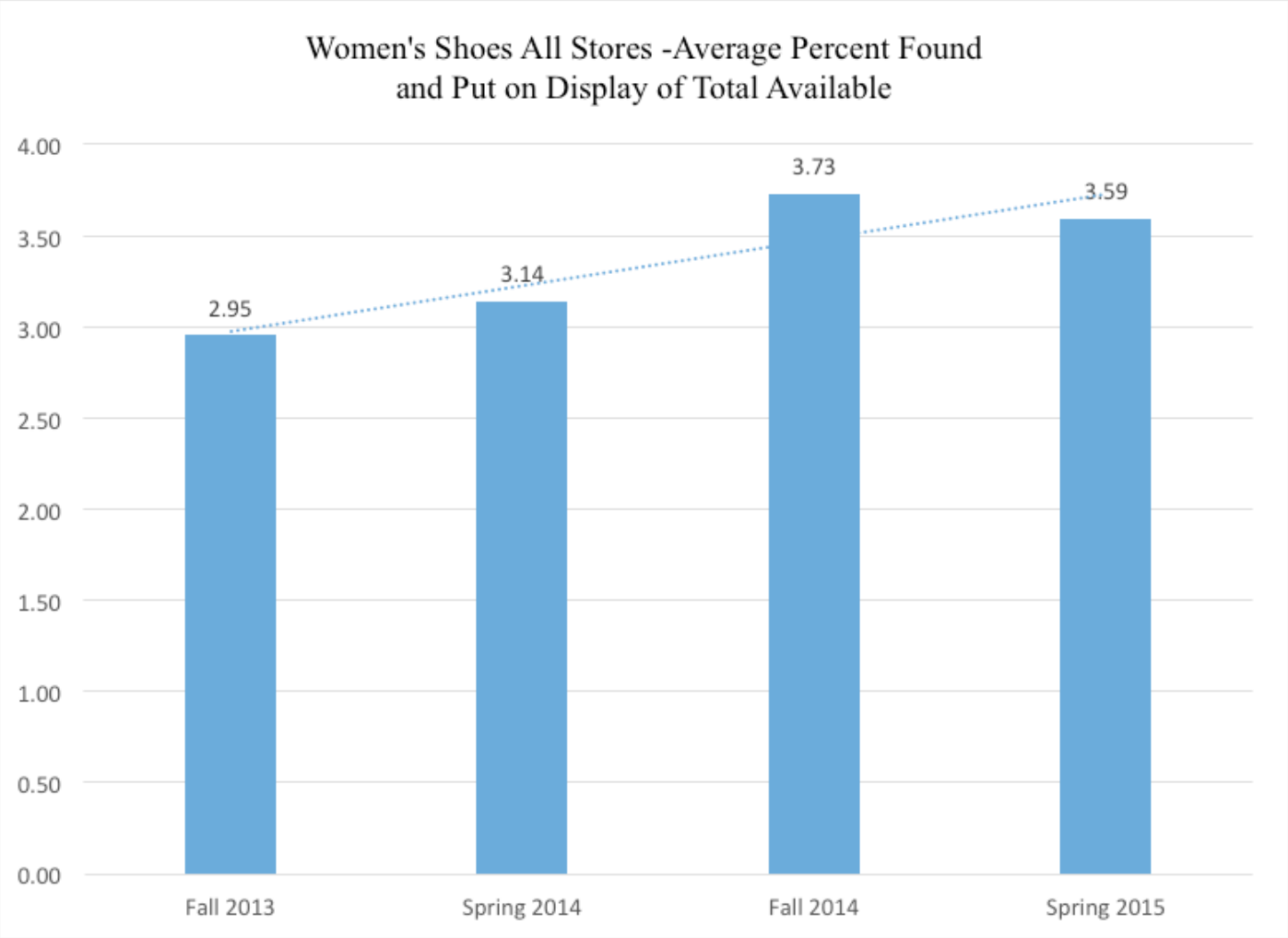
The following UC #1-Chart 3 illustrates the average percent ticketed. This refers to the percentage of those SKUs that were initially determined to be missing from the sales area (7 to 9 percent; see UC #1-Chart 2), and were subsequently found and put on display. Generally, this is in the 37 to 44 percent range. Stated another way, of the 7 to 9 percent initially not on display, 37 to 44 percent of those were later located and presented to customers.

UC #1-Chart 3.



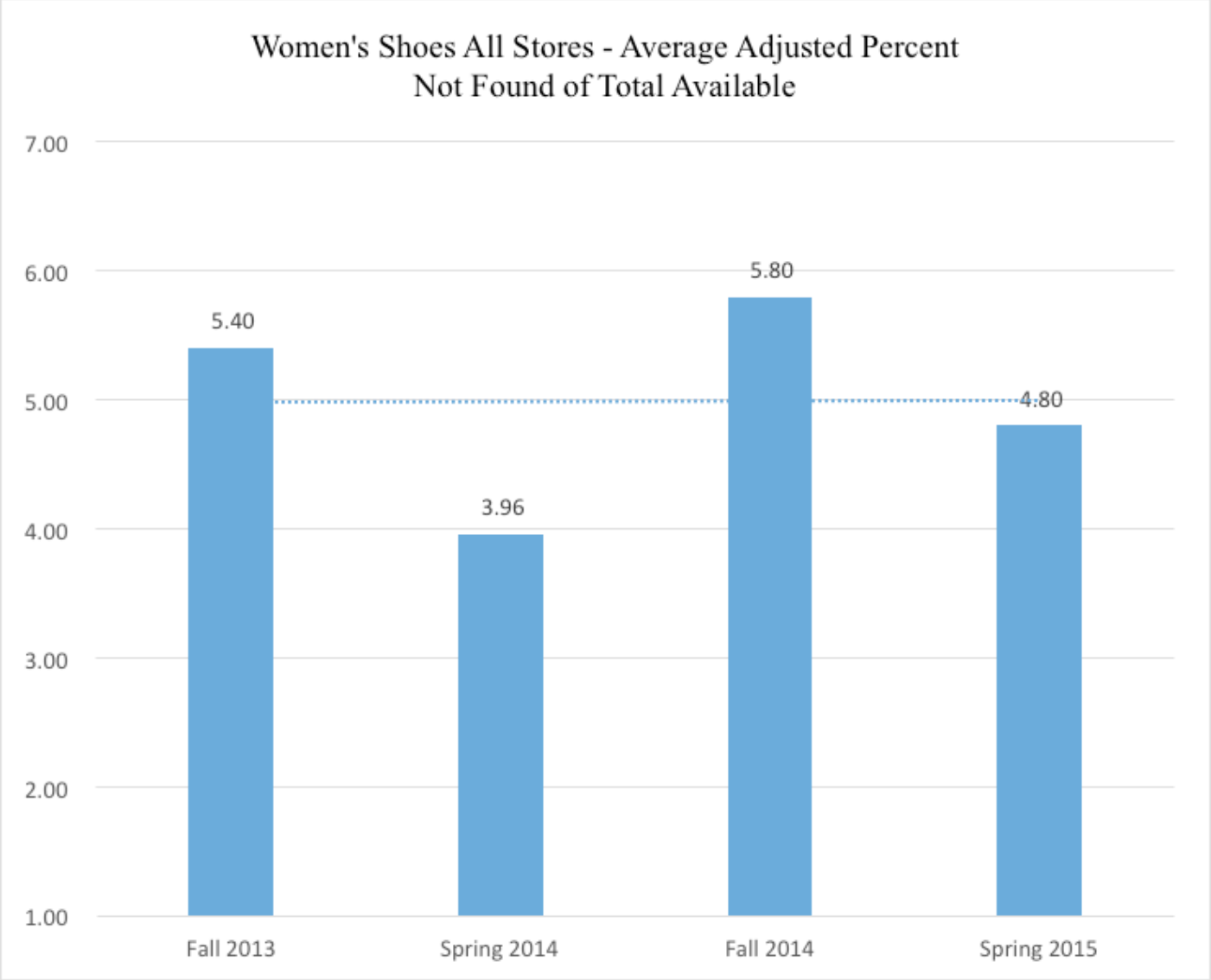
UC #1-Chart #4 illustrates the percentage of shoes found and later ticketed (put on display) as a percentage of the total available. (This is similar to the presentation in UC #1-Chart 3 in that it considers the units that were initially determined to be missing from the sales area that were subsequently found and put on display.) This shows that over time, the ability of sales associates to find and then display missing shoes is generally improving due to the ability to locate missing items using RFID technology.

UC #1-Chart 4.



The following UC #1-Chart 5 illustrates the average adjusted percentage of missing shoes not found (net of those found and displayed after RFID audit). Generally, this is in the 4 to 6 percent range. While this rate varies from period to period, it is again a vast improvement over the self-reported non-displayed rate prior to RFID deployment.

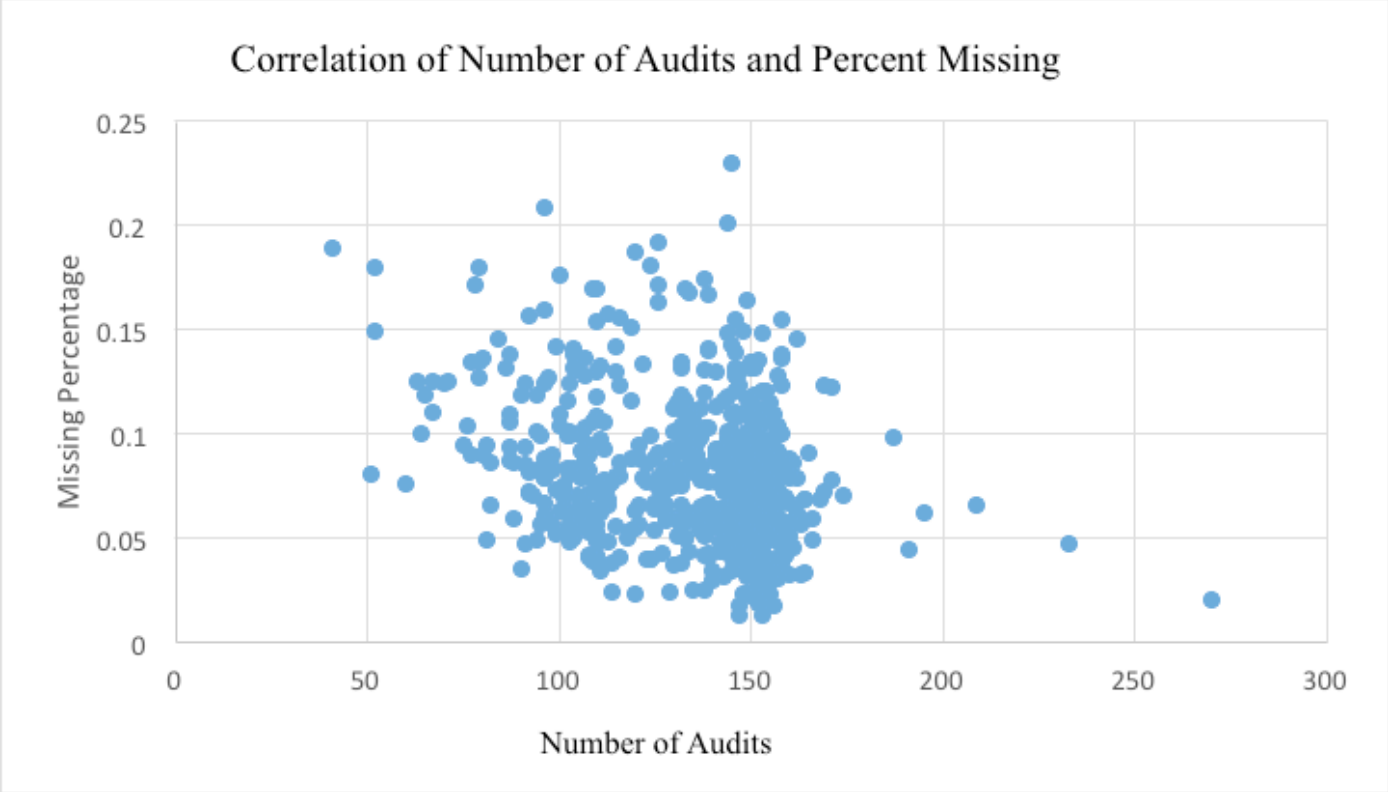
UC #1-Chart 5.



A series of tests also were undertaken to ascertain the relationship between the number of display audits conducted and their impact on determining the percentage of styles missing; percentage of styles missing, found, and put on display; and percentage not found. In other words, we wanted to understand the minimum number of audits required, and then determine at what point more audits failed to generate a return. As UC #1-Chart 1 above illustrates, the firm conducts approximately 150 audits per season.

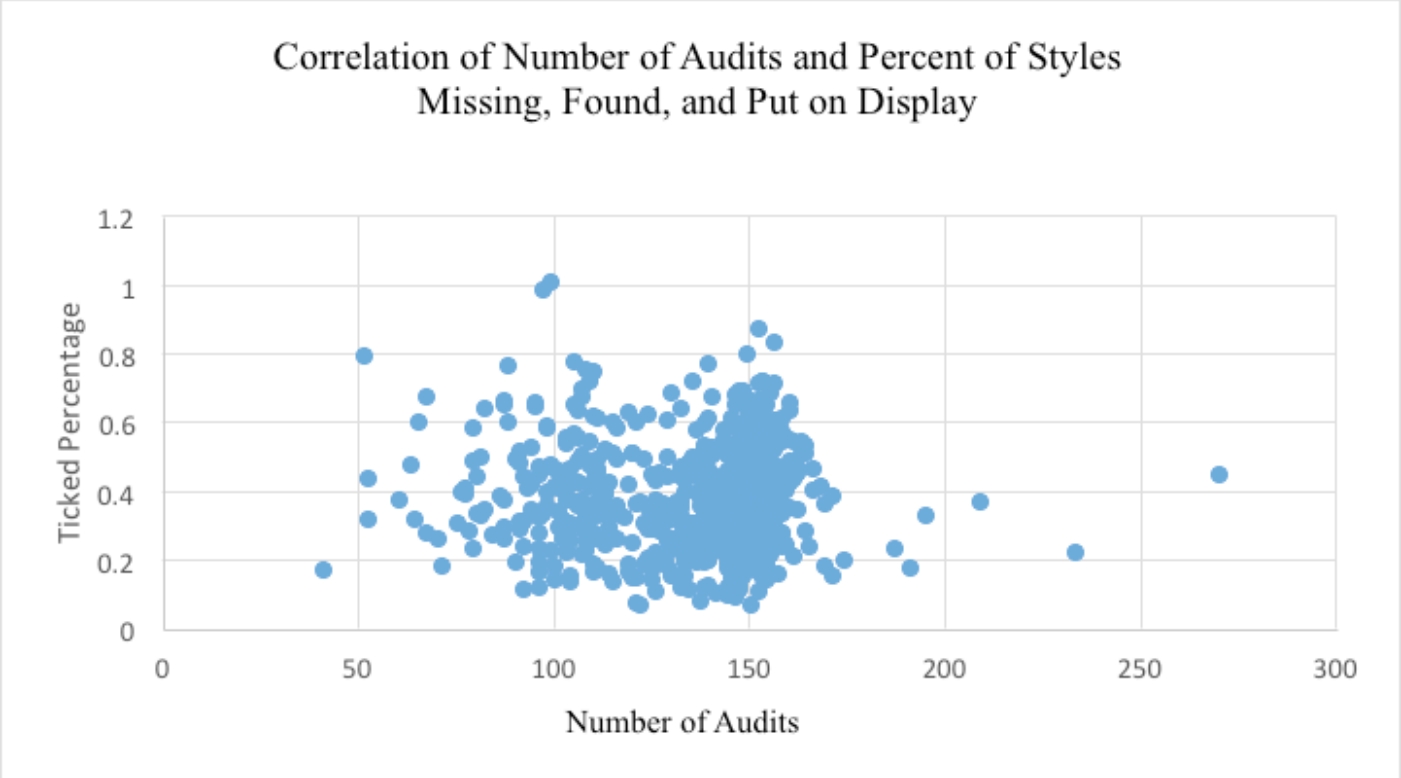
The findings in UC #1-Chart 6 demonstrate that approximately 125 to 150 audits per season is the appropriate number of audits. That is, with fewer than 125 audits, the results deteriorate (indicated by the number of blue dots increasing, indicating the missing percentage starts to increase), whereas conducting more than 150 audits does not increase accuracy (indicated by the number of blue dots decreasing, indicating the missing percentage starts to decrease).

UC #1-Chart 6.



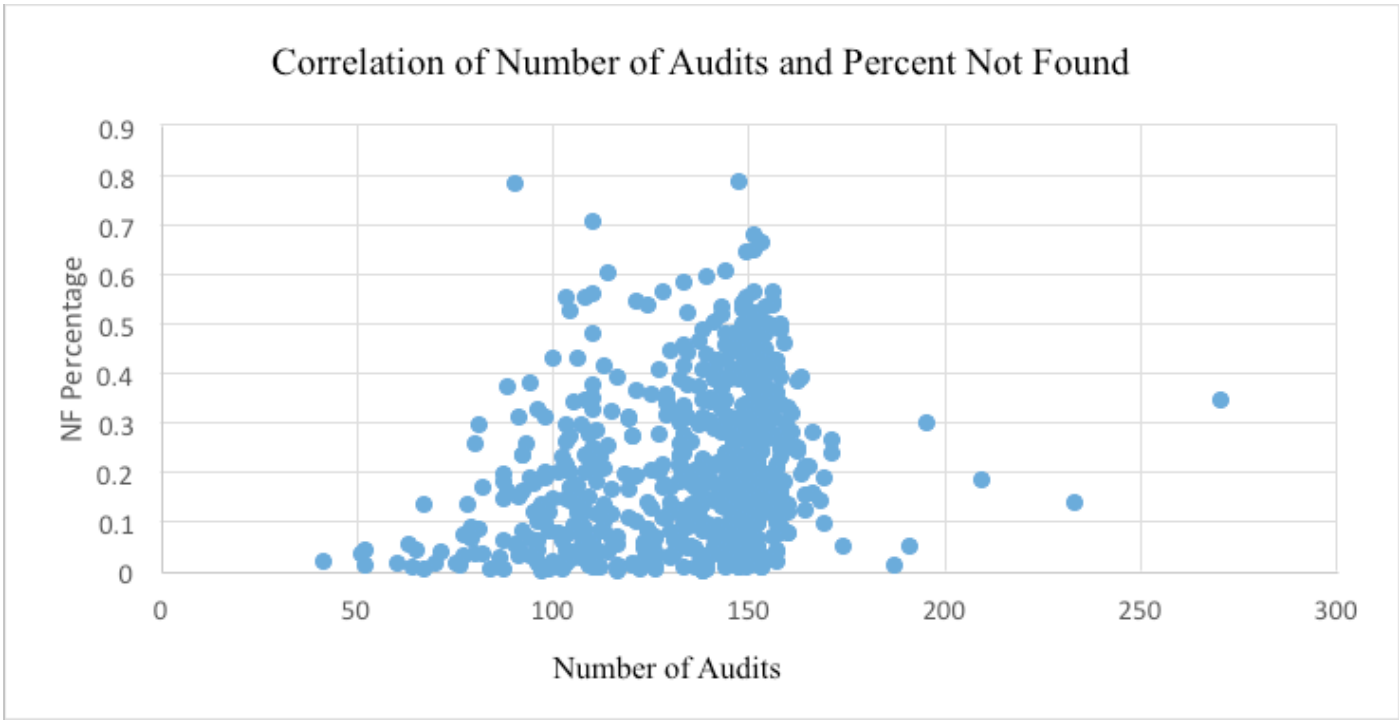
A similar observation is made when the percentage of styles missing, found, and put on display is considered (see UC #1-Chart 7).

UC #1-Chart 7.



When the percentage not found is considered (as illustrated in the upward and downward slope in UC #1-Chart 8), the 150 audit per season level again appears to be the optimal number, as the not-found percentage decreases if fewer audits are undertaken, and conducting more audits does not enhance detection.

UC #1-Chart 8.



Customer Satisfaction

Customer satisfaction surveys during fiscal 2013 and 2014 were distributed daily by email to various shoppers in 660 stores within 24 to 48 hours of a visit. The survey itself allows the customer to select and rate a Macy's store's overall performance, as well as various departments, i.e., women's shoes, home goods, etc. Four broad categories of questions are presented including price and value, product selection, shopping environment, and customer service. The survey results are presented as a net promoter score (NPS).[10] Various questions are also related to specific departments. In the WSD these include, among others, asking if the shoe clearance area was neat and organized, whether shoes were retrieved in a reasonable time, etc.[11]

From the survey conducted by Macy's, we compared overall customer satisfaction for the Stores versus the WSD (as indicated by the NPS). We also considered customer sentiment regarding the Store versus the WSD in response to the customers indicated ability to "find all items."[12]

Customer Satisfaction: Macy's Stores versus WSD

Macy's stores' NPS, as an indicator of customer satisfaction, increased from 100.3 to 101.2 (0.9) between fiscal 2013 and 2014.[13] During the same period, the overall NPS in the WSD rose from 103.8 to 105.5 (1.7),

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[10] Net Promoter Score is an index that measures the willingness of customers to recommend a company. It is a method to gauge customer satisfaction and loyalty.

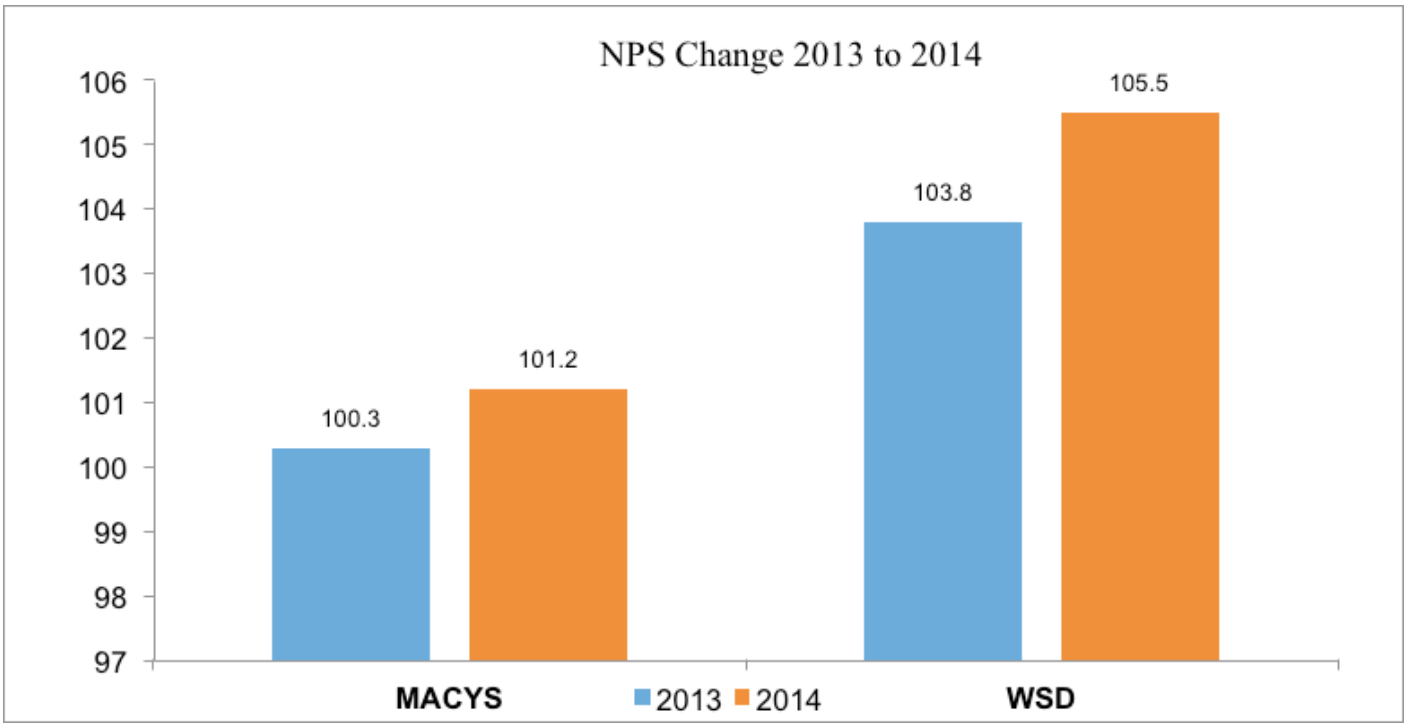
[11] WSD individual survey sample size (n) ranged from 188 to 533.

[12] The specific question asked regarding the WSD is: "easy to find shoes I am looking for."

[13] The actual NPS scores differ from those presented, but the changes shown are consistent with the actual reported scoring.

as seen in UC #1-Chart 9. This 1.7 increase in customer satisfaction in the WSD versus the Stores overall may be attributable, in part, to the RFID implementation (which facilitated increased display compliance and more store associate availability).

UC #1-Chart 9.

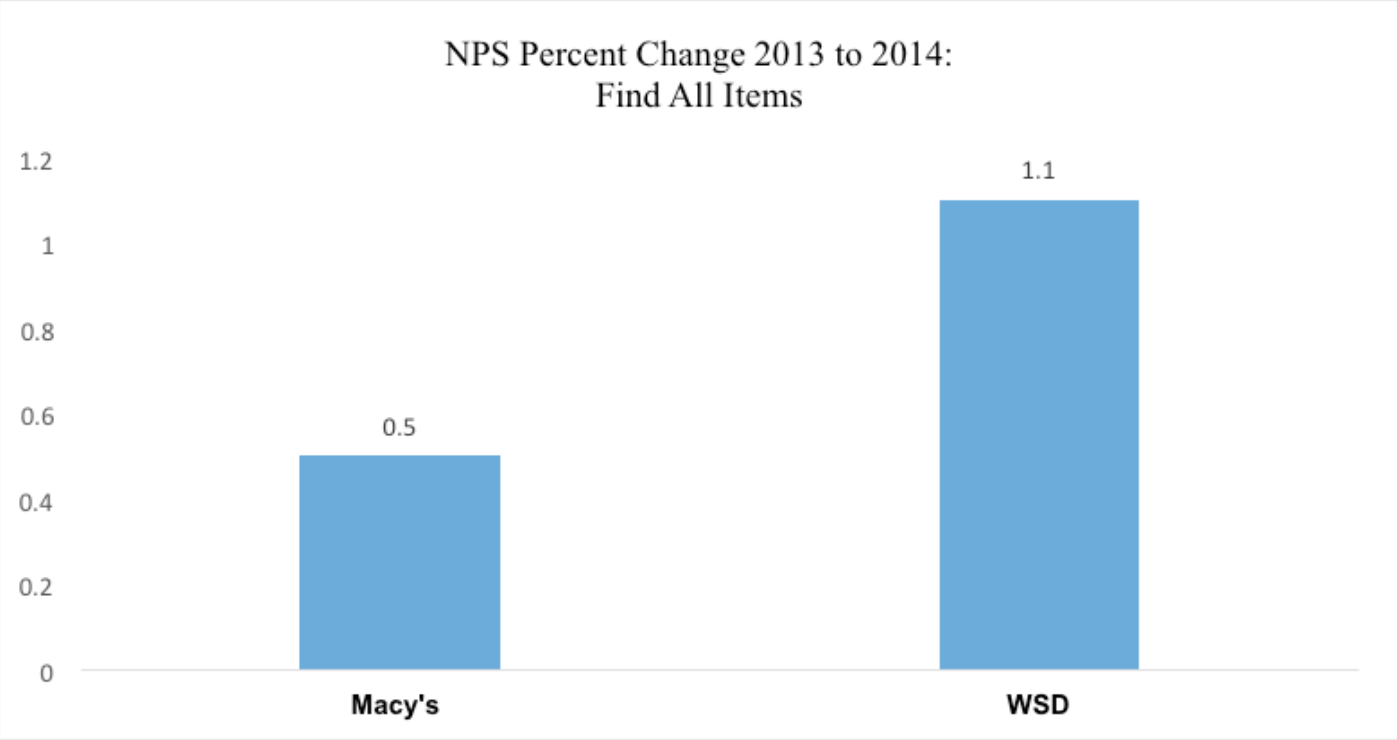


Note: WSD scores are directional, as customers typically shop in three departments on a given shopping trip.

Ability to Find Items: Macy's Stores versus WSD.

Macy's stores' overall score relating to the percent of respondent's ability to "find all items" in the store, as an indicator of customer satisfaction, increased from 108.1 percent to 108.6 percent (0.5 percent) between fiscal 2013 and 2014.[14] During the same period, the percentage of respondents surveyed reported that their ability to "find all items" in the WSD rose from 107.2 percent to 108.3 percent (1.1 percent), as seen in UC #1-Chart 10).[15] This improved performance in the customers' ability to find all items in the WSD versus the Stores overall may again be due to the increase in display compliance realized through the RFID implementation.

UC #1-Chart 10.



Note: WSD scores are directional, as customers typically shop in three departments on a given shopping trip.

[14] The actual NPS scores differ from those presented, but the changes shown are consistent with the actual reported scoring.
[15] We assume that an improvement in customers' ability to find the shoes that they are looking for is attributable, at least in part, to increased display audit compliance.

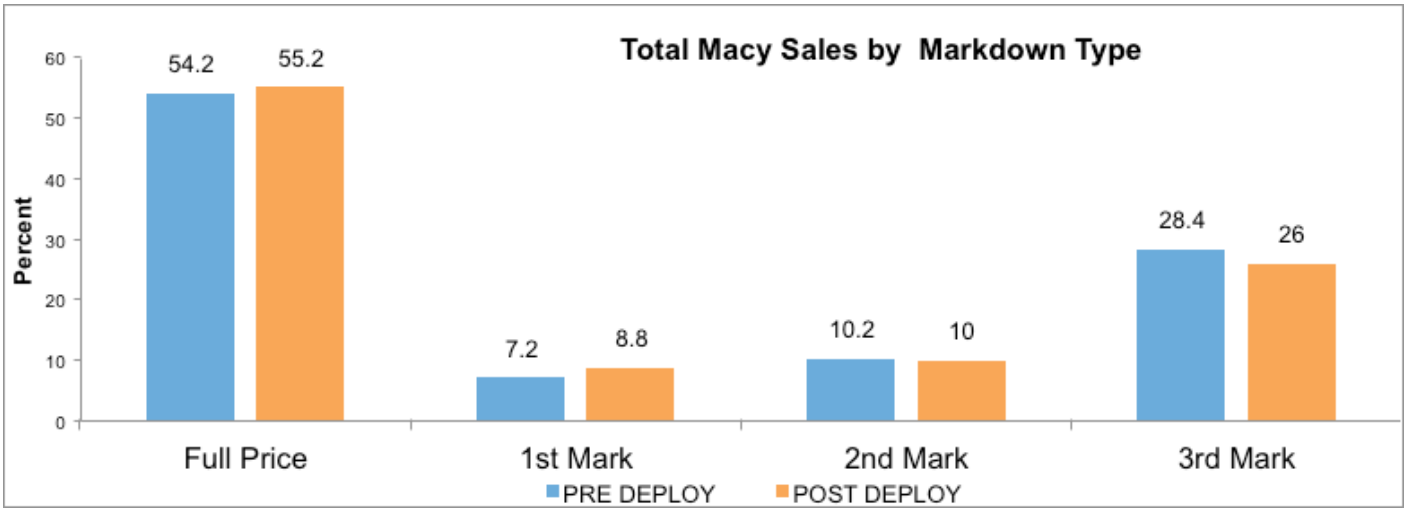
Sales and Markdown Indications

Here we considered whether increased display compliance could have an impact on sales and the number of markdowns. Due to the existence of many variables that could not be accounted for, these results should be considered as indicative of a trend, rather than as a conclusion.[16]

Data provided was from the pre-and post RFID deployment periods for all stores. The pre-deployment period included eight months, from January 2012 to August 2012. The post-deployment period was also for eight months, from January 2013 to August 2013. This insured that part of the holiday period was included in the results, and also allowed for a period for the stores to adapt to implementing the technology (August 2012 to December 2012).

As UC #1-Chart 11 illustrates, 1 percent more units were sold in the post-RFID deployment period at full price than during the pre-deployment period, while 2.6 percent more units were sold in the post-RFID deployment period at full price and after the first markdown than during the pre-deployment period. In the post-RFID deployment period, 2.6 percent fewer units were sold after the second and third markdown than during the pre-deployment period.

UC #1-Chart 11 Pre- and Post-RFID Sales and Markdown Comparison Illustration.



[16] Based on the data made available, a link between the use of RFID and unit sales and markdowns in the WSD could not be undertaken in this research. This is because both unit sales and markdowns can be impacted by many variables that could not be accounted for here. These can include, for example, the economy, weather, fashion trends, the ability of merchandisers to select in-demand products, etc. It is noteworthy that Macy's internal testing has found a +2 percent annualized sales increase due to the improved rate of display.

B. Use Case #2: Inventory Accuracy.

The Men's Department at Macy's consists of eight divisions. The two considered for this research will carry, on average, some 297,666 SKUs, representing some 10 million units.[17] Historically, it was estimated that Gross Unit Variance (GUV) in the typical men's department increased from two to five percent per month, resulting in a 20-30 percent distortion annually.[18]
These variances occur for various reasons, including:

- Misplaced, stolen, or damaged merchandise.
- Vendor and/or associate error.
- A physical inventory occurs only once per year in January (excluding various cycle counts that may be undertaken).

The Company felt that by implementing RFID and moving toward monthly cycle counts (which could be implemented due to the technology's speed in physically counting inventory), it could improve its operations during the year and realize various benefits including:

- Improve omni-channel fulfillment due to the enhanced ability to locate desired merchandise.
- Ensure that all merchandise is represented on the sales floor.
- Improve customer satisfaction, as today's "consumer wants when and where she wants."
- Reduce out-of-stock positions due to more accurate reorder points.
- Reduce markdowns.
- Positively impact sales.[19]
- Reduce inventory investment.

The data considered was from eight New Jersey stores. Three brands were examined. Brand #1 and Brand #2 were not enabled with RFID at the eight stores; Brand #3 product was RFID-enabled during the periods considered in the following research.

Based on the data that was made available by Macy's, two studies, as detailed below, were undertaken. The summary findings are as follows:

1. Gross Unit Variance (GUV): We compared the GUV of an RFID-enabled brand versus two non-RFID-enabled brands. At the end of each year, the RFID-enabled Brand #3 was found to have a lower GUV (19 percent less in 2013, 17 percent less in 2014, and 24 percent less in 2015 than Brand #1; and 7 percent less in 2013, 6 percent less in 2014, and 7 percent less in 2015 than Brand #2). The tests further demonstrate that the GUV accumulates at a 4 to 5 percent monthly rate when monthly cycle counts of the RFID-enabled brand were not taken. When monthly cycle counts of the RFID-tested brand occurred, the GUV is maintained in a 2 to 4.5 percent range.
2. Markdown: While many other factors may be at work, the data tends to support the proposition that better inventory accuracy can lead to fewer markdowns because better buying decisions are being made.

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[17] These are known as Collections (Brands #1 and #2) and Millennial (Brand #3).
[18] Gross unit variance refers to the difference between merchandise that is on hand in the store, as compared to what is shown in the inventory record as being available. A variance of zero would indicate, for example, that both the on-hand and record inventory were the same. As an example, assume that the inventory record indicates 5,147 total SKUs of men's pants are available in a store. A physical count finds 255 individual SKUs more than in the record were found (over), and 175 individual SKUs fewer then indicated in the record were found (under). The total department GUV is thus calculated as 255+175/5,147 or 8 percent.

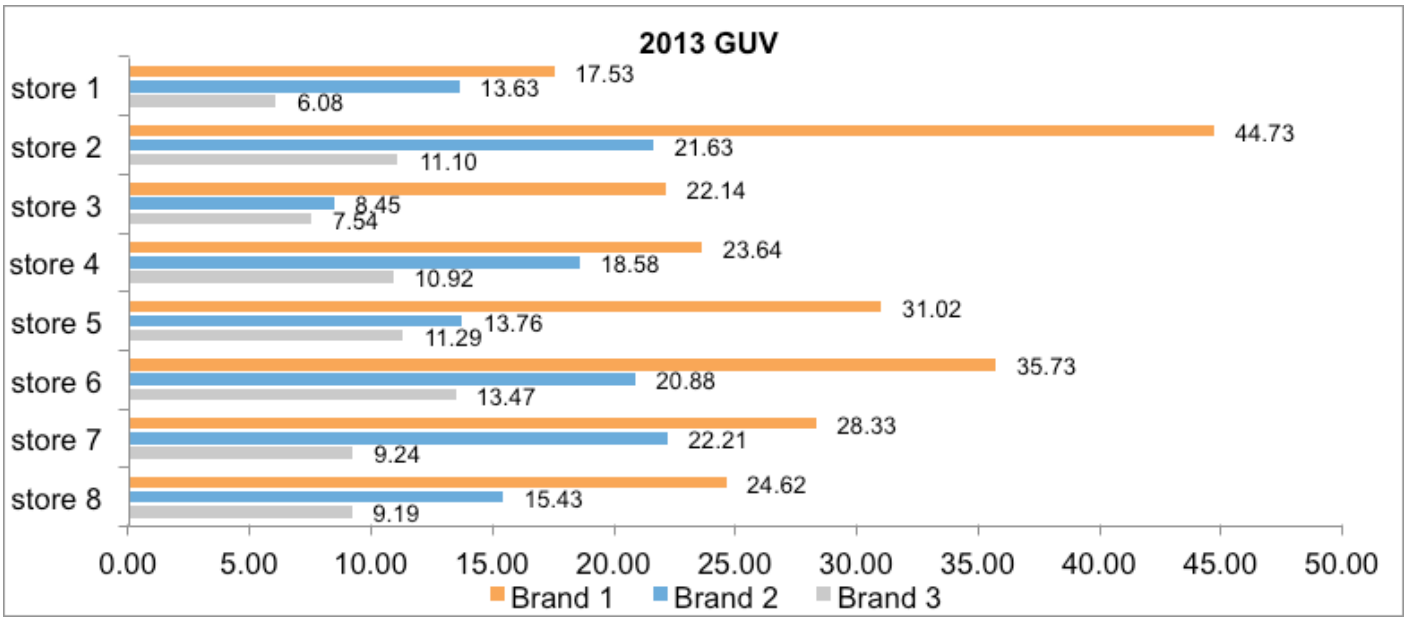
[19] We could not test here whether a relationship between the use of RFID to increase inventory accuracy and unit sales could be established due to a lack of test and control data.

Gross Unit Variance

To gauge the impact of RFID on inventory accuracy, the following tests were conducted.[20] It is important to note that this information presents both year-end (UC #2-Charts 1-8) and month-to-month data (UC #2-Charts 9-11). The year-end GUV results reflect the fact that cycle counts are not undertaken every month during the year, thus the year-end GUV was found to be greater than when monthly cycle counts are undertaken.

UC #2-Chart 1 is a comparison, by brand by store, of the year-end inventory GUV for fiscal 2013. Note that RFID was fully deployed during the year to all Brand #3's products, but not to the two other brands. It is also noteworthy that monthly cycle counts of Brand #3's products were undertaken for the majority, but not all of months during this time. From this cycle count information, purchasing decisions were made (rather than the book inventory records being adjusted). In six of eight stores, Brand #3's GUV is substantially less than that of the two other brands. In two of eight stores, Brand #3's product GUV is less than that of the two other brands (stores three and five).

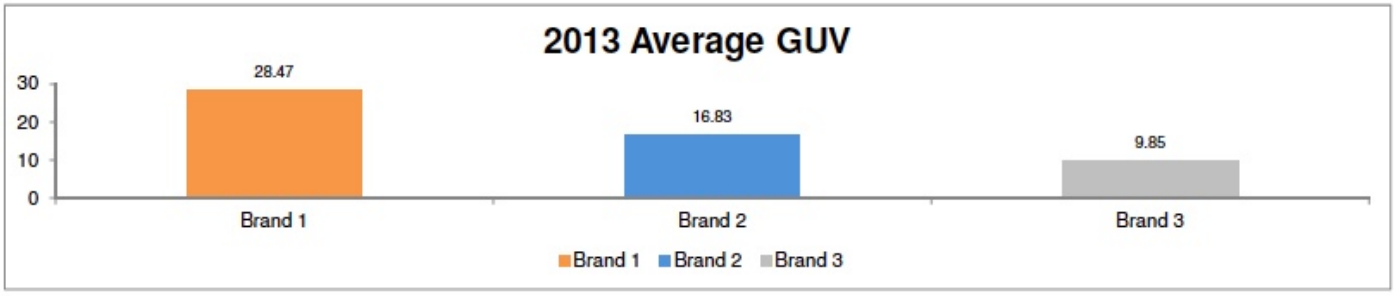
UC #2-Chart 1.



[20] All primary data examined was accumulated and provided by Macy's. As the Men's Pants Inventory Accuracy test occurred more than three years ago, the amount and depth of investigation has, in certain instances been limited, as certain historical information was difficult to locate. In addition: 1. A test of customer satisfaction could not be performed because the Macy's survey itself only considers the "Men's" department as a whole, and 2. Control comparisons could not be made with stores not involved in the test because those stores only undertake a full inventory count in January. Also, note that all brand product styles were considered for these tests, i.e., denim, knit, and sweaters, and within each product type, GUV itself may vary. Finally, as 85 percent of Brand #3's products are replenishment items (versus 37 percent for Brand #1 and 30 percent for Brand #2), GUV may tend to fluctuate less than for the more fashion-oriented Brands #1 and #2. This may have an impact on markdowns as well, which is considered in the second study that follows.

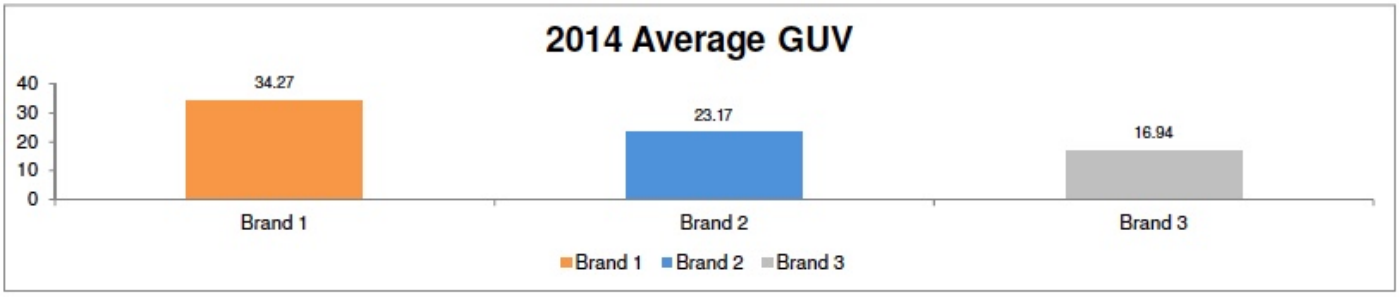
UC #2-Chart 2 shows the GUV percentage for each brand at the eight stores at the end of fiscal 2013. Brand #3 (RFID-enabled) product variance was lower than the other two brands at 9.85 percent. That is, the inventory level was better managed than the other brands (7 percent less variance than Brand #2 and 19 percent less variance than Brand #1).

UC #2-Chart 2.



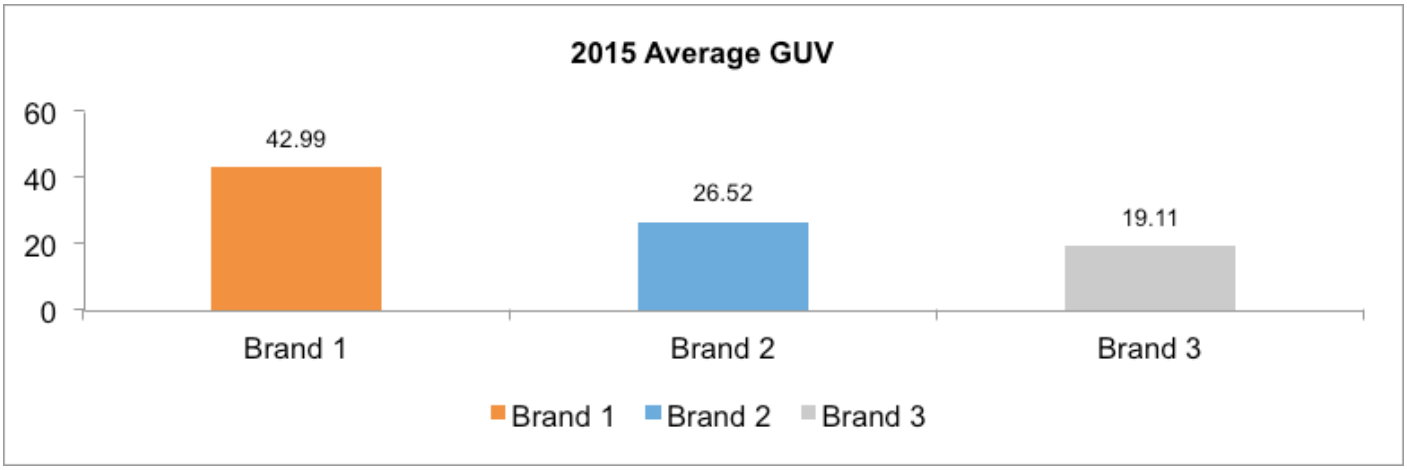
UC #2-Chart 3 compares the GUV percentage for each brand at the eight stores at the end of fiscal 2014. Brand #3 (RFID-enabled) product variance was again lower (6 percent less variance than Brand #2 and 17 percent less variance than Brand #1).

UC #2-Chart 3.



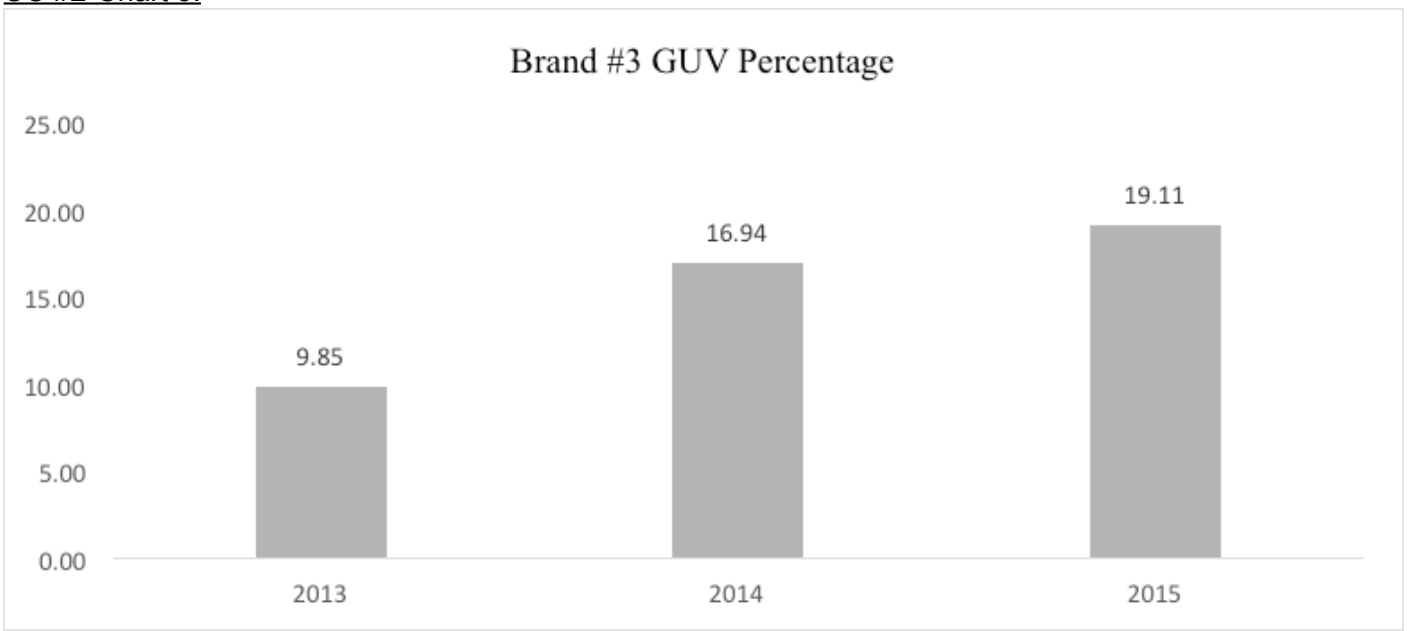
Finally, UC #2-Chart 4 compares the GUV percentage for each brand at the eight stores at the end of fiscal 2015. Brand #3 (RFID-enabled) product variance was once again lower (7 percent less variance than Brand #2 and 24 percent less variance than Brand #1).

UC #2-Chart 4.



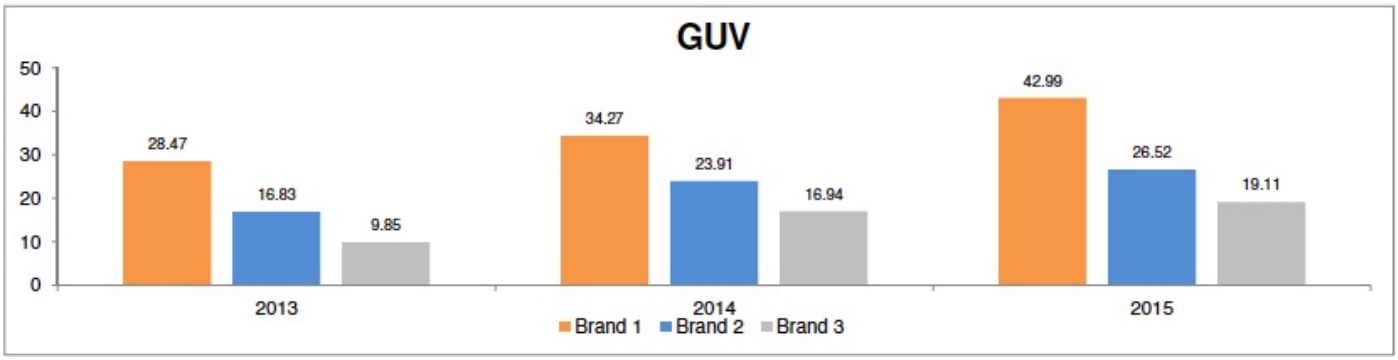
UC #2-Chart 5 compares the RFID-enabled Brand #3's GUV percentage for YE 2013, YE 2014, and YE 2015. While performing better than the other brands, this illustrates that over time the variances have been increasing, even with RFID.

UC #2-Chart 5.



We are unaware as to why this is occurring, but it is interesting to note that this annual GUV increase is occurring with the other brands as well (see UC #2-Chart 6).

UC #2-Chart 6.

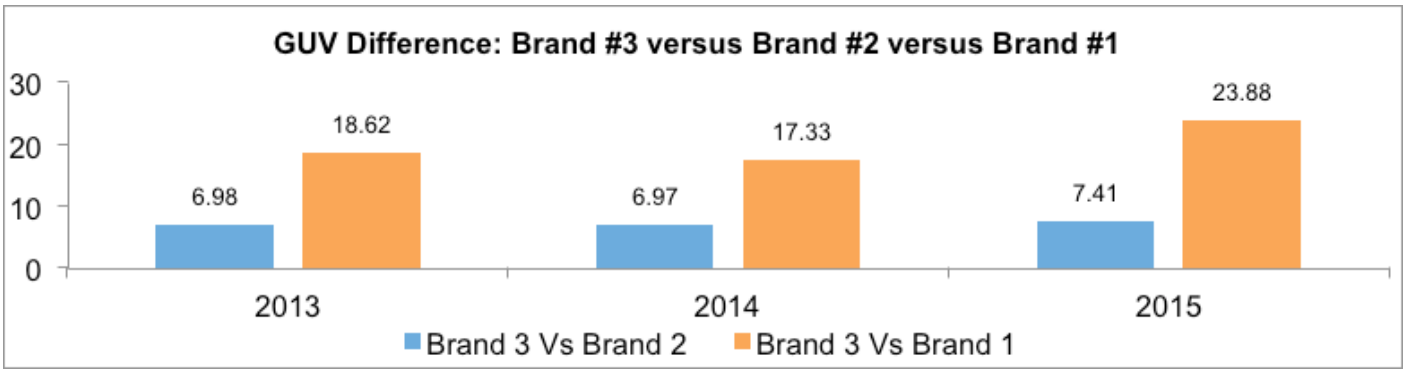


Notwithstanding the overall trend of increasing GUV for all three brands, Brand #3's GUV differential with the two other brands is generally consistent. That is, while the GUV trend is increasing for all three brands, the difference in performance by Brand #3 versus the other brands in each year is generally consistent. UC #2-Charts 7 and 8 illustrate this, comparing the GUV difference between Brand #3 and Brand #2, and Brand #3 and Brand #1.

UC #2-Chart 7. GUV Brand Difference.

	2013	2014	2015
Brand #3 GUV versus Brand #2 GUV Difference	6.98	6.97	7.41
Brand #3 GUV versus Brand #1 GUV Difference	18.62	17.33	23.88

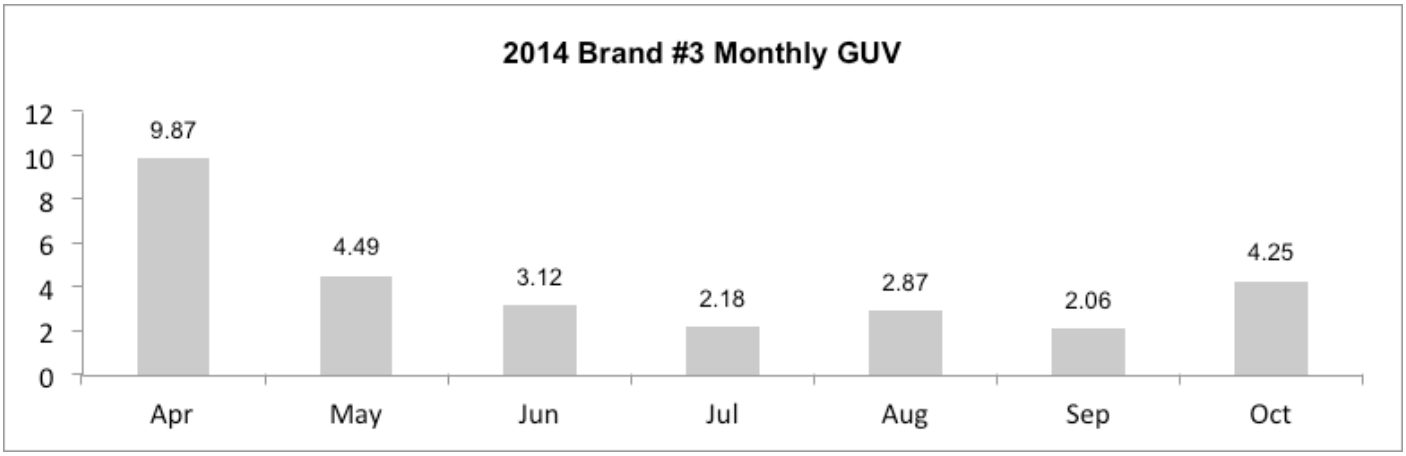
UC #2-Chart 8.



UC #2-Chart 9 illustrates Brand #3's GUV percentage by month for 2014. In January of 2013, inventory records were reconciled via manual bar code scans (although the records are reconciled, this does not mean that they are 100 percent accurate, as shown in UC #2-Chart 10). By April, the monthly GUV percentage is elevated, as detected by an RFID cycle count. This is because April reflects the inventory distortion that occurred during the months of February and March (as well as any inaccuracy that was encountered during the January reconciliation), when cycle counts did not occur. This is also illustrated when looking at the year-end GUV. At the end of 2014, Brand #3's GUV was 17 percent, which reflects the distortion that occurred during November and December, when RFID cycle counts were not performed.

This illustrates that an average variance of 4 percent per month occurred when cycle counts were not undertaken. For instance, the average GUV for the six months (May – October) was 3.87 percent. From another perspective, the 2014 year-end variance was 16.94 percent. Subtracting from this the October variance of 4.25 percent would indicate a monthly GUV creep of 4.23 percent (16.94 percent-4.25 percent = 12.69 percent or 4.23 percent per month for the three months cycle counts did not occur).

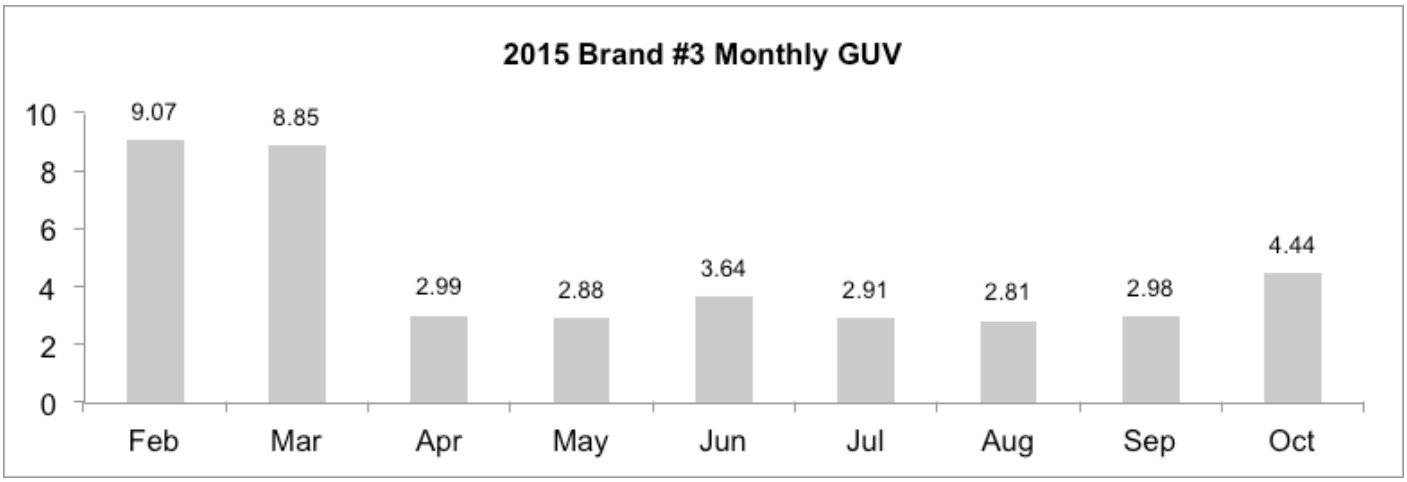
UC #2-Chart 9.



UC #2-Chart 10 illustrates Brand #3's GUV by month for 2015. In January of 2014, inventory records were again reconciled via manual bar code scans. However, bar code scanning is not necessarily 100 percent accurate, as shown by the elevated GUV levels in February and March. Cycle counts in February and March begin to adjust for year-end and monthly variances, and subsequently a 3 to 4 percent GUV was achieved for most of the balance of the year. No cycle counts occurred in November and December, with the result that a large variance is found for the January year-end (19.11 percent), when a physical count occurred. Charts 9 and 10 demonstrate how quickly these variances can occur without RFID-enabled monthly cycle counts.

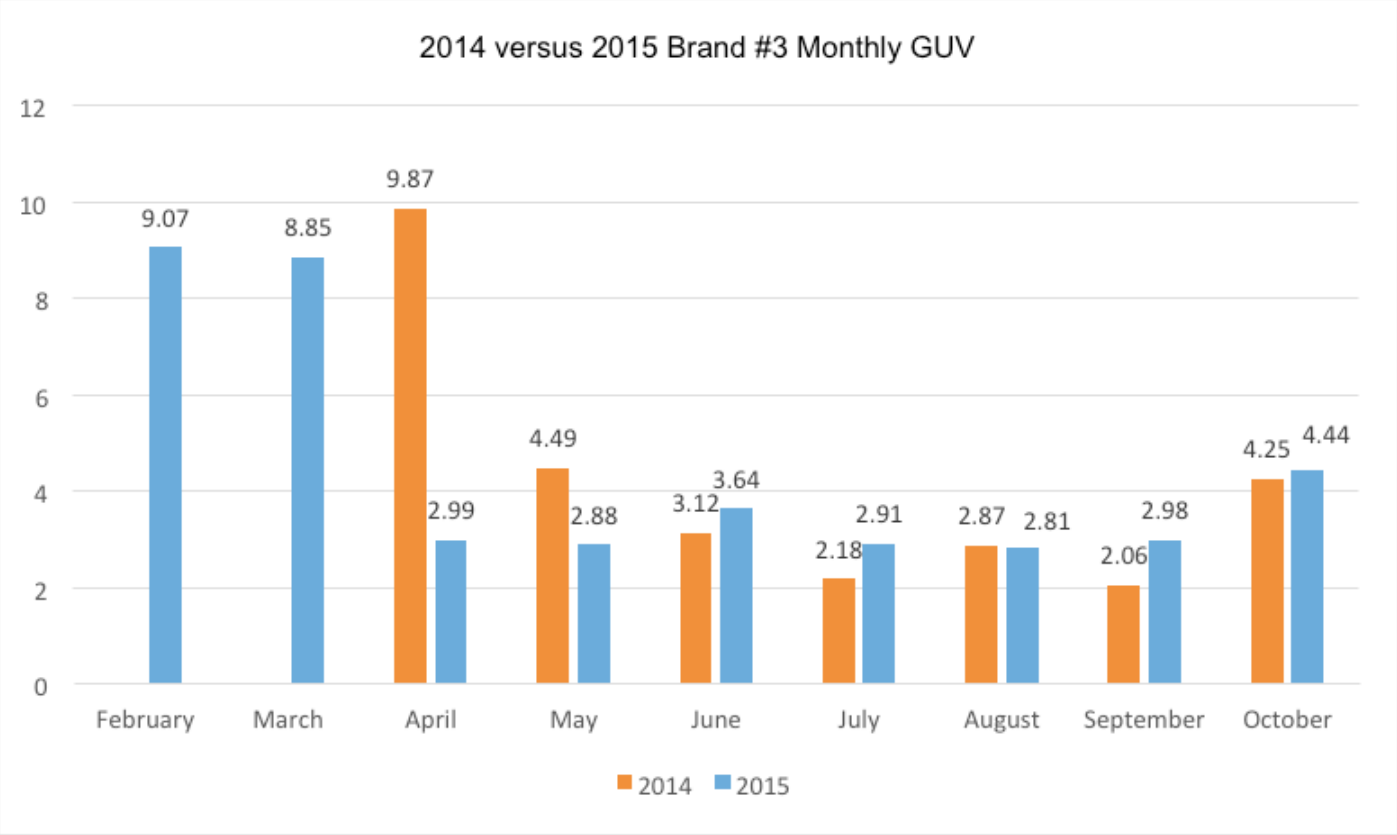
This also illustrates that an average variance of 4 to 5 percent per month occurred when cycle counts were not undertaken. To illustrate, the average GUV for the nine months (February - October) when cycle counts occurred was 4.51 percent. From another perspective, the 2015 year-end variance was 19.11 percent. Subtracting from this the October variance of 4.44 percent would indicate a monthly GUV creep of 4.89 percent (19.11 percent - 4.44 percent = 14.67 percent or 4.89 percent per month for the three months cycle counts did not occur).

UC #2-Chart 10.



UC #2-Chart 11 compares Brand #3's monthly GUV percentage for 2014 and 2015. From the data, we are unable to ascertain the monthly relationships in each year or year-to-year. That is, there is no apparent explanation or pattern as to monthly differences by year.

UC #2-Chart 11.



Markdowns

Here we considered whether increased inventory accuracy could have an impact on the number of markdowns. That is, we sought to establish if a relationship exists between inventory accuracy and the amount of unit markdowns. Stated another way, if a retailer had more accurate inventory information due to more frequent cycle counts enabled by RFID, would this information provide insights that would lead to fewer overstock positions and therefore, potentially, fewer markdowns? We compared three levels of markdown (first, second and third),[21] comparing the RFID-enabled Brand #3 with products from Brands #1 and #2 for 2013, 2014, and 2015.

Our premise is that better inventory accuracy may lead to fewer markdowns. However, the data that has been made available does not enable us to definitively establish this relationship.[22] There are a variety of reasons for this. One is that markdowns, like sales, can be impacted by many variables, such as the economy, weather, fashion trends, the ability of merchandisers to select in-demand products, etc. Also noteworthy is that Brand #3 may be considered more of a replenishment product than a fashion item, unlike Brands #1 and #2.[23] Notwithstanding, we can surmise from the data that better inventory accuracy can lead to fewer markdowns.

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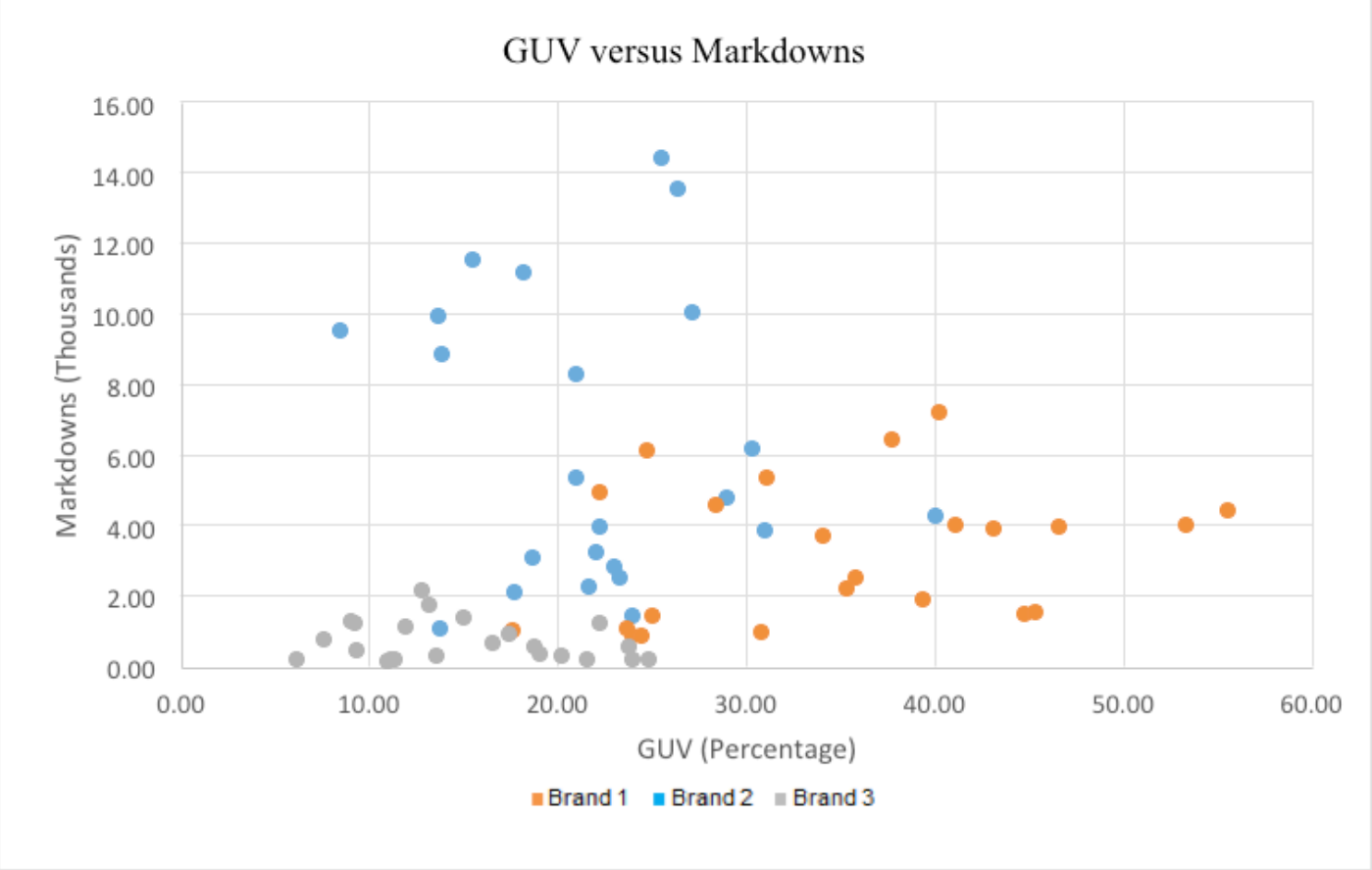
[21] In the following analysis of eight stores, only the first, second and third markdowns are considered.
[22] As noted elsewhere, Macy's provided historical data, which did not include test and control comparisons.
[23] As stated in a prior footnote, 85 percent of Brand #3's products are replenishment items (versus 37 percent for Brand #1 and 30 percent for Brand #2). Thus, fewer markdowns may occur of Brand #3's product than for the more fashion-oriented Brands #1 and #2.

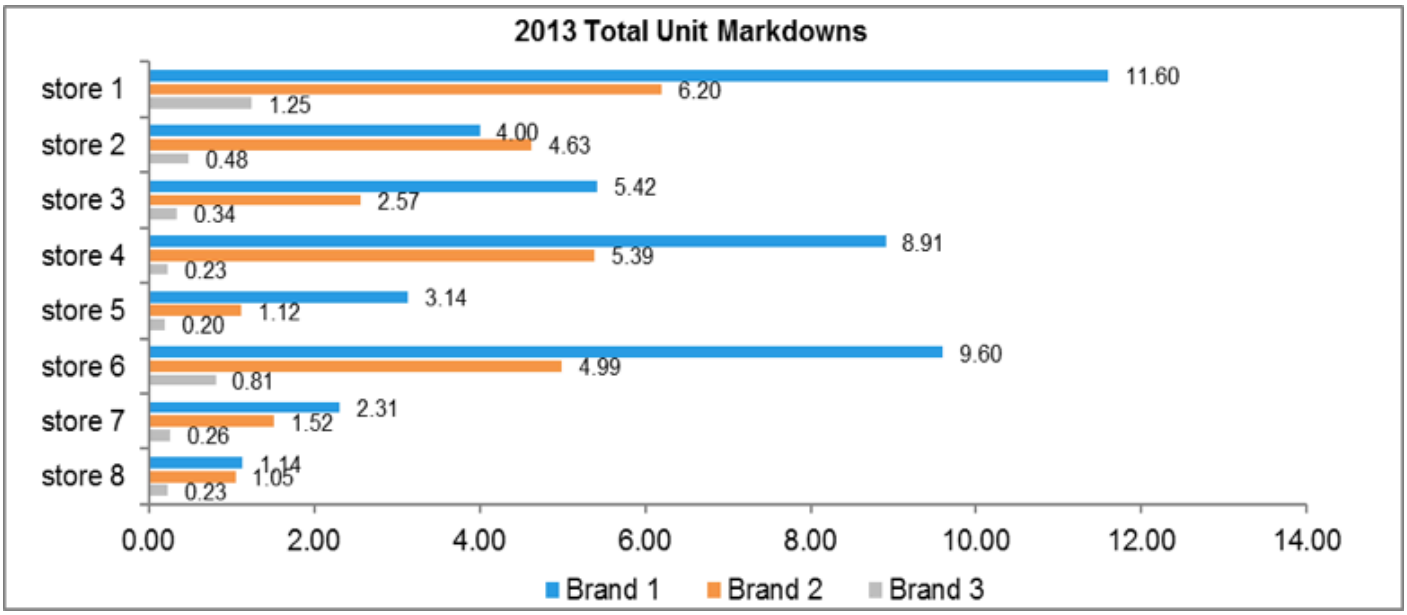
UC #2-Chart 12 compares the number of units marked down, by brand, to the GUV. As the GUV percentage increases for Brand #2 (shown in blue), notice that the number of markdowns trends upward. This is also observable for Brand #1 (shown in orange). On the other hand, it is observed that the lower level of GUV for Brand #3 tends to lead to fewer markdowns.

UC #2-Chart 12.

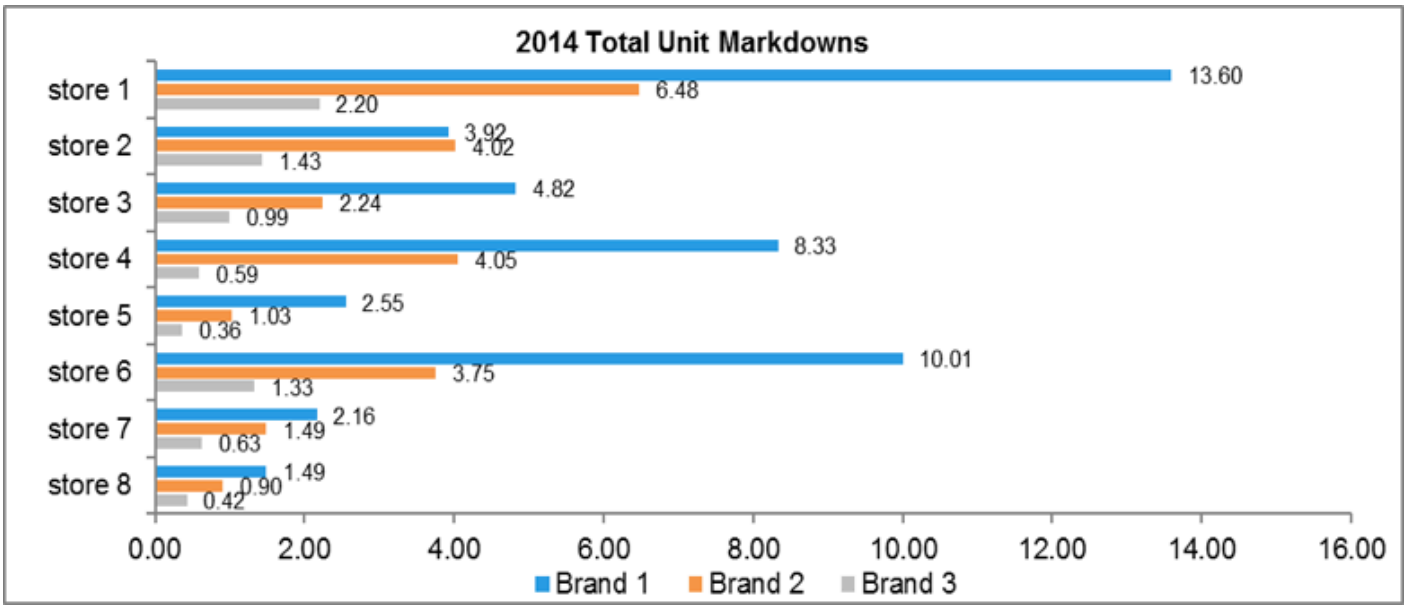


UC #2-Charts 13, 14, and 15 illustrate that in each year, the RFID-enabled Brand #3 had significantly fewer markdowns at the eight test stores versus the other brands.

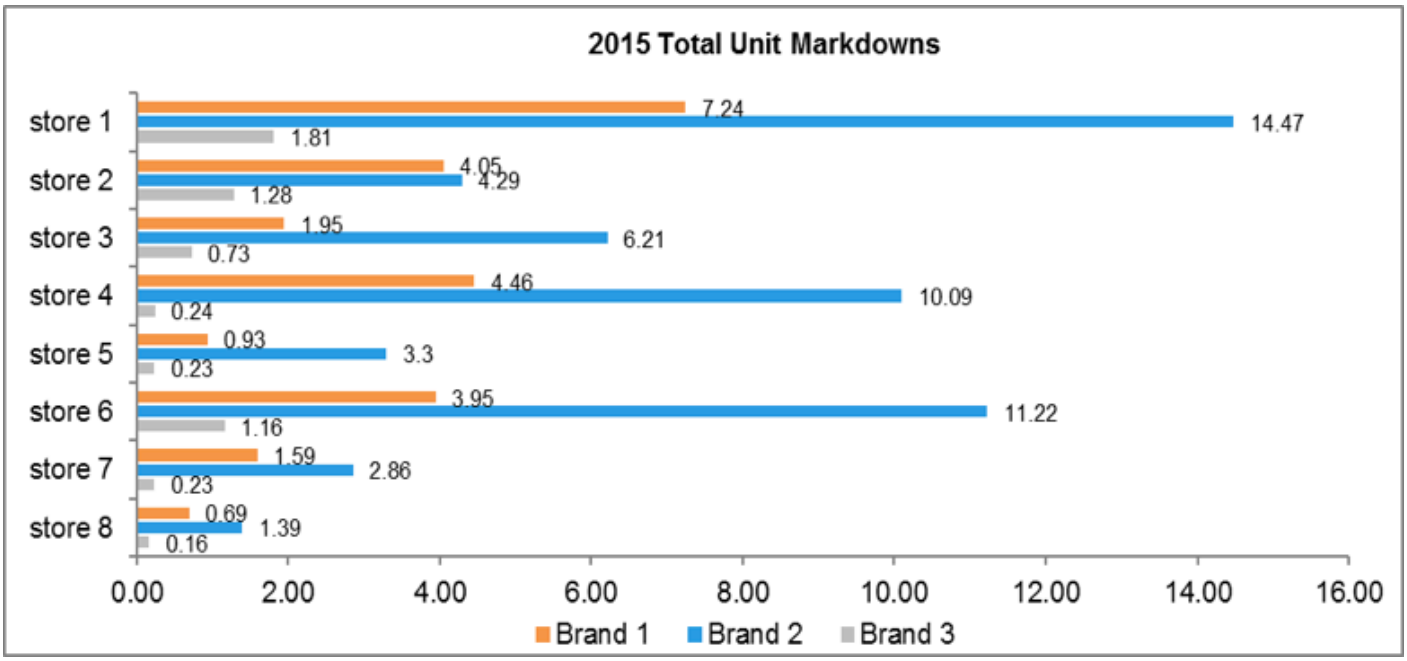
UC #2-Chart 13.



UC #2-Chart 14.

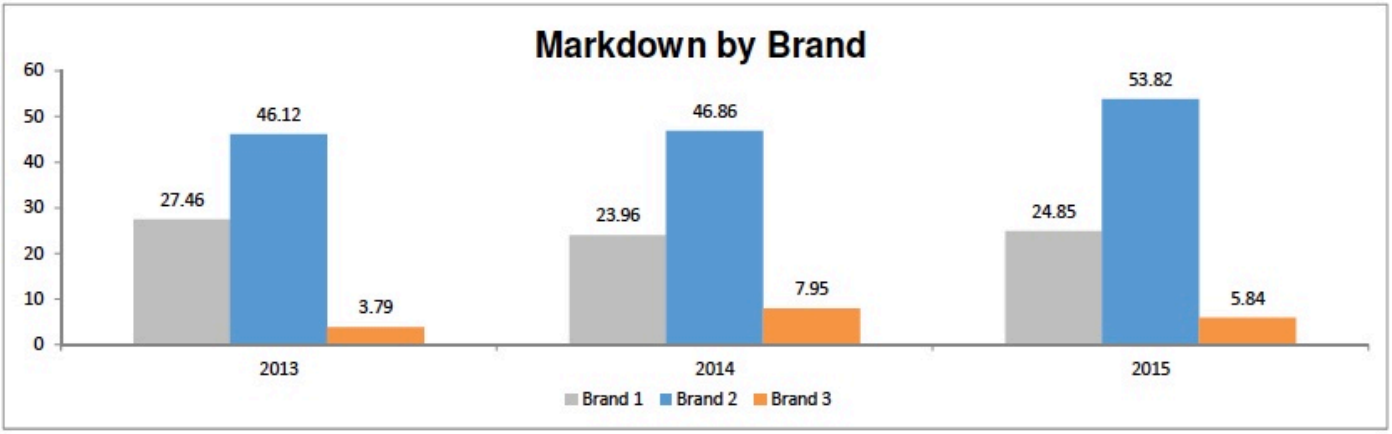


UC #2-Chart 15.



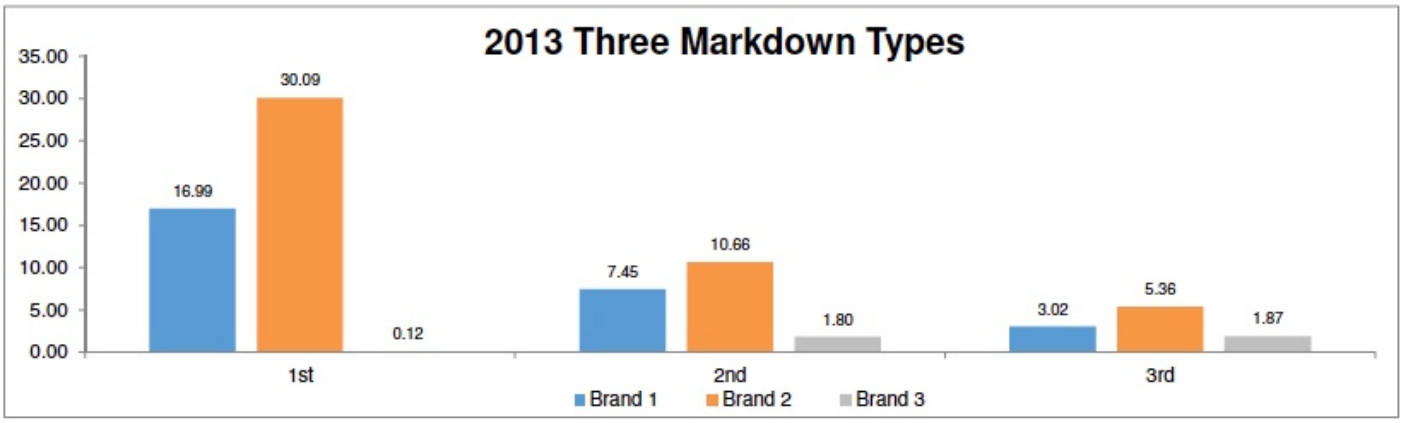
UC #2-Chart 16 compares markdowns, by brand, for 2013, 2014, and 2015.

UC #2-Chart 16.

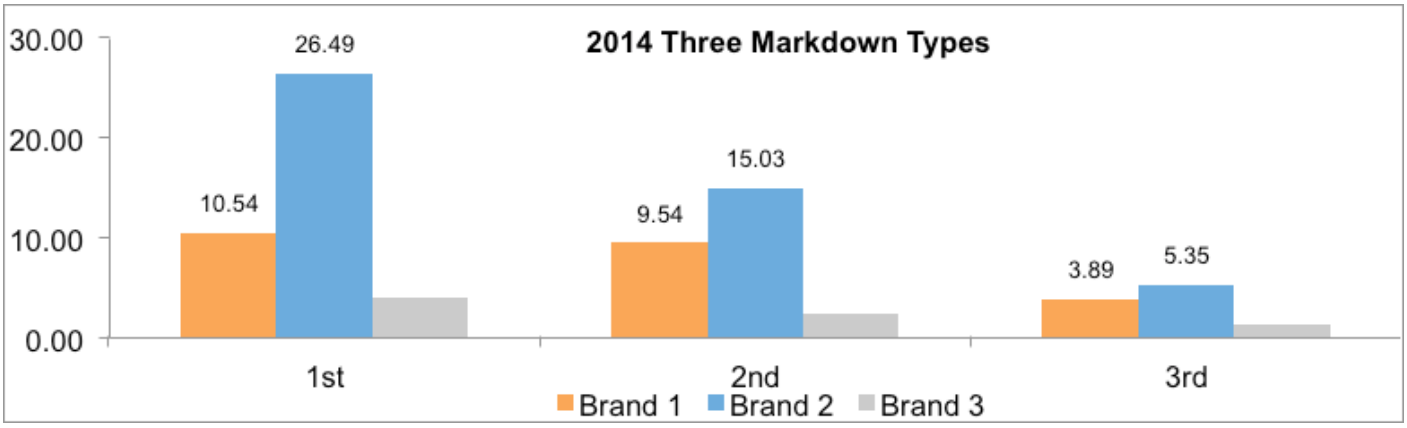


UC #2-Chart 17 presents the total number of markdowns, in units, by the three markdown types for each brand in 2013. UC #2-Charts 18 and 19 present data for 2014 and 2015, respectively.

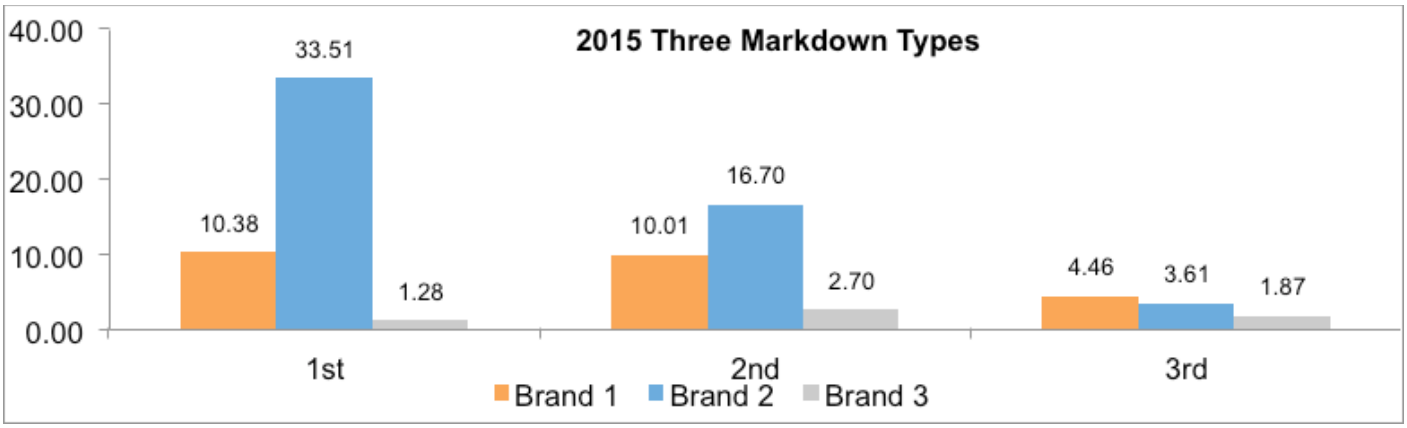
UC #2-Chart 17.



UC #2-Chart 18.

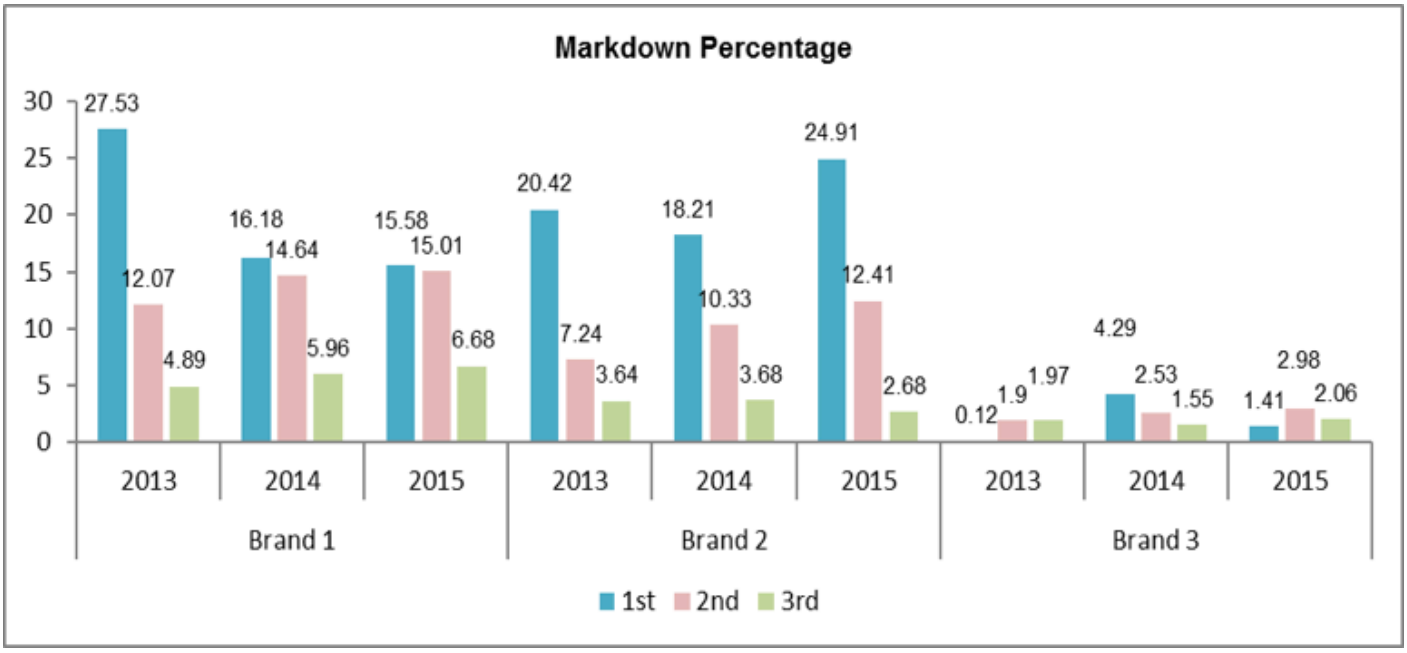


UC #2-Chart 19.

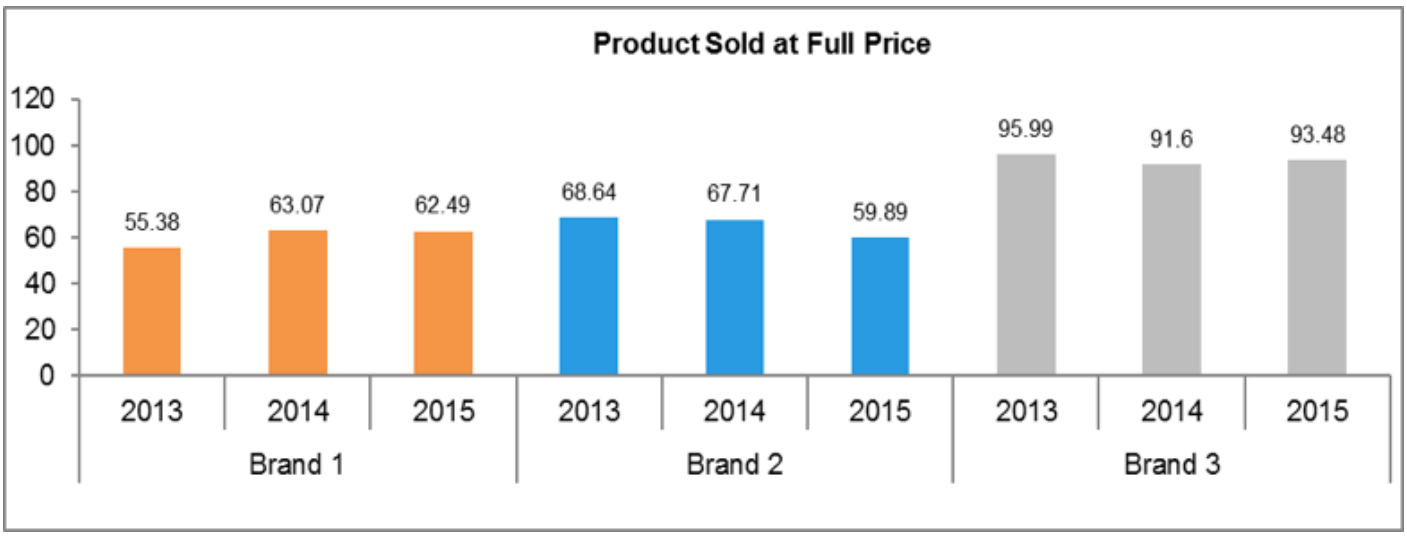


UC #2-Chart 20 shows the markdown percentage, by brand by mark, as a percentage of total unit sales. UC #2-Chart 21 shows, by brand, the percentage of product sold at full price.

UC #2-Chart 20.



UC #2-Chart 21.



C. Use Case #3: Single Unit Fulfillment

When a customer order is placed, either online or from a store, Macy's fulfillment system determines which store or warehouse should fill the order. Historically, if it was determined that a particular store should fill an order, the system would only place the order at the selected store if a minimal threshold of availability was met. This was because it was assumed that due to inventory availability issues and the difficulty associated with locating a single item in a store, picking from a store with only a single unit was not an effective option. The decision not to expose single units has the potential to result in missed sales opportunities and/or cause merchandise price markdowns, as the item was not broadly visible to customers online and at other stores.

It was felt that by moving to a single item fulfillment, enabled by RFID, that various benefits could be realized. These include:

- Making single-unit items visible and broadly available both system wide and to online shoppers. This is important to Macy's, as some 20 percent of its merchandise is single unit.
- Reducing the time to fill an order, and the increased assurance of knowing that a product is available, could have a positive impact on the customer experience.
- Positively impacting in-store labor productivity as associates can quickly find RFID-enabled items to fill an order, rather than hunting around the store trying to locate a single item of merchandise.
- Reducing shipping costs associated with moving a single unit of non-congruent inventory back to its store of origin,[24] as well as returns to vendors, as merchandise becomes fully visible for sale.
- Positively impacting sales.
- Reducing inventory levels.
- Reducing markdowns because product can be more easily located for sale. To illustrate, prior to RFID, if a single item could not be located (i.e., perhaps it had been misplaced in a store room or was somewhere in a dressing room) and it was later found and sold, this may have resulted in a price reduction, rather than an available item being sold at full price to a ready-to-buy customer.

Test Versus Control Store Study Summary

To gain insights into some of these benefits, Macy's conducted a six-month fulfillment test of online orders of women's social occasion dresses, from April 25 to October 27, 2014, at eight stores (four test and four control). Central to this assessment was that in the test stores only single-unit items were made available to fill online orders and orders placed by another store. Stated another way, at the RFID-enabled test stores, merchandise was made visible systemwide to fill orders even if only a single unit was shown in the inventory record as being available. At the control stores, merchandise orders were filled based on meeting a minimal threshold of units being available in inventory. Three studies, as detailed below, were undertaken from the test data that was made available.[25] Summary findings are as follows:

1. Unit Requests. Increased merchandise visibility of single items produced an increase of 293 percent in unit requests at the test stores, while at the control stores pick requests increased by 1 percent during the test period. This result is not totally unanticipated, as single-unit items are now being made available for sale (that is, more merchandise is being offered to fill requests).

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[24] Congruent product refers to merchandise that is associated with a specific store. That is, it is stocked in a particular store due to the store's customer demographics. For example, if an expensive high fashion dress were sold to a customer in the Herald Square store in New York and that customer returns it later to a store in Florida that has different customer demographics, it would then be considered a non-congruent item to the Florida store. Historically, that non-congruent dress would, within a week, be returned to New York, but during the time that it was in transit from Florida, it was not available for sale.

[25] All primary data examined was accumulated and provided by Macy's. 2014 data compares outcomes during the test period to the prior year 2013 non-test period.

2. Units Picked: The fulfillment rate of merchandise orders shipped from a store increased by 273 percent at the test stores, while at the control stores units picked decreased by 2.6 percent during the test period.
3. Sales Generated. Improving merchandise visibility of single items resulted in a sales gain of 327 percent at the test stores, while at the control stores, sales decreased by a minimal amount during the test period.
4. Finally, we tested whether increased visibly can impact shipping costs associated with moving non-congruent inventory back to its store of origin. Our test was limited, but the trend indicates that in 14 of 20 months, the rate of non-congruent unit transfers of RFID-tagged merchandise is less than that of non-RFID-tagged merchandise, indicating a possible transportation cost savings.[26]

2016 Data Studies Summary

We also considered a much broader data set, again supplied by Macy's, for a five-month period in 2016. Unlike the test versus control study noted above, request and fill rates of RFID merchandise were made regardless of the number of units on hand. That is, the test versus control store study summarized above compared single unit fulfillment at the test stores, while the control stores maintained a multi-unit fulfillment requirement. Here, we are looking across the enterprise at RFID-tagged merchandise. Three studies, as detailed below, were undertaken. Summary findings are as follows:

1. Testing a much broader sample of merchandise, the ability to fill orders of RFID-enabled merchandise was 6.1 percent more than for non-enabled merchandise at the end of the five-month exam period.
2. Units picked/sold of RFID-congruent merchandise were 2.8 percent higher than for non-RFID merchandise. Units picked/sold of RFID non-congruent merchandise were 3.0 percent higher than for non-RFID merchandise. Again, both findings generally support the proposition that it is easier to find RFID merchandise in a store to fill an order.

Test Versus Control Store Studies

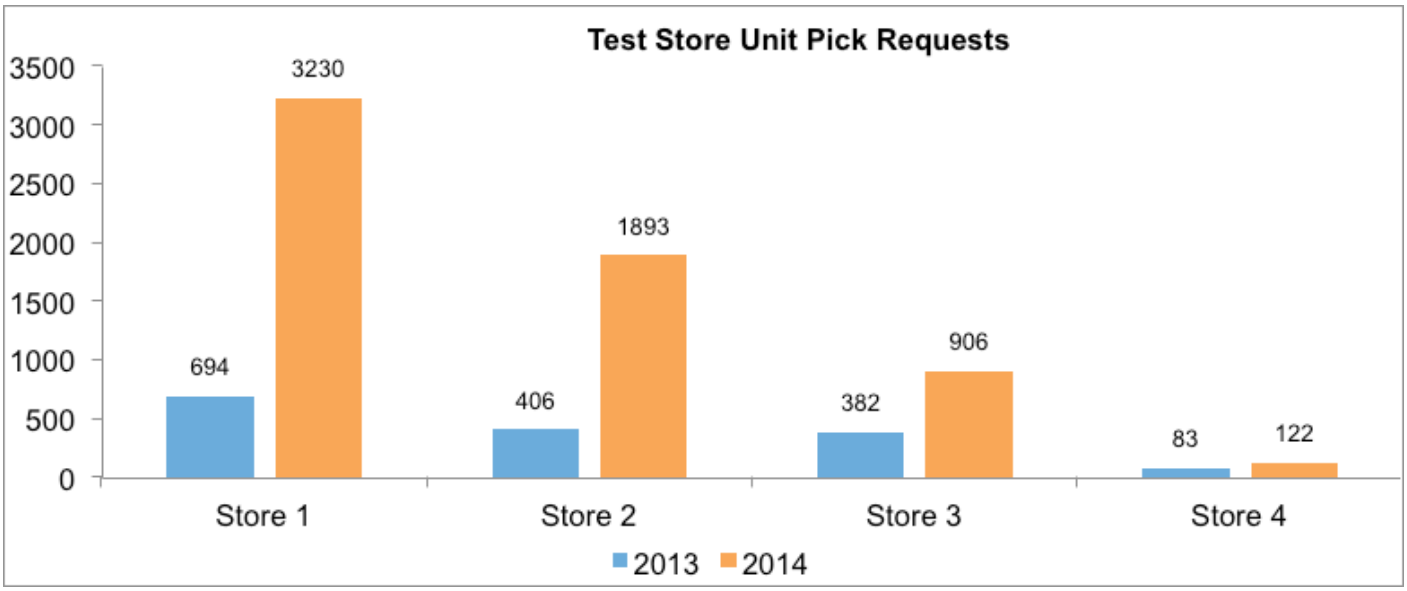
1. Unit Requests at Test Versus Control Stores

Changes in requests indicate that more orders are being received at a location due to increased product visibility. In this series, we look at the changes in the number of requests made to fill an order at the test versus the control stores (Charts 1-4).

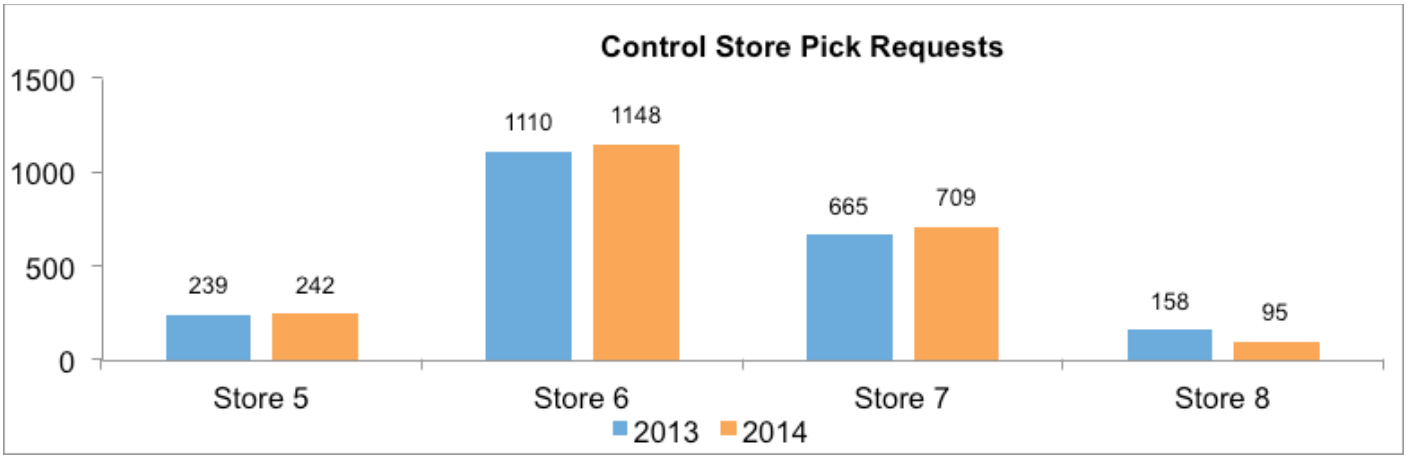
[26] Consider that findings 1, 2, and 3 are not totally unanticipated, as single-unit items are now being made available for sale (that is, more merchandise is being offered to fill requests).

UC #3-Chart 1 illustrates the change in unit requests at the four test stores, comparing 2013 to the 2014 test period. As can be seen, the request rates at the test stores increased substantially during this time. This result is not totally unanticipated, as single-unit items are now being made available for sale (that is, more merchandise is being offered to fill requests). What is noteworthy is that the findings indicate that significantly more merchandise is becoming visible to fill orders. UC #3-Chart 2 shows the change in unit requests at the control stores, comparing 2013 to the 2014 test period. At these stores, during the test period, pick requests increased marginally and, in one instance, decreased (Store 8). This result reflects the fact that only multiple units are being made available to fill orders.

UC #3-Chart 1.

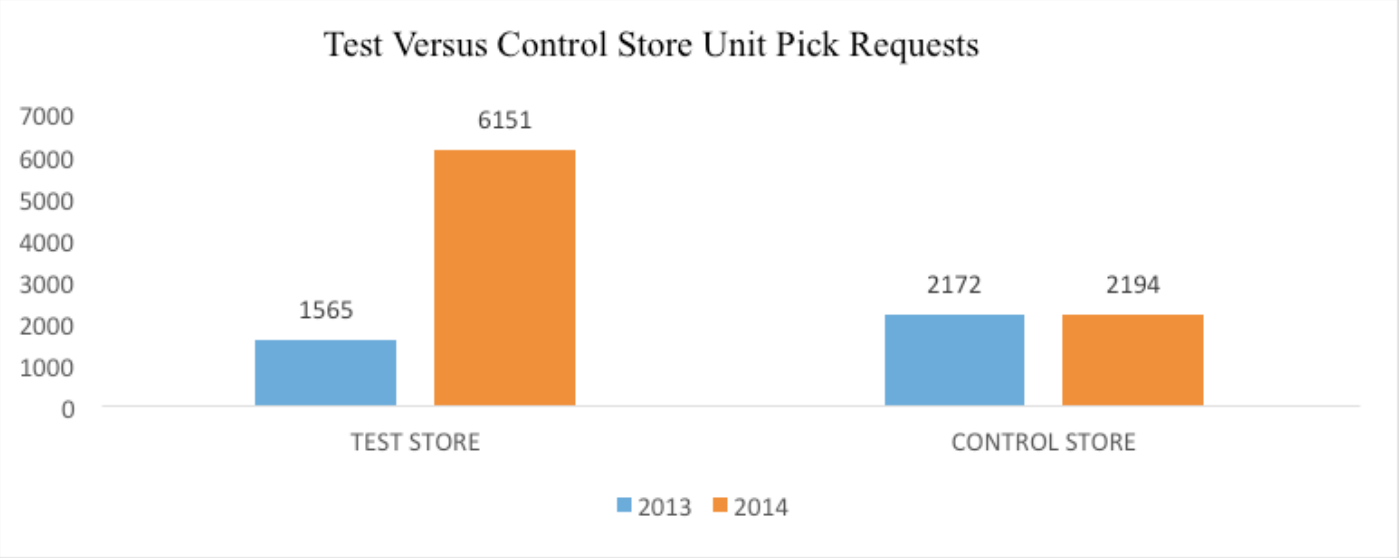


UC #3-Chart 2.



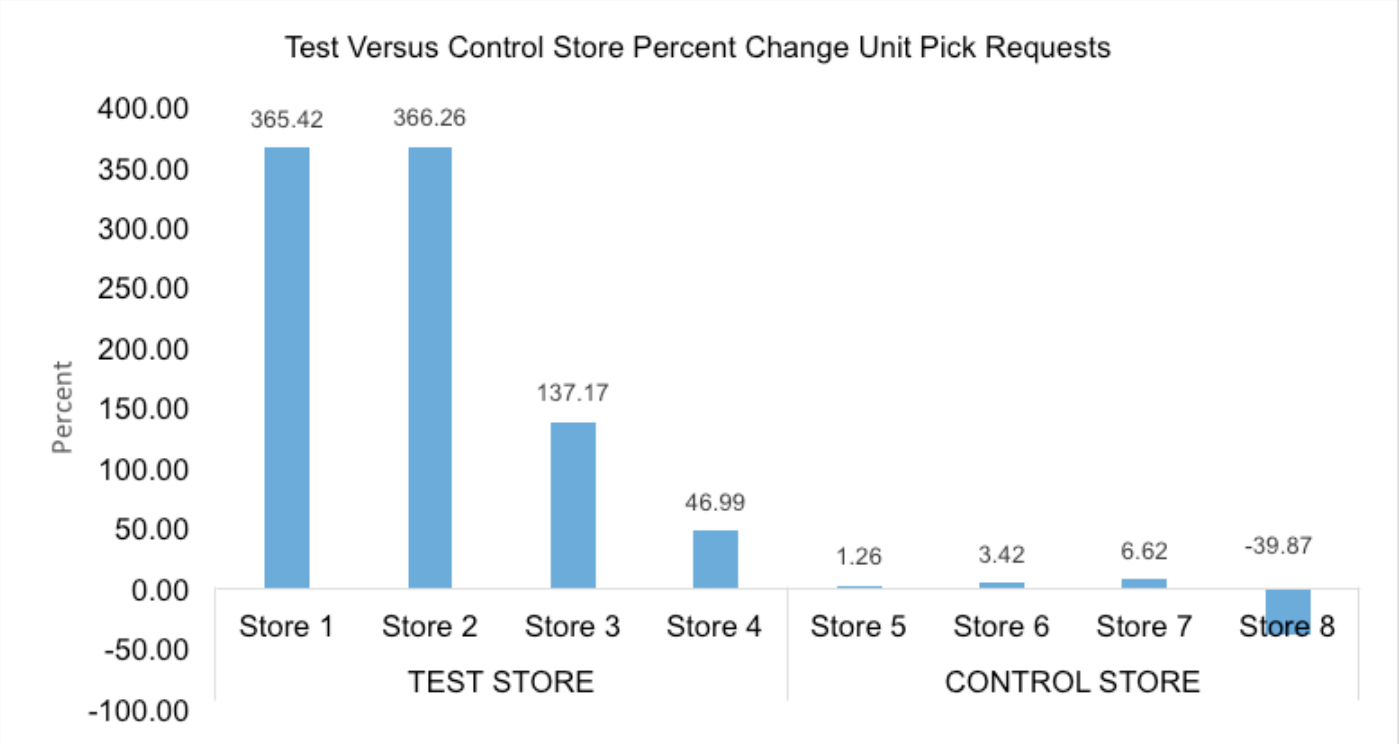
UC #3-Chart 3 demonstrates the combined change in unit request rates at the test and control stores for 2013 versus 2014. At the test stores, pick requests increased by 293 percent, while at the control stores, pick requests increased by 1 percent during the test period.

UC #3-Chart 3.



UC #3-Chart 4 demonstrates the percent change in unit request rates at the individual test and control stores for 2013 versus 2014.

UC #3-Chart 4.

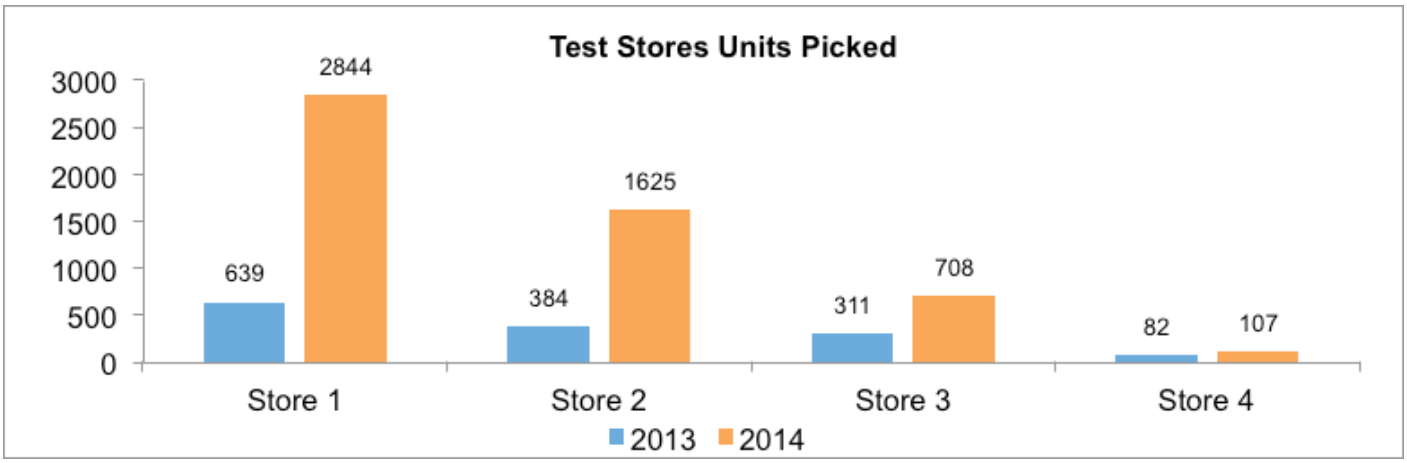


2. Units Picked

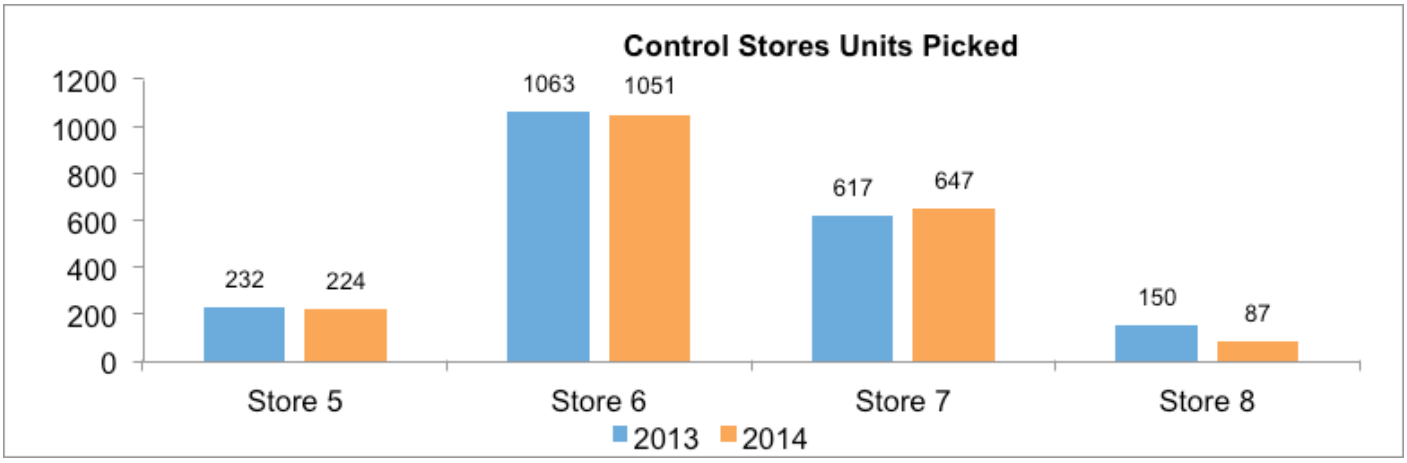
The term “units picked” refers to the fulfillment rate of merchandise orders placed by a customer that are shipped from a store. In this series, we look at the changes in the number of units picked (that is, order requests filled) at the test versus the control stores (Charts 5-8).

UC #3-Chart 5 illustrates the change in unit requests filled at the test stores, comparing 2013 to the 2014 test period. As can be seen, the fill rates increased substantially during this time. UC #3-Chart 6 shows the change in fill rates at the control stores, comparing 2013 to the 2014 test period, which decreased at three of the four control stores.

UC #3-Chart 5.

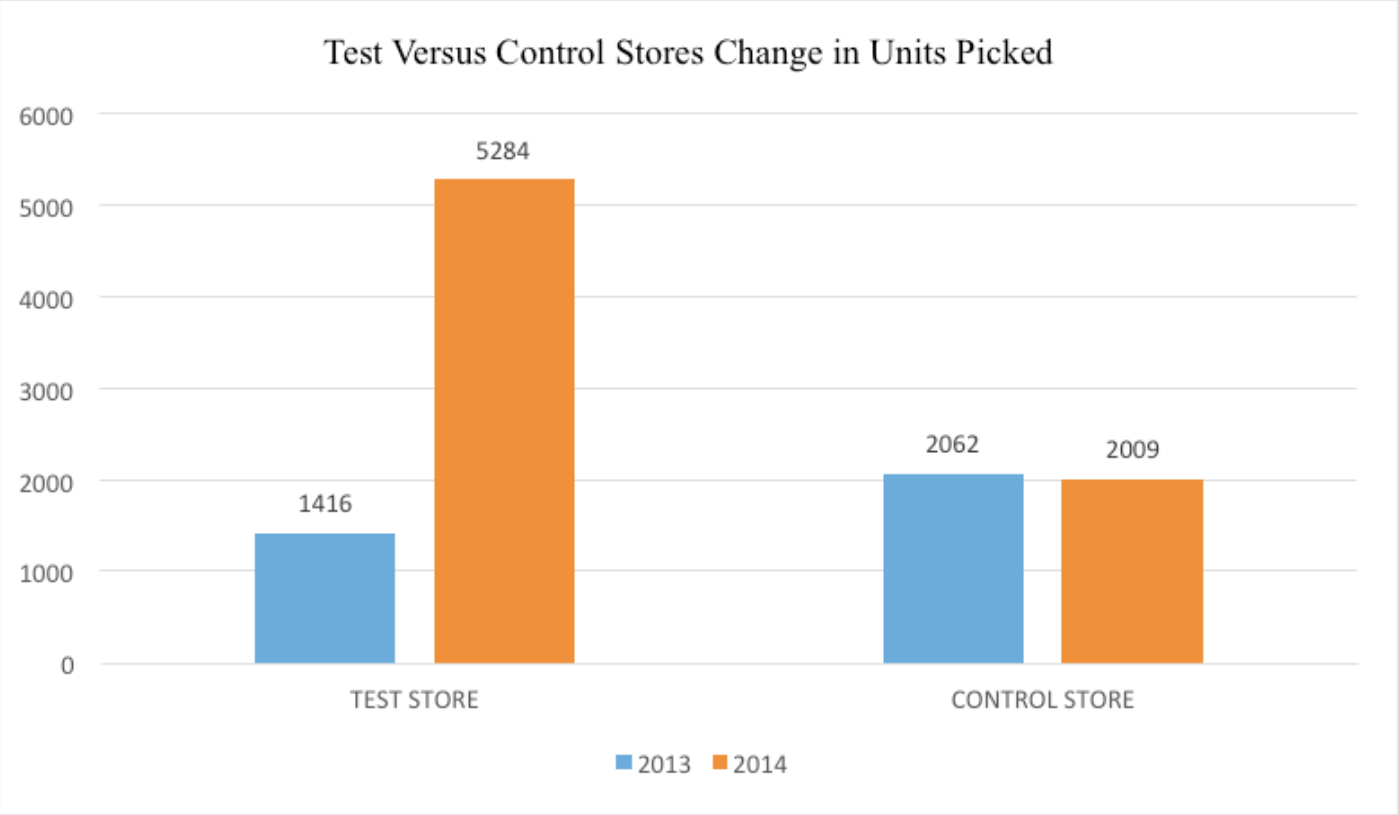


UC #3-Chart 6.



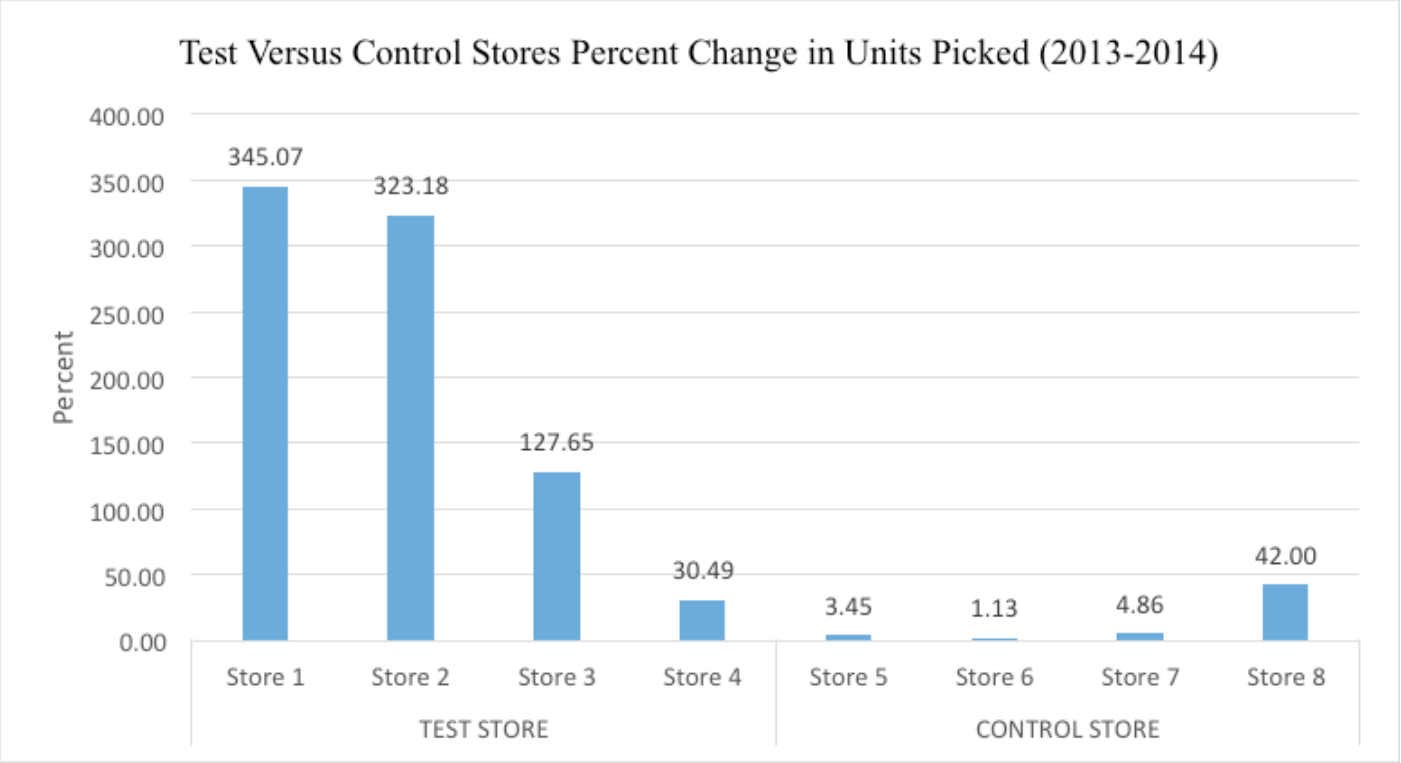
UC #3-Chart 7 demonstrates the change in combined fill rates at the test and control stores for 2013 and 2014. At the test stores, units picked increased by 273 percent, while at the control stores units, units picked decreased by 2.6 percent.

UC #3-Chart 7.



UC #3-Chart 8 demonstrates the percentage change in fill rates at the individual test and control stores for 2013 and 2014.

UC #3-Chart 8.

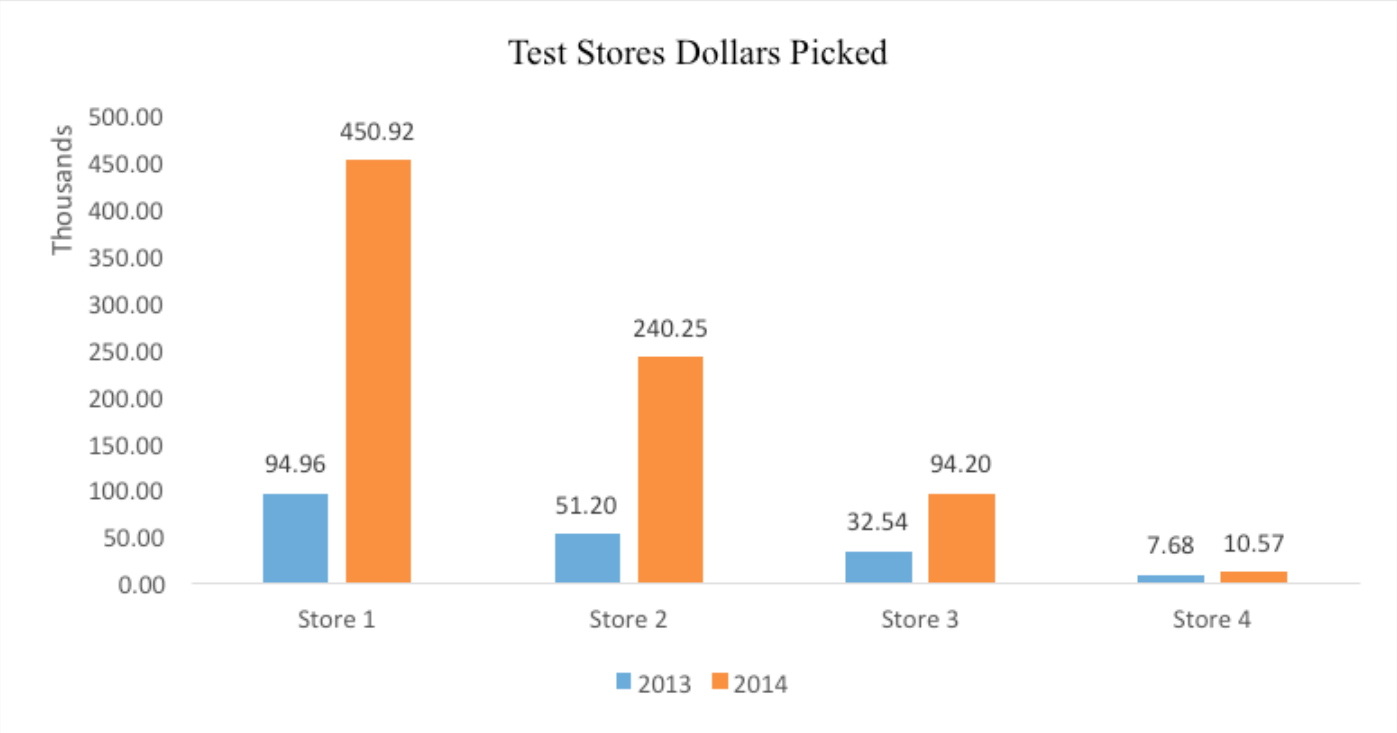


3. Sales Generated

Pick to last (i.e., to a single unit), enabled by RFID, has made more Macy's merchandise visible for sale both online and to other stores. This is an important component of Macy's omni-channel fulfillment strategy, which is to offer, find, and fill orders of single-unit merchandise regardless of its physical location. As noted, the significance of this is apparent, as some 20 percent of the chain's inventory is single unit in its stores (i.e., by color or size). This means that prior to RFID, this merchandise was only available for sale to customers at the location where the merchandise was located. In addition, "unintentional" single-unit items, which can occur, for example, when the last unit of merchandise is taken off the sales floor and put in a store room, now becomes available for sale at full price. Single unit sales improvements attributed to Macy's pick to last are significant, as illustrated below.

UC #3-Chart 9 illustrates the change in sales at the four test stores, comparing 2013 to the 2014 test period. As can be seen, sales increased substantially as the test stores that adopted a single-unit fulfillment strategy.[27]

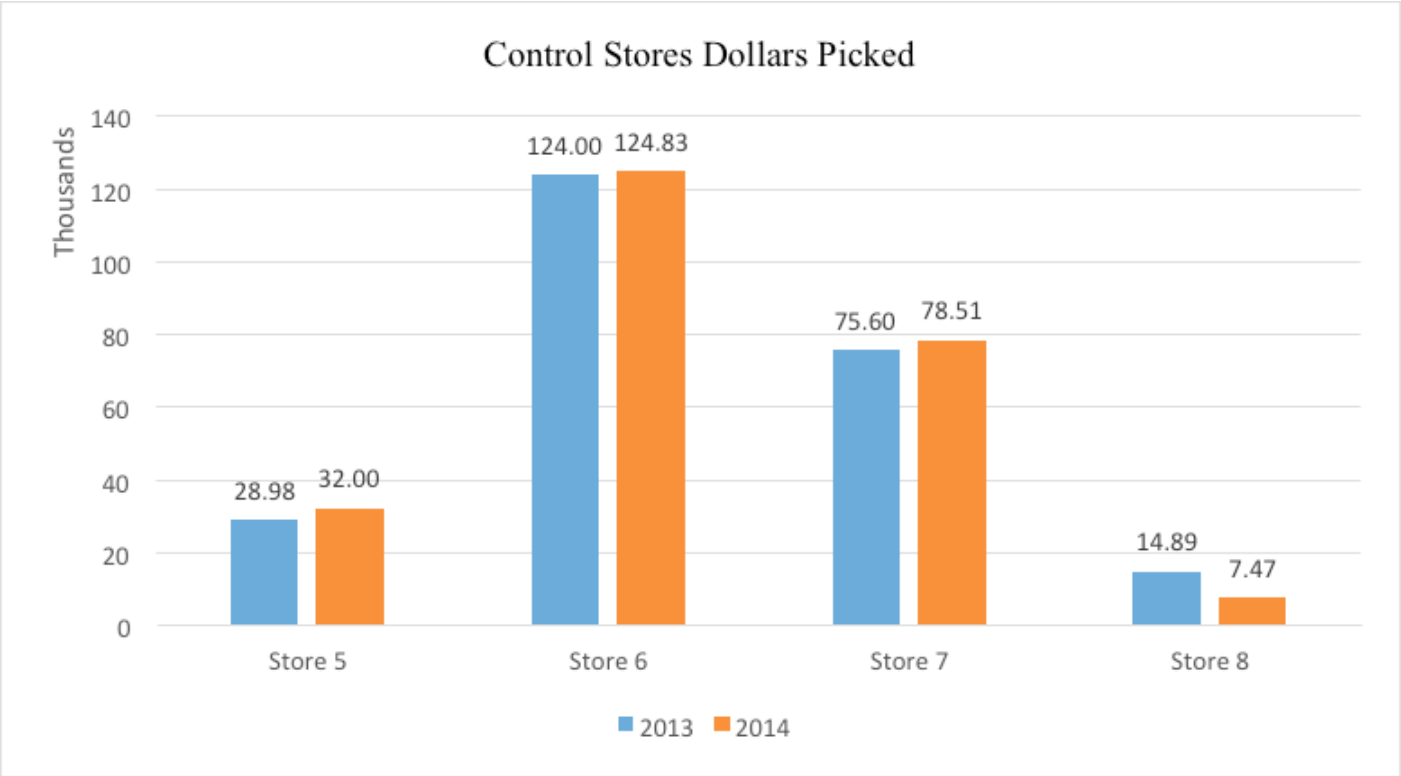
UC #3-Chart 9.



[27] It should be noted that the sales results, as indicated here, might be overstating the generalized impact that may result from moving to a pick to last approach. That is, in practice, the item may have eventually been located at another venue and the sale still realized by Macy's. What is being illustrated here is that the impact of moving to single-item fulfillment at the test versus the control stores (those that only have multiple units available for sale to fill an order) is significant.

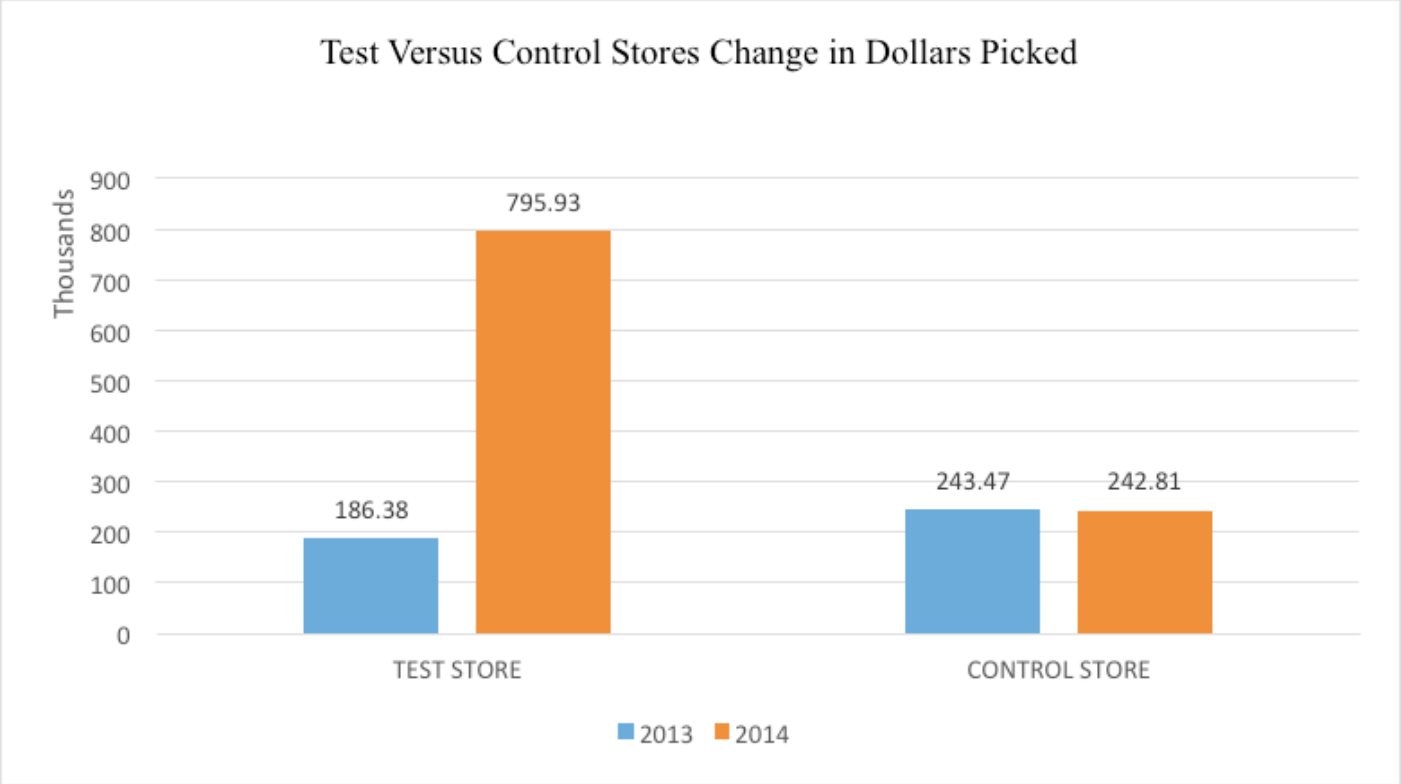
UC #3-Chart 10 shows the change in sales at the control stores, comparing 2013 to the 2014 test period.

UC #3-Chart 10.



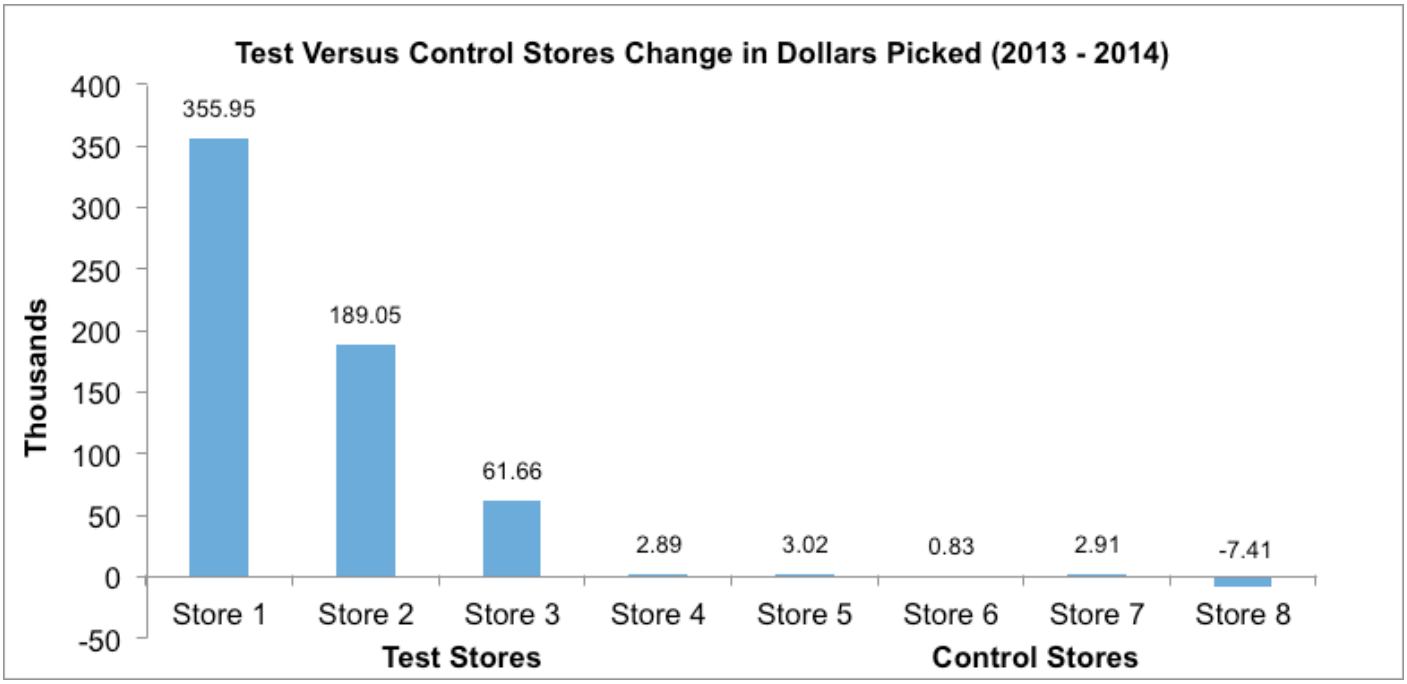
UC #3-Chart 11 demonstrates the combined change in sales at the test and control stores for 2013 versus 2014. At the test stores, sales increased by 327 percent, while at the control stores sales decreased fractionally.

UC #3-Chart 11.

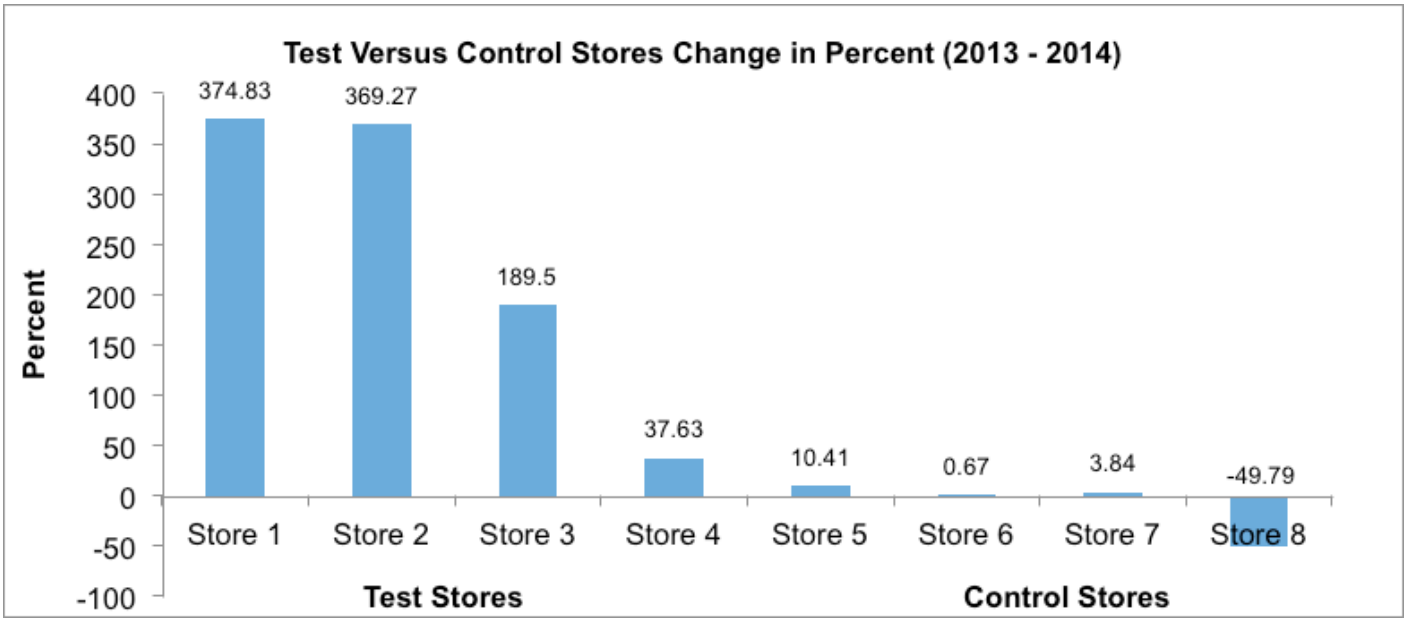


UC #3-Chart 12 demonstrates the change in sales at the individual test and control stores for 2013 versus 2014. UC #3-Chart 13 demonstrates the percentage change in sales at the individual test and control stores for 2013 and 2014.

UC #3-Chart 12.

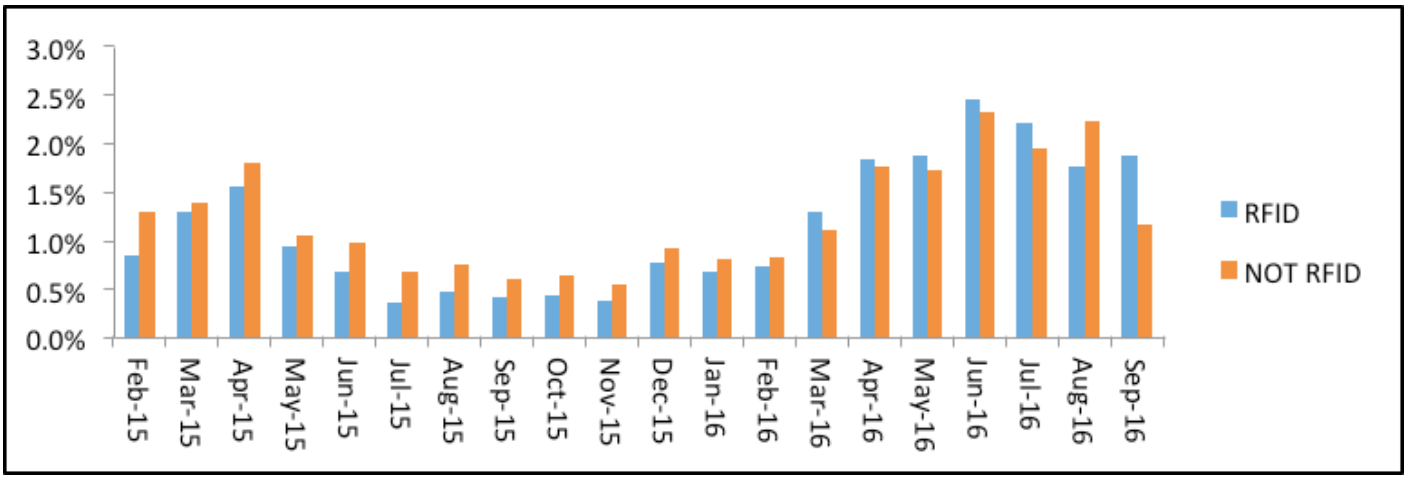


UC #3-Chart 13.



Finally, we considered whether increased visibility could impact shipping costs associated with moving non-congruent inventory back to its store of origin. In this instance, the entire dress category was measured over a 20-month period. We compared the percentage of non-congruent transfers versus the total units on hand of RFID- versus non-RFID-tagged merchandise. As with several other tests in this study, due to data limitations, these findings should be considered as supporting a trend, rather than as conclusive, as we could not control for many external influences. The principal limiting consideration here is that non-congruent merchandise is generally transferred on a weekly basis, regardless of whether it is RFID-tagged. Chart UC #3-Chart 14 illustrates that in 14 of 20 months, the rate of non-congruent unit transfers of RFID-tagged merchandise is less than that of non-RFID-tagged merchandise, indicating a possible transportation cost savings.

UC #3-Chart 14. Percent of Non-Congruent United Transferred.

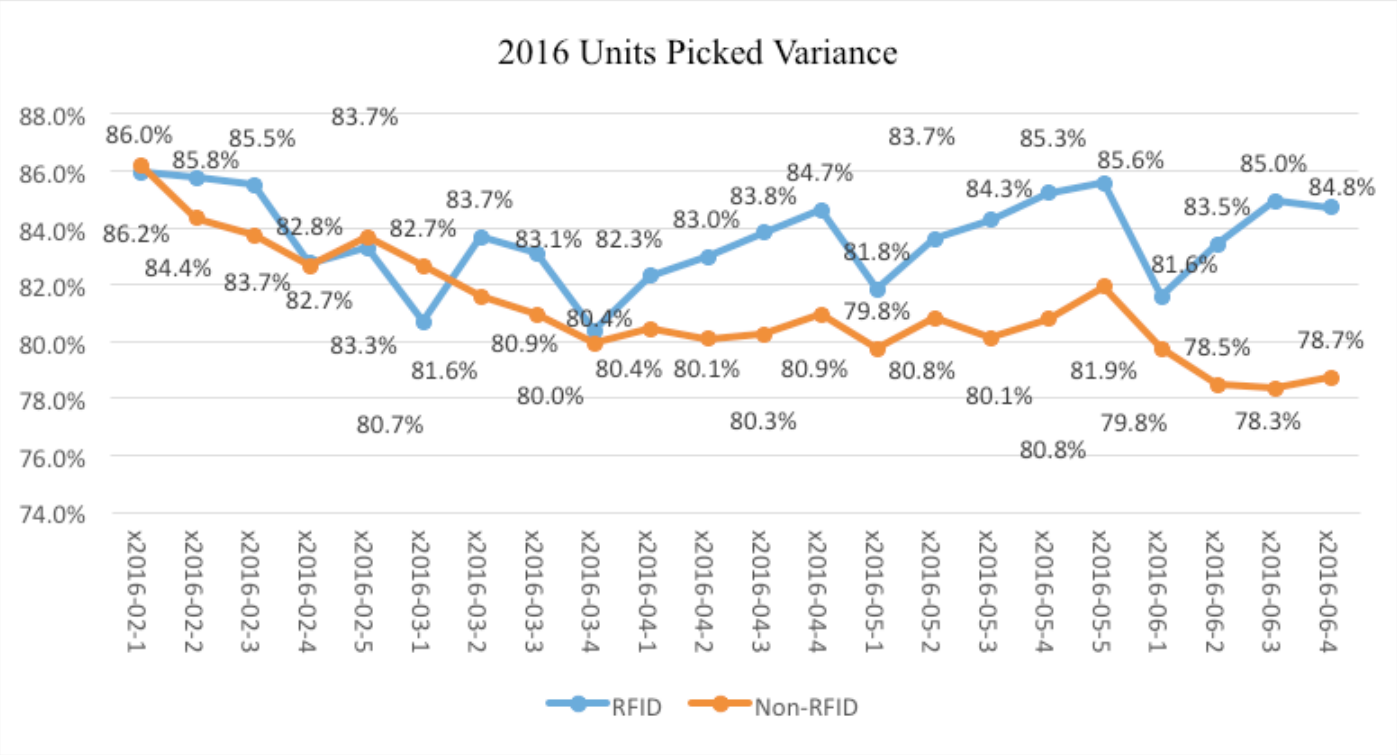


2016 Data Studies

Macy's also supplied a large data set for the first five months of 2016. This data encompasses the results from all store divisions that had at least 8 percent of the division's vendors RFID-enabled. From this, we then compared the performance of RFID-enabled merchandise with non-RFID-enabled merchandise.

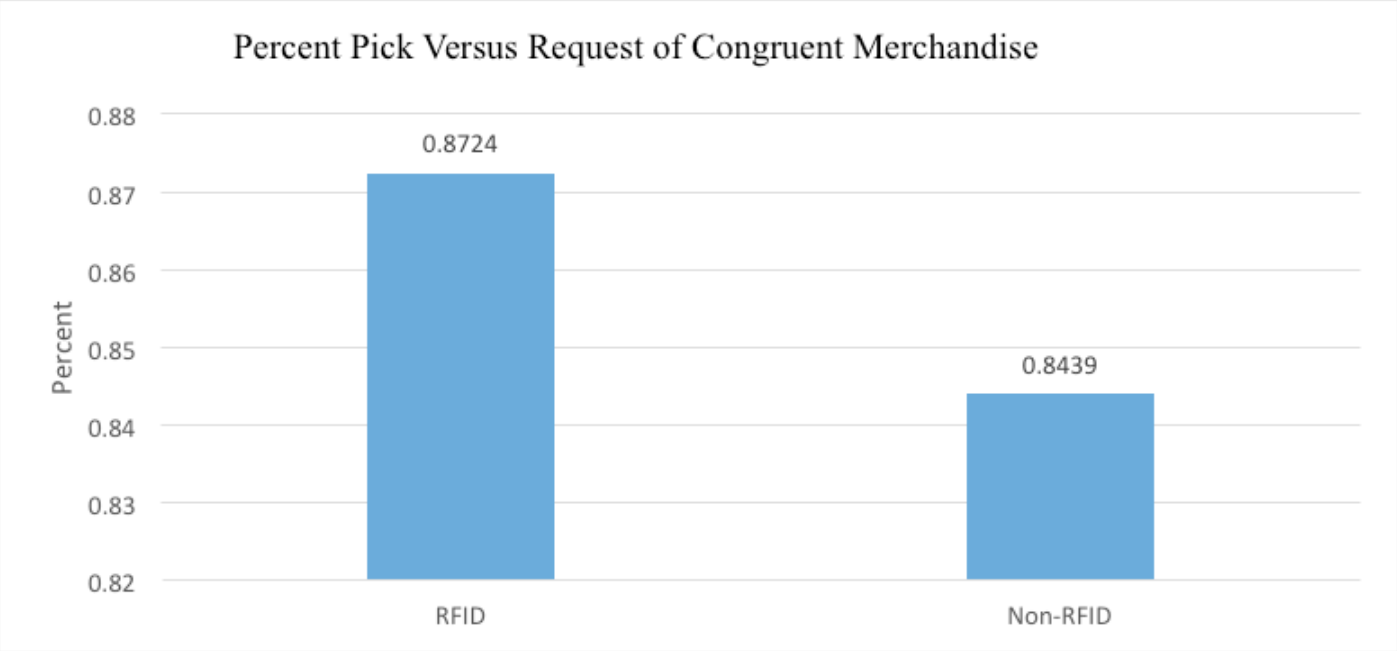
UC #3-Chart 15 compares the unit pick rate (orders filled as a percentage of orders requested) of RFID- versus non-RFID-enabled merchandise for the first five months of 2016 (this includes both online and orders from other stores). Note that at the end of fiscal 2015 (January 31, here shown as February 1), when a physical record is taken, pick rates are fairly consistent between RFID- and non-RFID tagged merchandise. As the year goes on, cycle counts are taken of the RFID-tagged merchandise and the inventory records are adjusted. The non-RFID merchandise inventory records are not adjusted. As the Chart illustrates, over time, the fill rates of RFID merchandise are generally higher than the non-RFID merchandise. This indicates, among other things, that the ability to locate and sell RFID-enabled merchandise (as merchandise is picked to fill an order) is higher than for non-RFID enabled merchandise. Stated another way, the ability to fill orders of RFID-enabled merchandise is more efficient than that of non-enabled merchandise.

UC #3-Chart 15.



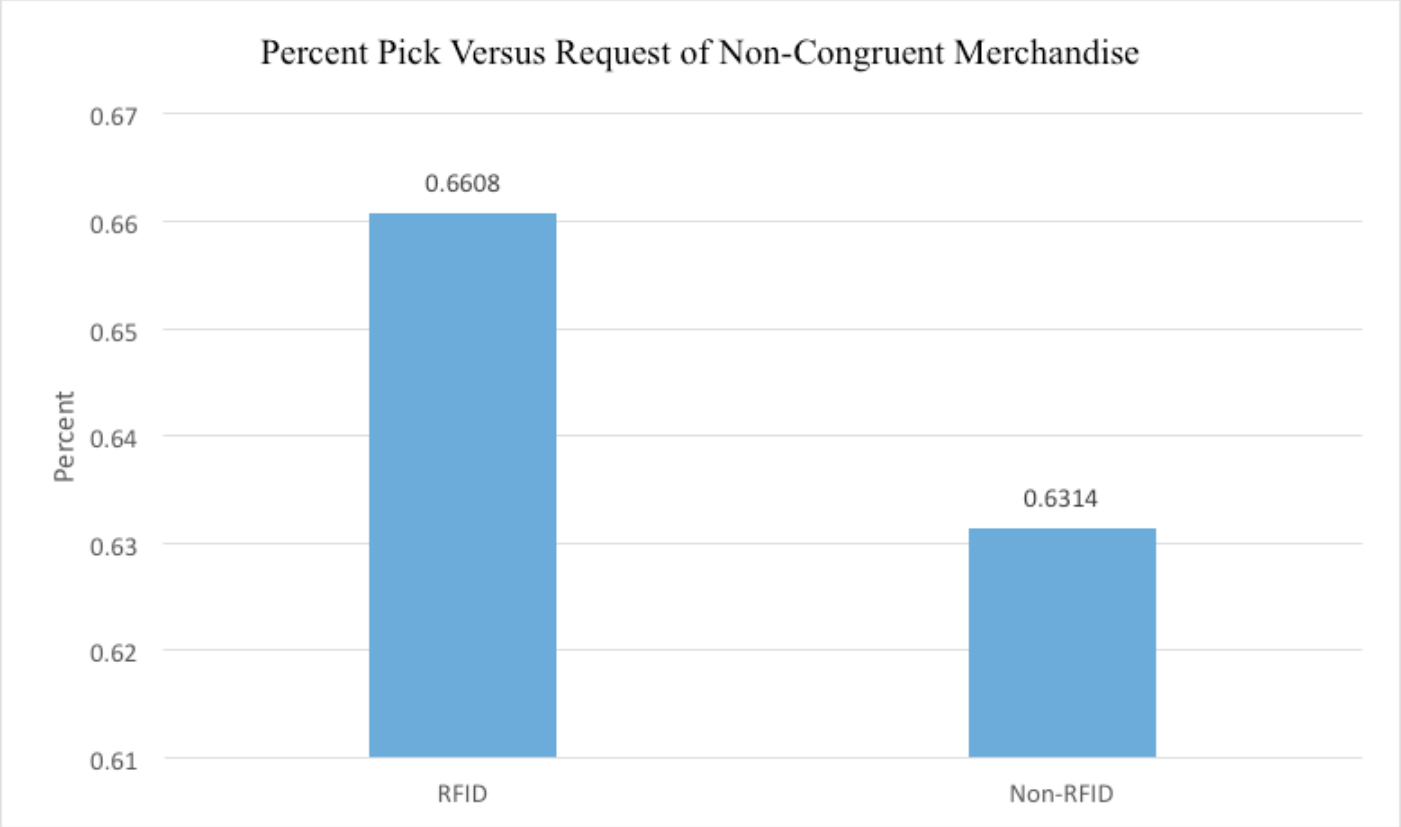
In UC #3-Chart 16, we compare unit sales of RFID- and non-RFID-congruent merchandise. Congruent merchandise again refers to merchandise that is native to a store. As we are comparing the request to fill rate, this supports the proposition that it is easier to find RFID merchandise in a store to fill an order.

UC #3-Chart 16.



In UC #3-Chart 17, we again compare unit sales of RFID and non-RFID merchandise, here looking at merchandise that is not native to a store. As we are comparing the request to fill rate, this once again supports the proposition that it is easier to find non-congruent RFID merchandise in a store to fill an order. In both instances (congruent and non-congruent), the RFID-tagged merchandise fill rate outperforms the non-RFID-tagged merchandise by approximately 3 percent.

UC #3-Chart 17.



D. Use Case #4: Back to Front

This final Use Case Four is a study of selling floor replenishment. It presents the benefits that can result from utilizing RFID technology to improve the sales floor fill-in process by increasing the amount of merchandise that is represented on the sales floor. It was felt that by adopting back to front (BTF) procedures, enabled by RFID, a near real-time approach to replenishment could be achieved and impact sales due to increased customer merchandise visibility.

By way of background, Macy's estimates that 13 to 20 percent of all merchandise is kept in store stock rooms. Of that 13 to 20 percent, some 5.5 percent of Universal Product Codes (UPCs) that should be represented on the sales floor at any one time are not, in terms of the appropriate assortment of colors and sizes. To address this, various tests of BTF were undertaken beginning in August 2015. The process itself involves scanning either the back room or on-the-floor merchandise. Items that are detected as not on display, that should be, then become part of a missing file that generates a pick list for sales associate merchandise fill-in. Satisfied with the early test results, Macy's began implementing BTF systemwide in August 2016.

It should be noted that BTF is still in the early stages of implementation at Macy's and being refined. For example, store level compliance procedures are still being developed. As the findings below indicate, as items placed on display tend to have higher sales rates, improvements in this process can be beneficial. These improvements can include, for example, increasing the number of picked items placed on display that are found on the missing file.

Three studies, as detailed below, were undertaken from the test data that was made available by Macy's.[28] Summary findings are as follows:

1. Unit Sales: There is a strong correlation between sales and units picked. The data supports the finding that items placed on display sell at a higher rate than those that are not displayed.
2. No Prior Sales: The data also supports the conclusion that items picked and put on display, which have not been sold before, sell at a higher rate than those that are not put on display.
3. Sales by Merchandise Category: Sales of units put on display outperform those that are not found (i.e., not displayed) in all categories considered. In addition, the impact of BTF on sales among categories varies.

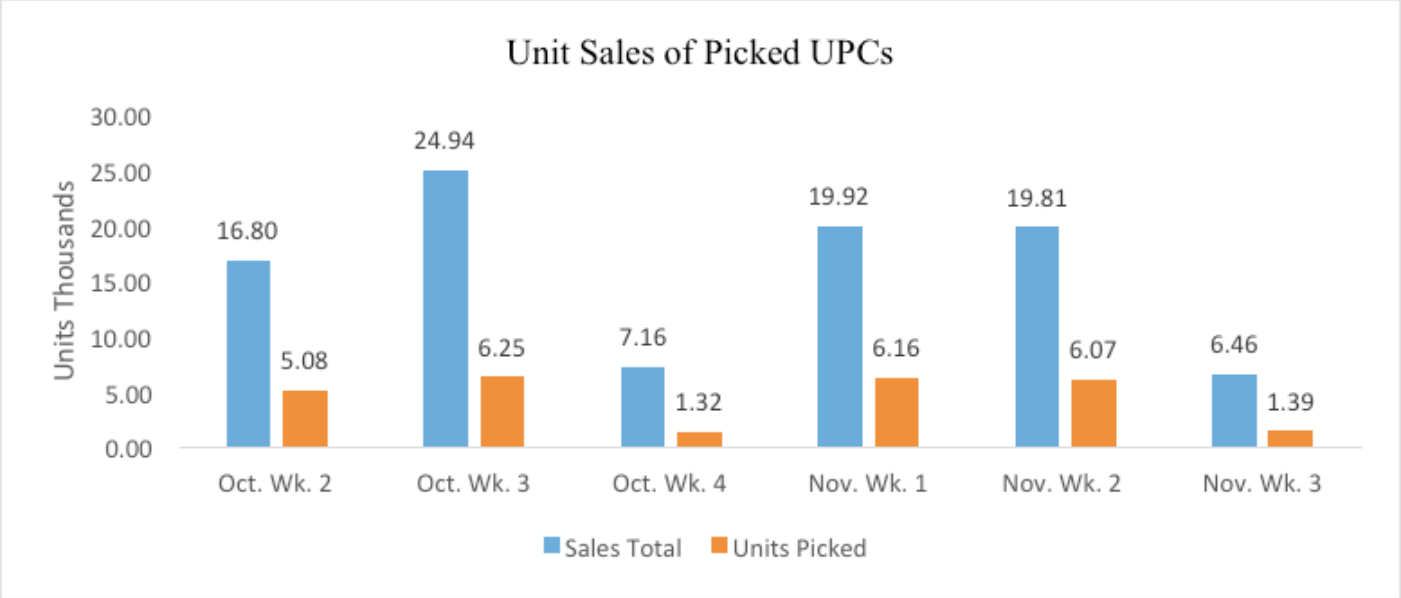
1. Unit Sales.

Here we consider the relationship between the rate of sales (Sales Total) of items that were found to be missing from the sales floor (on the missing file) and merchandise that was put on display (Picked). Sales are included if a UPC pick and sale of the same UPC occur during the same week (that is, both the pick and the sale).

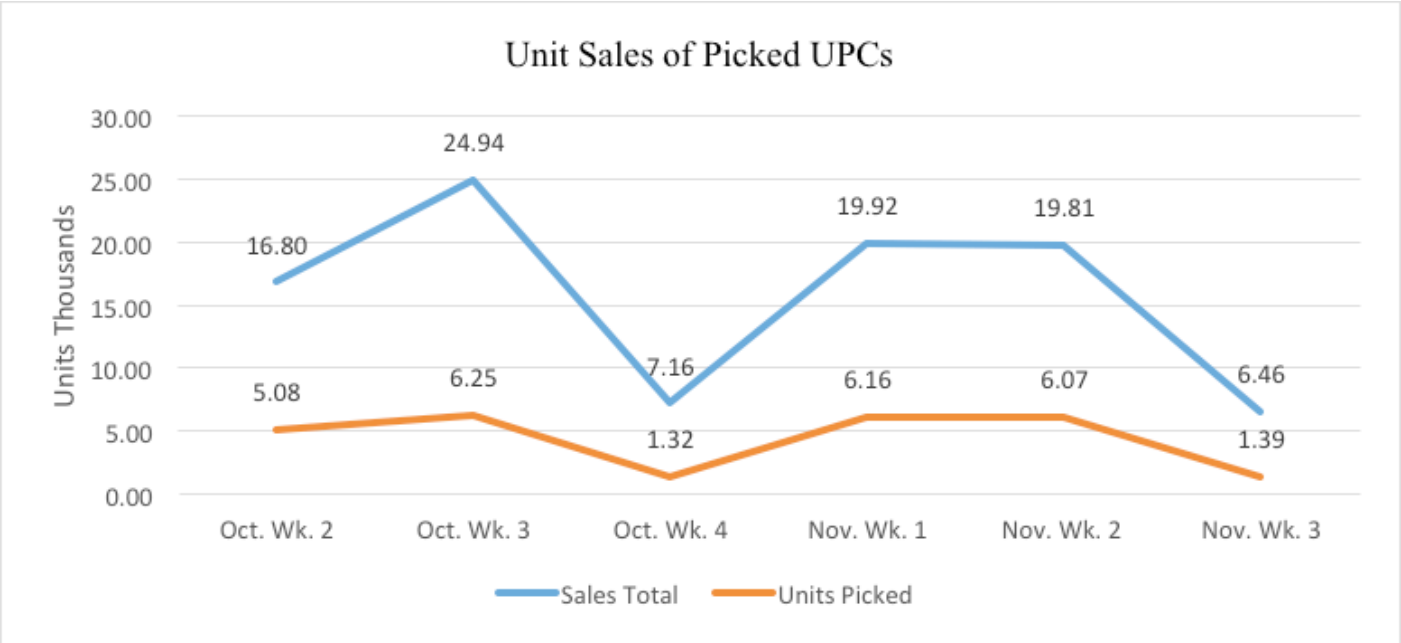
[28] Macy's accumulated all the primary data that was examined. Data provided includes six weeks during October and November 2016.

UC #4-Charts 1 and 2 show the unit sales of picked UPCs relative to total sales. The sales total and sales of units picked generally follow the same trend.

UC #4-Chart 1.

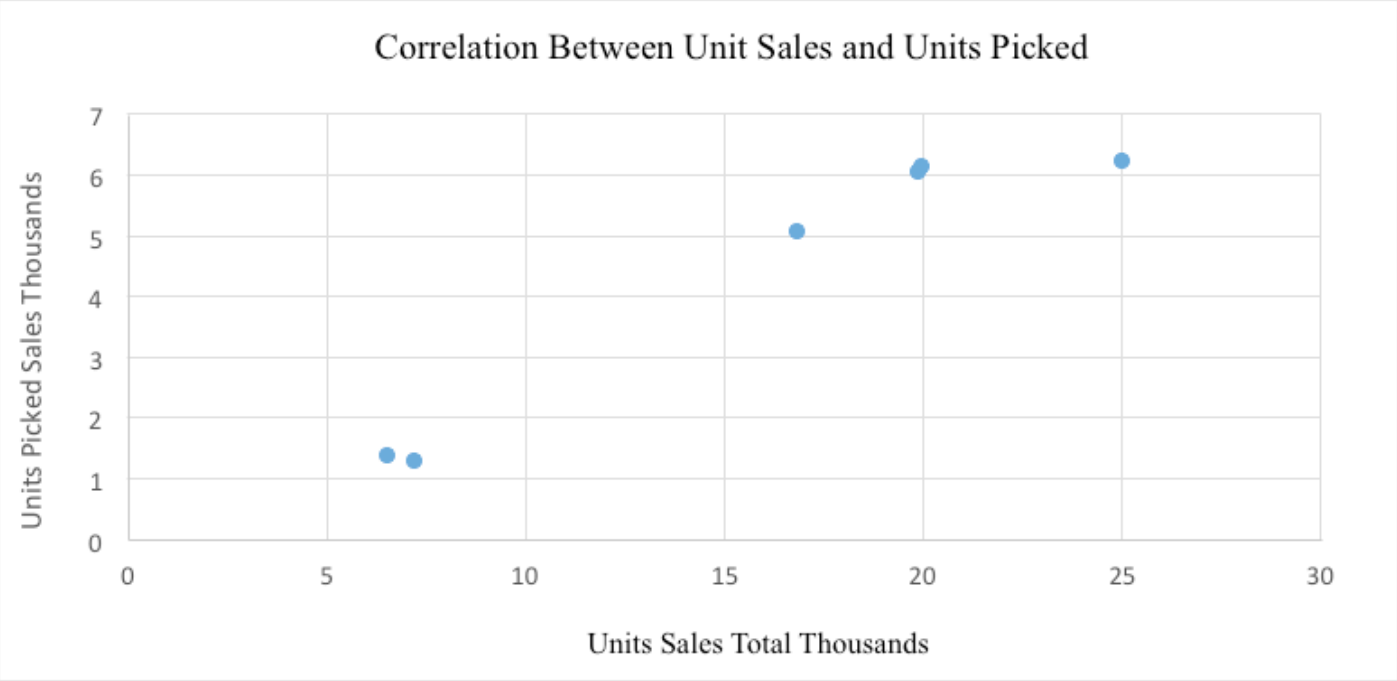


UC #4-Chart 2.



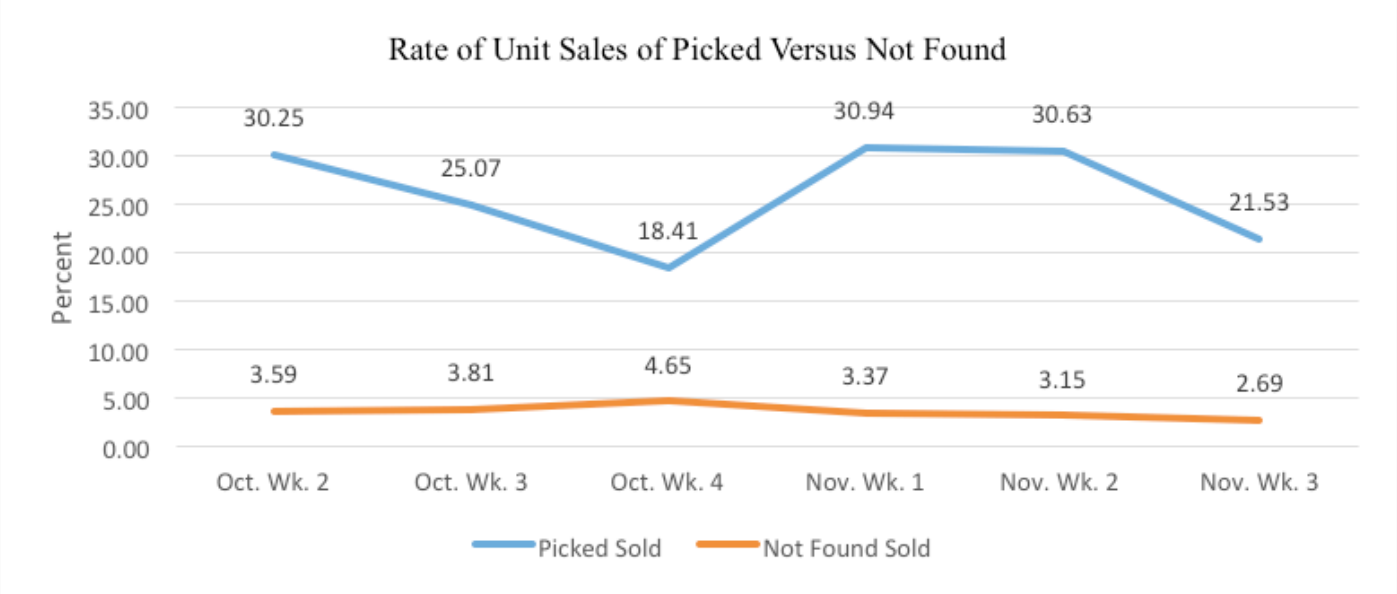
In UC #4-Chart 3, we show the correlation between units picked sales and unit sales total. As total sales increase, unit picked sales also increase, as shown by the blue dots on the chart. This again demonstrates that the sales total and sales of units picked (those placed on display) have a strong positive correlation.

UC #4-Chart 3.



UC #4-Chart 4 compares the rate of unit sales of picked items with those that were not placed on display (that is, not found). As can be seen, the rate of sales of those placed on display greatly exceeds those that are not.

UC #4-Chart 4.

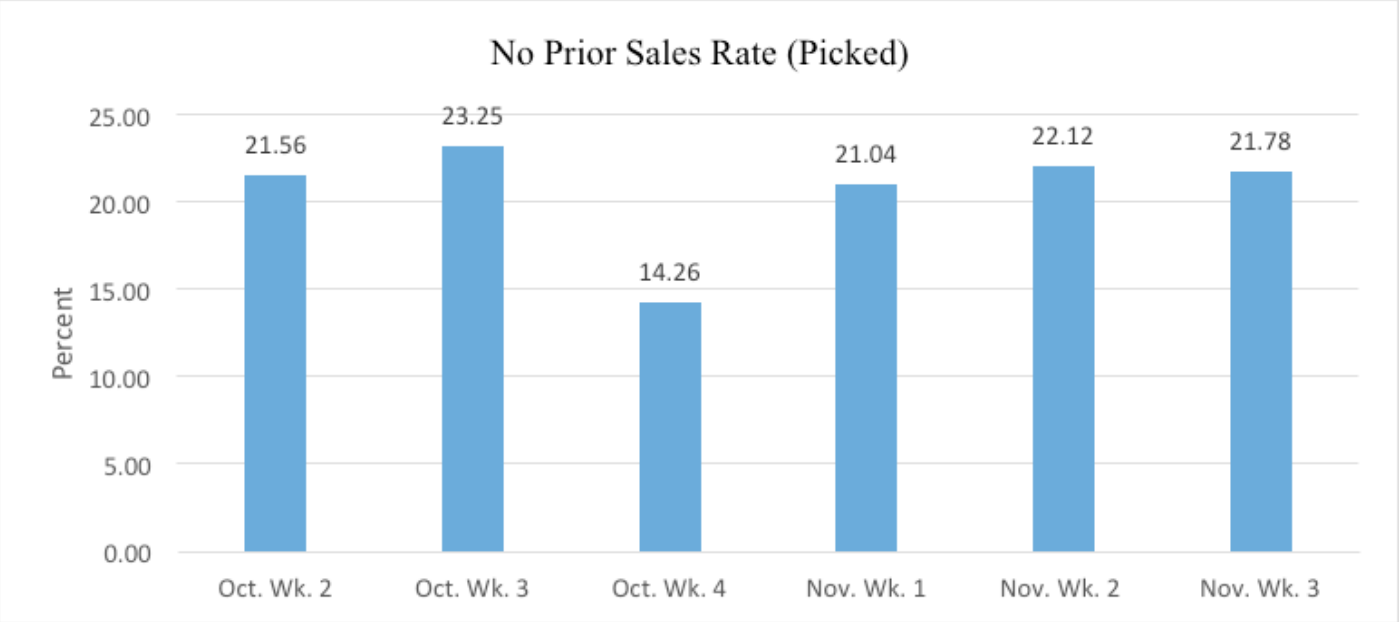


2. No Prior Sales

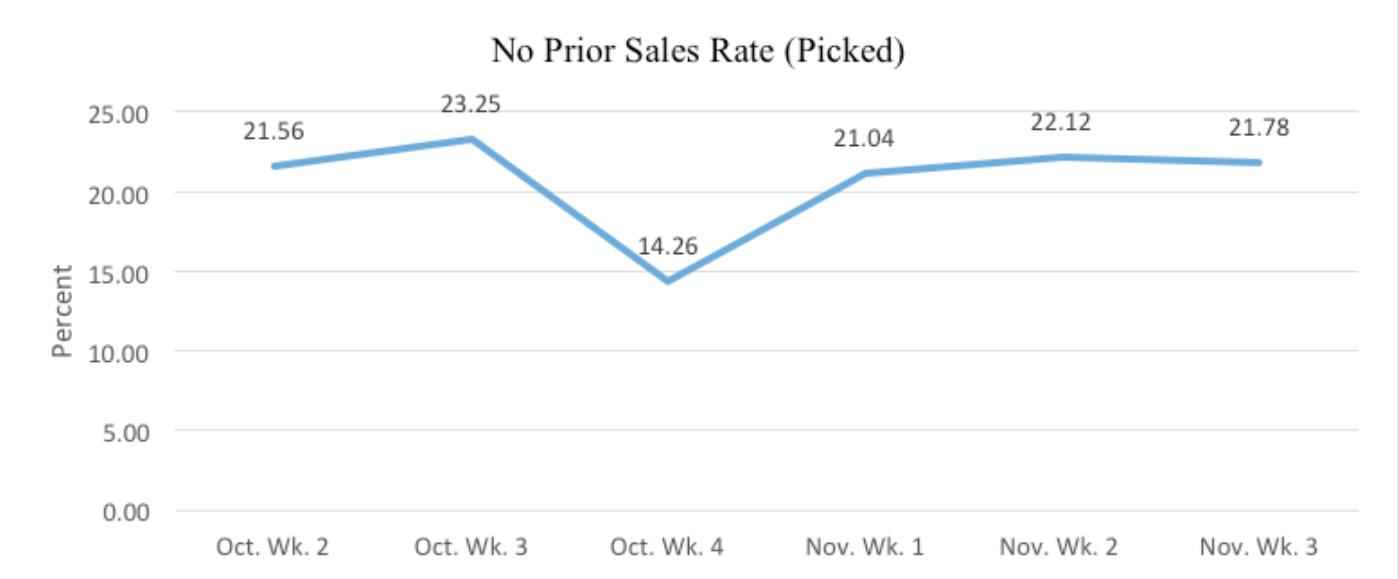
In this data set, the sale of items that were missing from the sales floor (on Missing File) that had no prior year-to-date sales is considered. This includes no prior year-to-date sales of picked and not found merchandise. This is shown as a percentage (no prior year-to-date sales of an item picked and again for an item not found divided by unit sales total for the week).

The rate of no prior sales rate (Picked), is shown in UC #4-Charts 5 and 6.

UC #4-Chart 5.

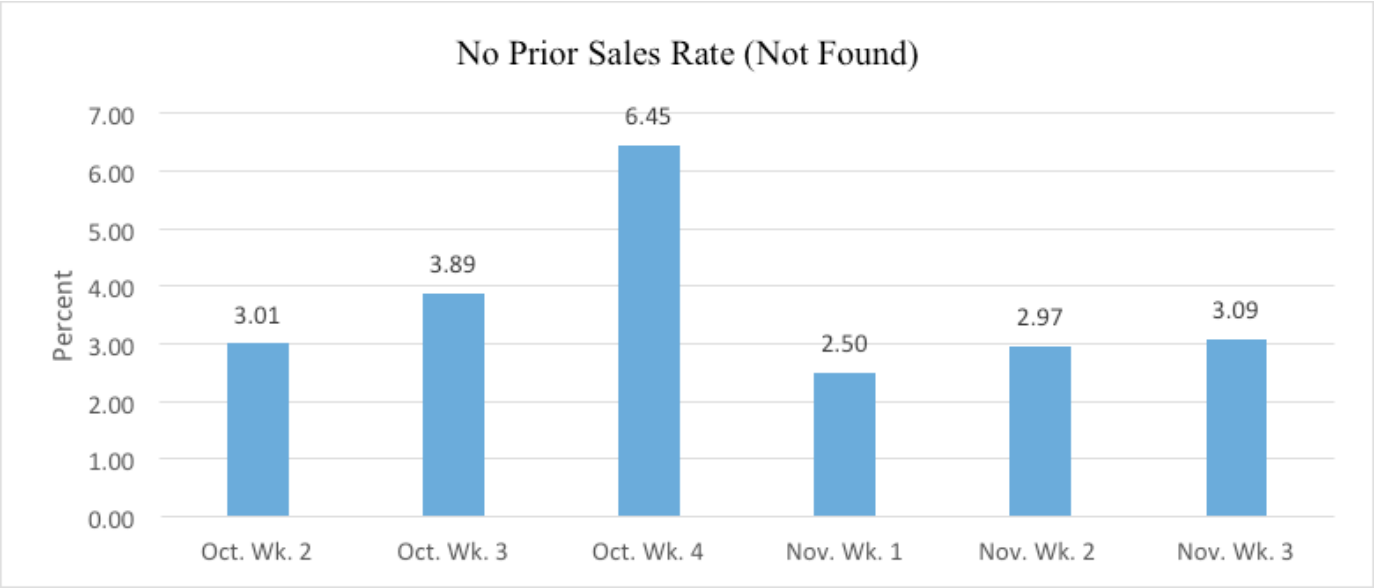


UC #4-Chart 6.

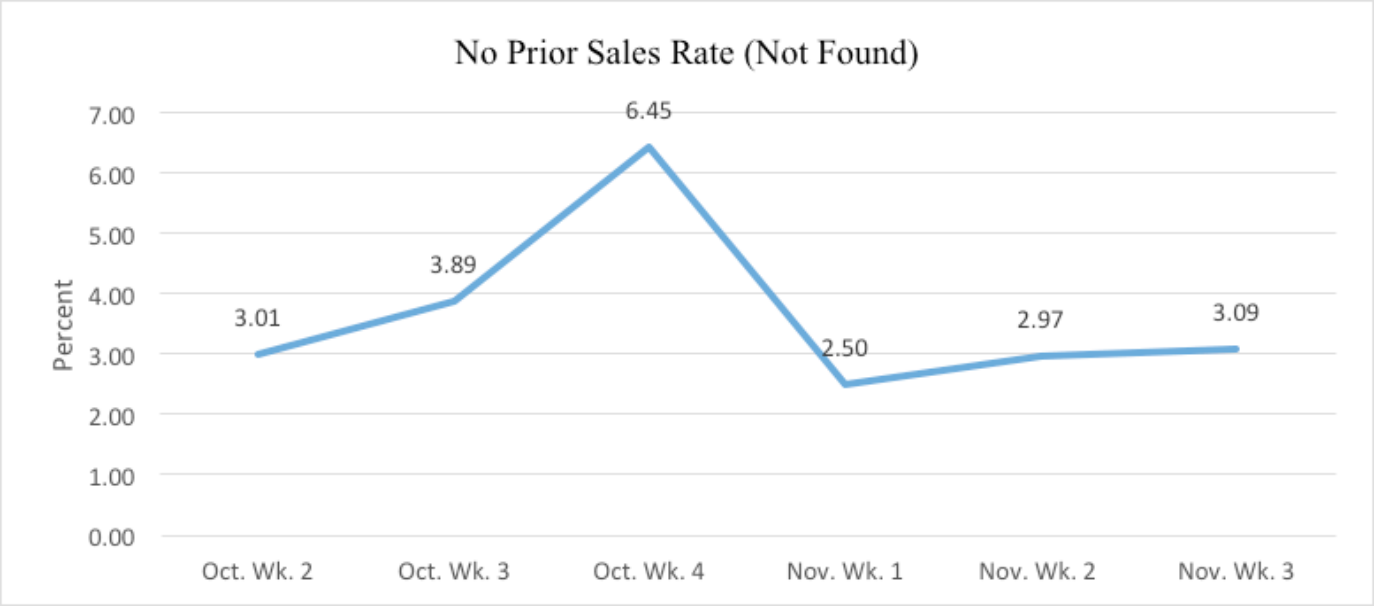


The rate of no prior sales rate (Not Found), is shown in UC #4-Charts 7 and 8.

UC #4-Chart 7.

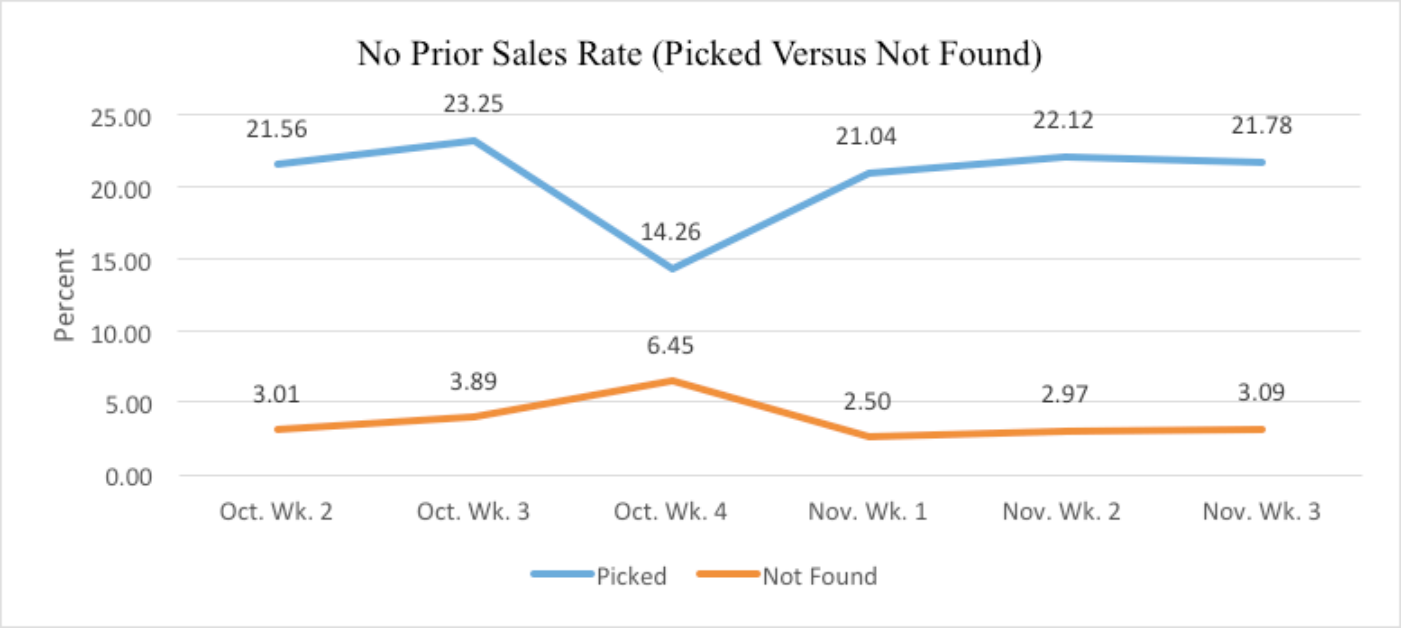


UC #4-Chart 8.



In UC #4-Chart 9, a comparison of the rate of no prior item sales is presented of picked (put on display) versus not found (not put on display). The data supports the conclusion that items picked and put on display (that have not been sold before) will sell at a higher rate than that of not found items.

UC #4-Chart 9.



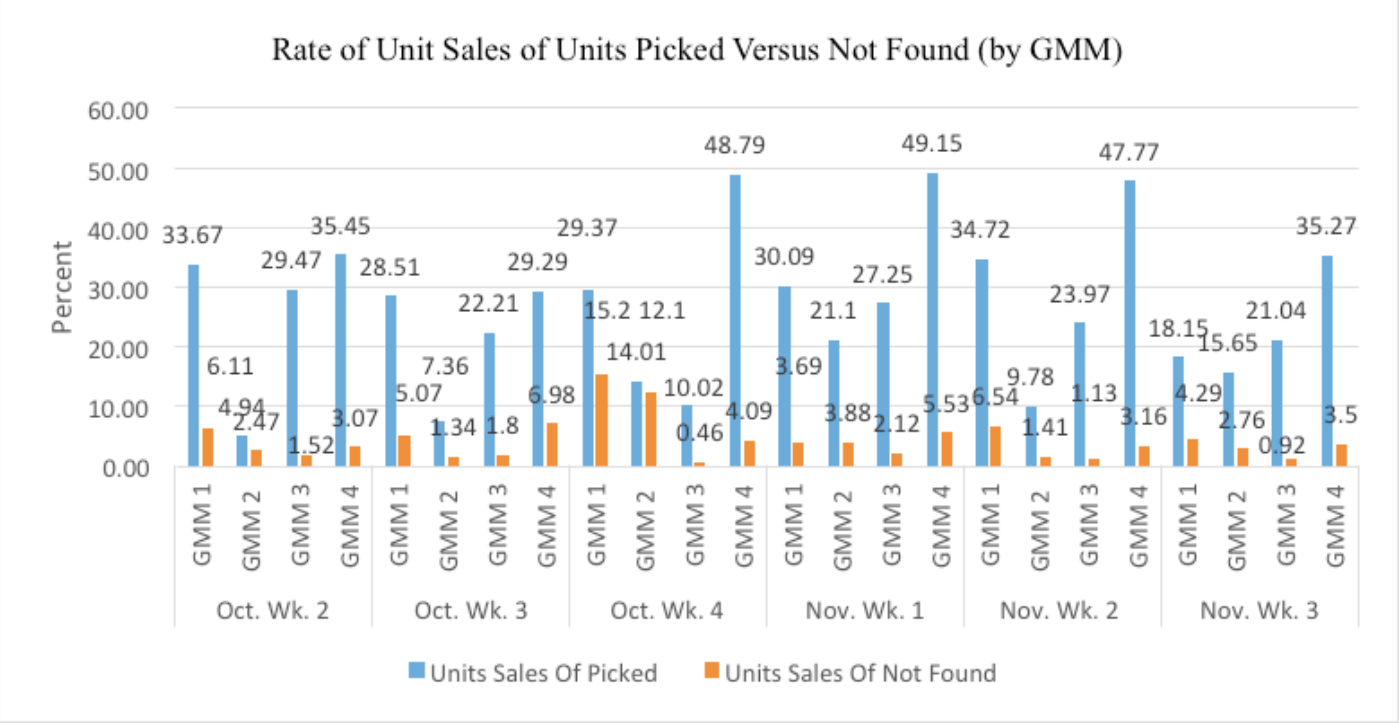
3. Sales by Merchandise Category

Here we consider the impact of BTF on sales performance among various general merchandise categories. These include Center Core, Ready to Wear, Men's and Kid's, and Home. Due to confidentiality concerns, the specific performance of each category cannot be made public. Notwithstanding, the data illustrates that the impact of BTF on sales performance in the various categories differs.

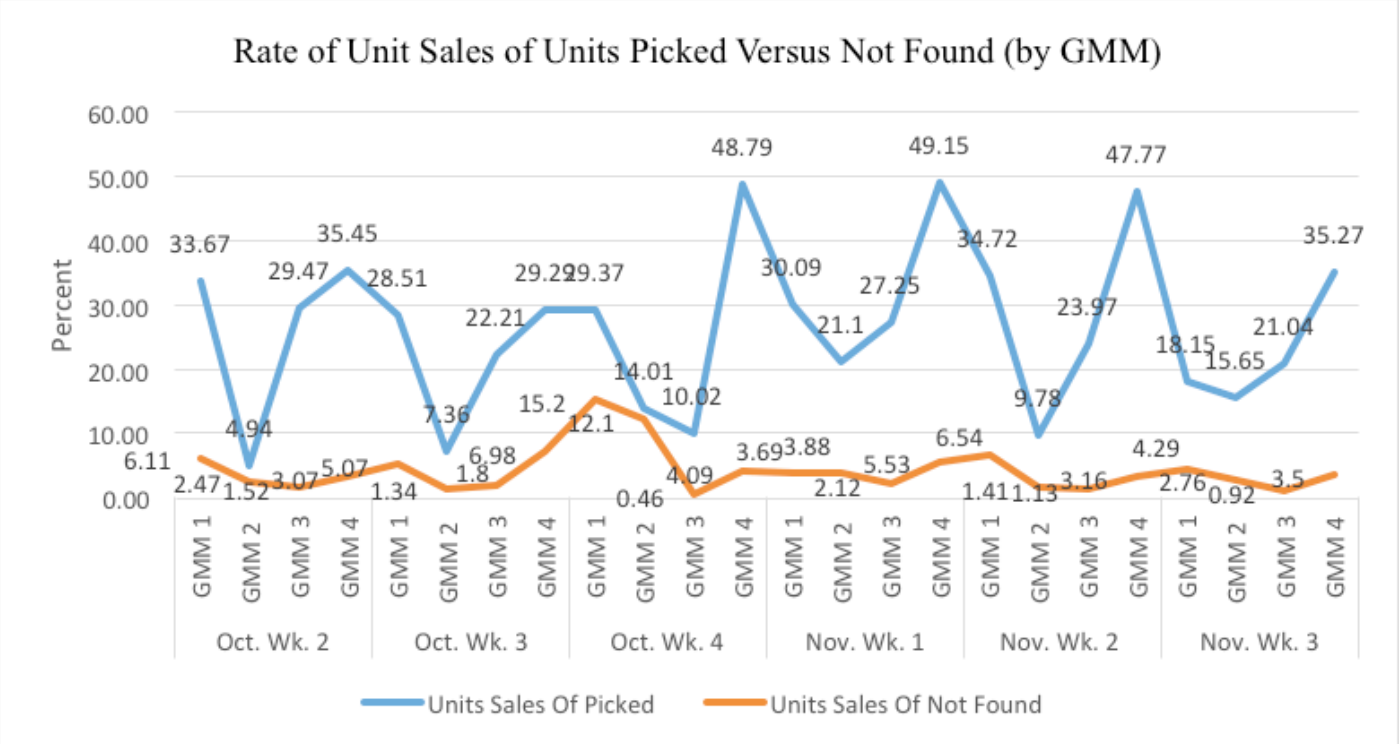
UC #4-Charts 10 and 11 compare the rate of sales of units picked versus not found. From this comparison, several observations can be made. First, sales of units put on display (picked) outperform those that are not (not found) in all categories considered. Second, as would be expected, the impact of BTF on sales among categories varies. What is worth further investigation are the sales variances from week to week between

picked and not found within each category. To illustrate, in October Week 4 for GMM 2, the difference between the two was 1.91, and in November Week 1, it was 17.22. As well, more effort may be directed to putting units on display that sell at a greater rate (note in October Week 4, GMM 4 sold 48.79 percent of picked units sold).

UC #4-Chart 10.

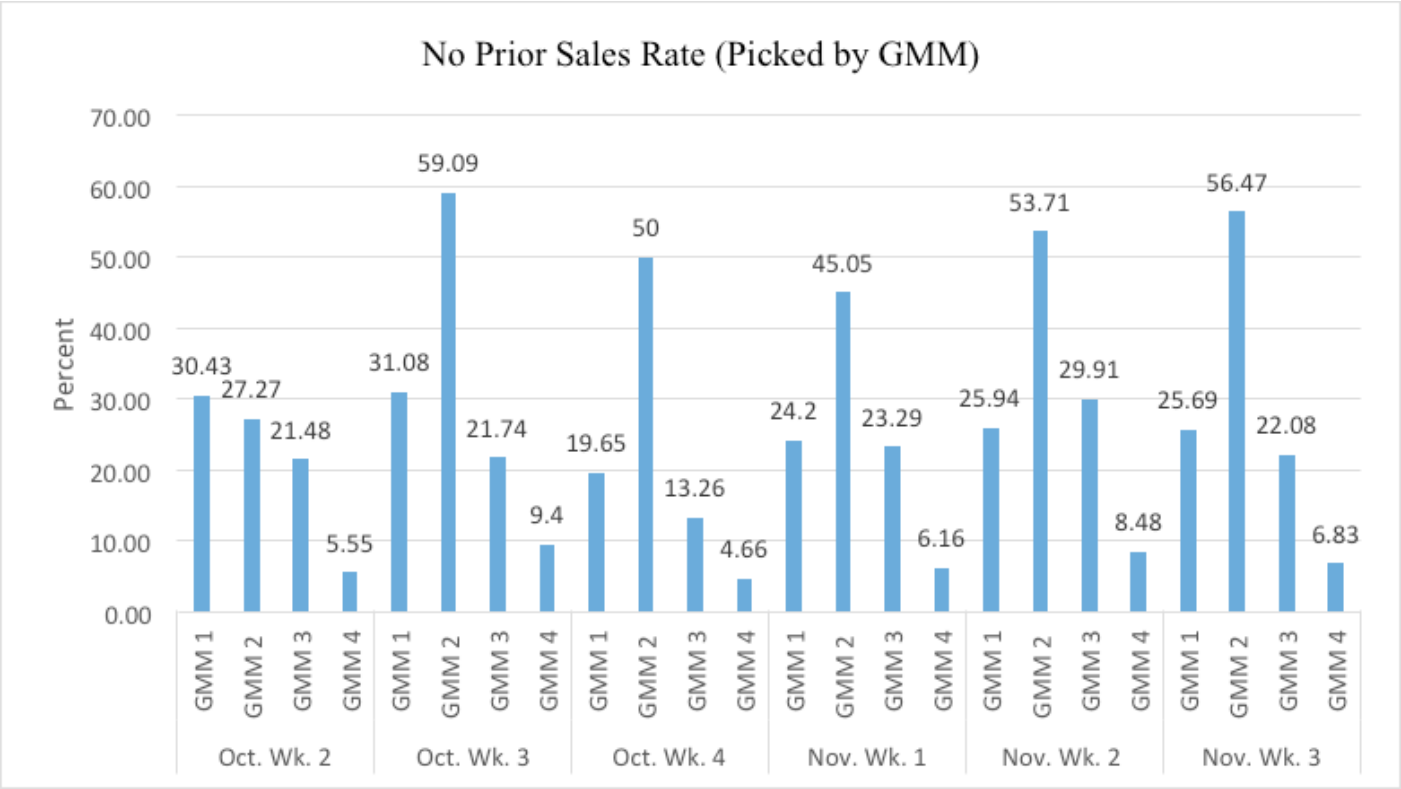


UC #4-Chart 11.

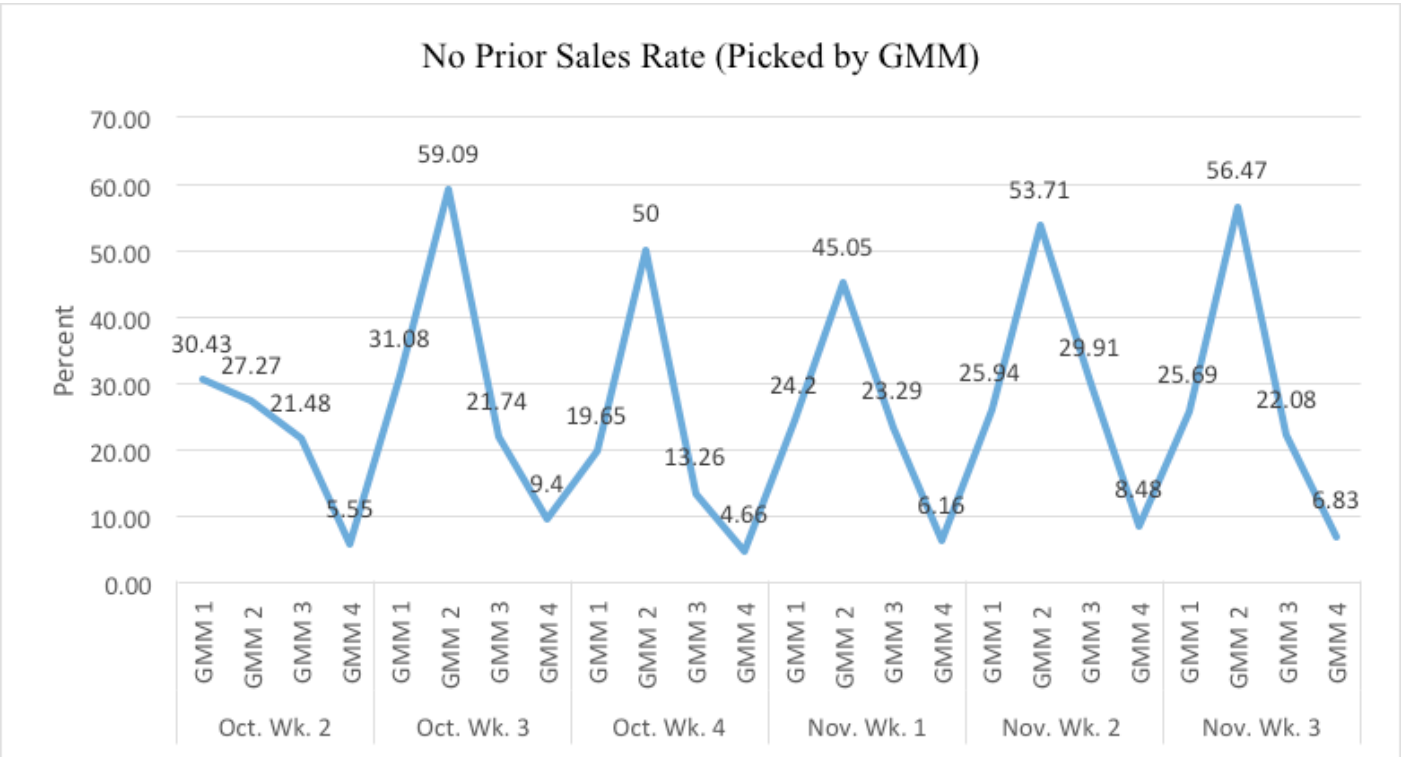


UC #4-Charts 12 and 13 illustrate the rate of no prior sales by the four general merchandise categories.

UC #4-Chart 12.

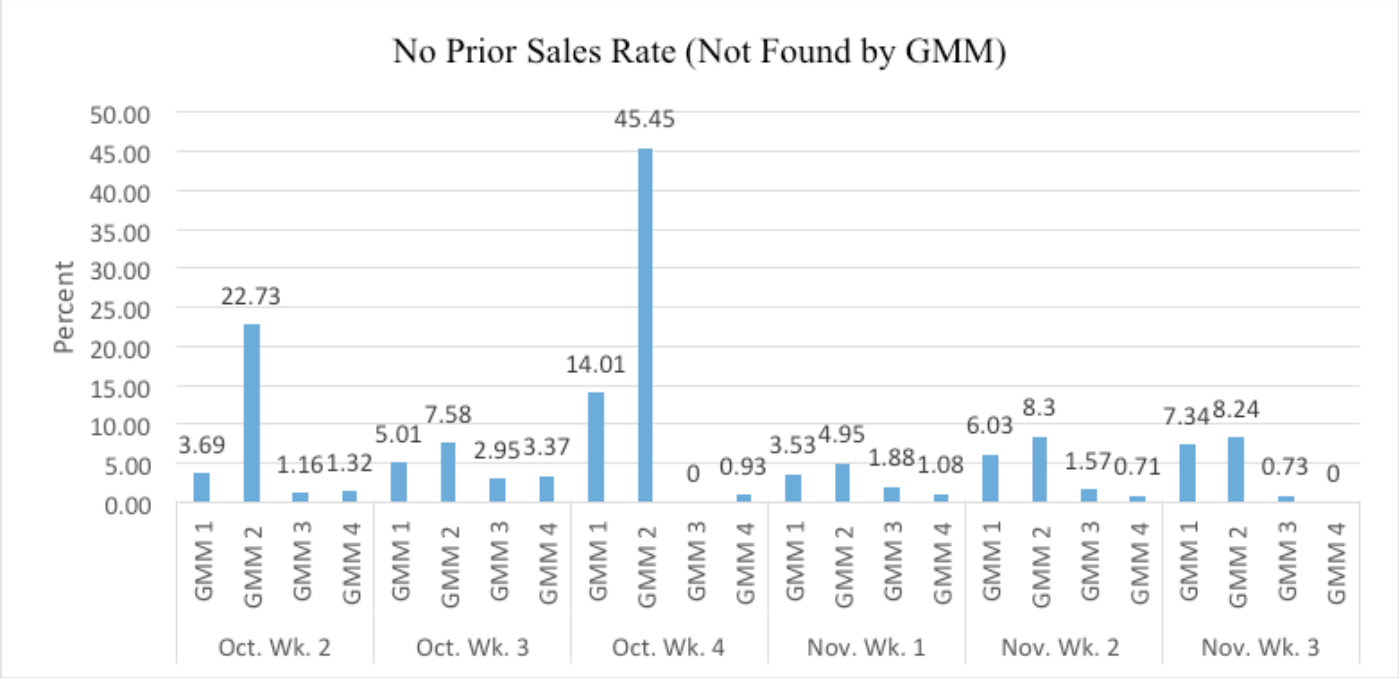


UC #4-Chart 13.

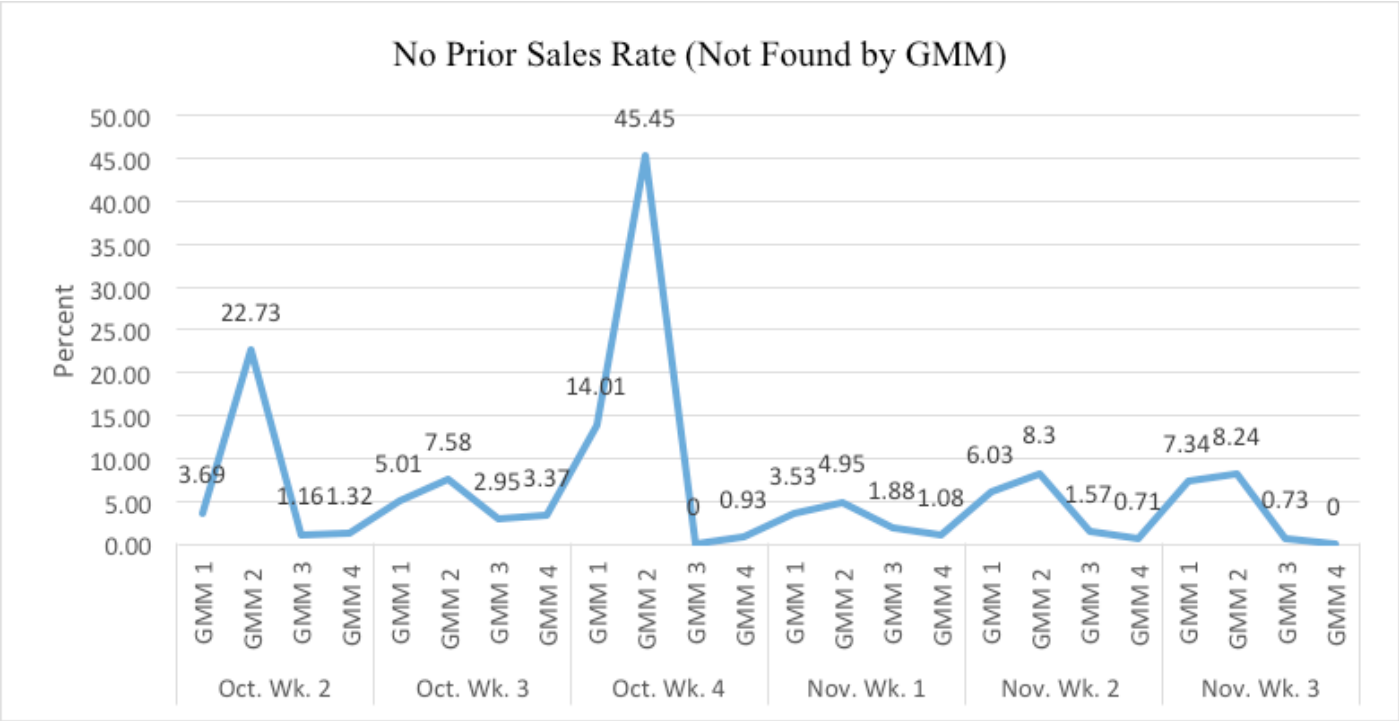


UC #4-Charts 14 and 15 illustrate the rate of no prior sales for the four general merchandise categories of items not found. As can be seen, the rate of sales of picked items greatly exceeds that of not found items for all general merchandise categories.

UC #4-Chart 14.



UC #4-Chart 15.



IV. Integrated Analytical Applications

Retail analytics has become a particularly popular topic as of late. J.C. Penney Co. noted, for example, that it was working on the "Science of Retailing," which is to include a focus on data analytics.[29] The Gartner organization has predicted that by 2019, 90 percent of large organizations will have a chief data officer. [30] Research firm Markets and Markets projects that the retail analytics market will grow from "$2.2 billion in 2015 to $5.1 billion by 2020, at an estimated compound annual growth rate of 18.9 percent from 2015 to 2020." [31]

Fueling this movement are, among other things, findings that firms that invest in big data and analytics outperform their competitors by 5 percent in productivity and 6 percent in profitability.[32] Similarly, it has been stated that: "The aggressive adoption and exploitation of analytics has led to competitive advantage among some of the world's most successful retailers." [33] Finally, research has found that "firms in the retail industry have the most to gain from increasing their deployment of customer analytics." [34]

In this section, we address information produced by RFID and how, in combination with other data, additional analytics can be generated to produce valuable business insights. While not addressed at length here, it is noteworthy that the structure for a successful retail data and analytics program rests upon a solid plan for implementation and information distribution. Underlying such a strategy requires an understanding of the business decisions that are sought to be addressed, what data is required to answer them,[35] data ingestion, modeling and processing, analysis, and ensuring that actionable insights are distributed to the appropriate parties within the organization. For RFID data to be optimized it would, of course, need to be integrated into such a structure.

RFID measurement technology serves as an instrument to accumulate information that generates data. In this regard, RFID has been described as possessing "powerful and dynamic data-acquiring capabilities."[36] Data, in turn, can be defined as the "an elementary description of things, events, activities and transactions that are recorded, classified, and stored, but not organized to convey any specific meaning."[37] The value of RFID ultimately is, of course, associated with the ability to use that data to analyze and address business issues. Stated another way, "the value of the data originating from RFID devices can be determined by the context in which it is interpreted and the subsequent business value derived."[38]

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[29] See: http://risnews.edgl.com/retail-news/jcpenney-working-on-the--science-of-retailing-103373?referaltype=newsletter.

[30] See: http://www.information-age.com/it-management/skills-training-and-leadership/123460847/90-large-organisations-will-have-chief-data-officer-2019-gartner.

[31] See: "Retail Analytics Market Global Forecast and Analysis to 2020," *Markets and Markets*.

[32] See: "Big Data: The Management Revolution," *Harvard Business Review*, October 2012, and "Making Advanced Analytics Work for You," *Harvard Business Review*, October 2012.

[33] "Realizing the Potential of Retail Analytics; Plenty of Food For Those With the Appetite," *Babson Executive Education,* 2009.

[34] "Do Retailers Benefit from Deploying Customer Analytics?" *Journal of Retail*, 2014.

[35] See: i.e., "Companies must hire, develop, and retain skilled analysts who can distinguish relevant from irrelevant data," *Perspectives on Retail and Consumer Goods*, McKinsey & Company, Spring 2013.

[36] "Emerging Technologies to Support Supply Chain Management," *Communications of the ACM*, Vol. 46, No. 9, 2003.

[37] *Information Technology Management: Transforming Business in the Digital Economy*, 3rd ed., 2002.

[38] "Information Quality Attributes Associated with RFID-Derived Benefits in the Retail Supply Chain," *International Journal of Retail & Distribution Management,* Vol. 35, No. 1, 2007.

In general, RFID information has been viewed in a vacuum. That is, RFID data has, for the most part, been applied in the context of how it relates to merchandise in the supply chain and store (as outlined, for example, in the Use Cases presented in this research). Some firms are also starting to recognize its value in the loss prevention arena as well. Yet this valuable information, when combined with other data, can produce many advantageous business insights that have not been fully explored.[39] Considered in another way, RFID intelligence can be used to generate many additional retail insights that can "help organizations make better fact-based decisions with the aim of driving strategy and improving performance."[40]

We begin this discussion with reference to Figure 1, which lists various types of retail-generated data. This is followed by examples of how this data, when processed in various combinations, can generate valuable retail business insights in combination with RFID information.

Figure 1. Retail Data Sets

DATA SET	Summary of Information Provided for Purposes of This Research
Customer	ID, Name, Address, Gender, DOB, CRM/Loyalty Program, Demographic, In-Store Location
Store	Location, Description, Traffic, Promotions, Associate Location and Skill Set, Environmental and Locational Inputs
Mobile App.	Activity, Location, Customer Interactions, Promotions/ Events, Transactions
Social/Online	Activity, Customer Interactions, Promotions/Events
POS/Transactional/Product	Transaction Type, Payment Type, Product(s) Purchased, Product Purchase Associations, Transaction Dollar Amount, Demand, Category, Price
Inventory Systems/RFID	Inventory, Product Information and Location, Supply Chain

Integrated Analytical Application Models

The following models are presented that incorporate RFID data, in combination with other data sets, to produce additional retail intelligence. These are:

1. Demand Forecasting and Merchandise Trends.
2. Dynamic Pricing.
3. Fitting Room Utilization and Conversion.
4. In-Store Marketing.
5. Merchandise Placement.

[39] For example, it was noted that the process of creating new RFID application scenarios has not been investigated in the available literature, "Methodology for the Development of RFID Value Added Services to Improve Supply Chain Operations," *Transactions of FAMENA*, 2012.

[40] "Data is the Next Frontier: Analytics the New Tool," *Executive Briefing, Lancaster University,* 2012.

A. Demand Forecasting and Merchandise Trends

Background

Demand and trend forecasts are key to effective merchandise management. Improving forecasting can result in better buying decisions, fewer stock-outs, and reduced overstock positions (which can lead to markdowns). In addition, sales and customer satisfaction can be positively impacted because of better merchandise planning and the maintenance of appropriate stock levels. In certain verticals, such as fashion and electronics, the need to place advance orders, short product life cycles, high product variability, and demand uncertainty make such forecasting difficult.

Forecasting has generally relied on quantitative methods based on historical attributes (i.e., prediction models that may incorporate expert judgment, market research, and fashion and trend service forecasts). By incorporating social media information with accurate inventory and POS information, it is suggested that better merchandising decisions can be made.

Data Sets

Relevant data sets may include: Social/Online, Inventory Systems/RFID, and POS/ Transactional/Product.

Process

Monitor social media (the term electronic word of mouth or eWOM is now in use) to aid in demand planning and to detect merchandise trends. A model to accomplish this will require a taxonomy of descriptive terms associated with each product.[41] Figure 2 illustrates this (with a sample of comments associated with each product found online):

[41] Image analysis can also be key, especially for fashion retailers. Ingesting sample images and analyzing them to detect objects in an image may address this.

Figure 2. Sample Taxonomy of Descriptive Terms.

Product	Descriptive Terms	Example of Comments
Women's Yoga Pants (by color, description, material)	Sweat pants, gym pants, yoga pants, workout pants, lounge pants, athletic pants, fleece pants	Very comfy and lightweight Great loose fit but light colors are see through EXCELLENT FIT Fabulous Comfy Cool & comfortable Love it! Can't go wrong Slimming Perfect for workout Love the fabric and color Comfy and cute
Girls Athletic Tops (by color, description, material)	Active top, sportswear, athletic wear, workout wear, active top, active wear, gym clothes	Great workout tank Great fit! Nice top Love it Great workout top! Perfect! Love the fabric and fit Love this top Perfect workout tank Cute AND functional! Stylish and comfortable Sexy cute! Was hesitant Love these tops Styling at the Gym!! OK for a workout top Too thin and clingy A little big

This information is then correlated with related social activity generated by social web mashup/aggregation tools that measure volume (frequency of comments) and valence (a measure of positive and negative comments). Each retailer will need to build and test models to gauge social media impact accuracy as it relates to merchandise planning, and its impact on category variety (depth of merchandise) and assortment (breadth of merchandise), and correlate those with sales and inventory information to determine model reliability. Piloting and fine-tuning the process using historical information will provide insights on the various factors and how they relate. Over time, these correlations should improve as more intelligence is accumulated. POS data will supply demand side information, while RFID data provides current supply level data against which to timely reconcile inventory levels.

For example, consider that a fashion retailer notices an uptick in positive social activity about a dress style in the color yellow. Using historical data, it has determined its social media correlation between style, color, and sales. Current inventory can then be considered in relationship to anticipated demand to ensure that this style and color of dress is on hand. A related example, for the same retailer, is that they notice that a color that was thought to be in demand is now producing negative commentary on social media. With confidence in their model, decisions to cancel orders, quickly markdown, or divert merchandise can prove beneficial.

Rationale

Studies have found relationships on the predictive value of social media text data. For example, a high correlation has been found between social media content and movie revenue.[42] Social media has also supported the use of search words for prediction capabilities.[43] Apparel, especially fashion items, are a consumer opinion-driven market and, as such, it is believed that "opinions, experiences and expectations might play a relevant role within (the) fashion forecasting processes,"[44] thus it is suggested to integrate consumers' opinions within the demand and trend forecasting process.[45]

B. Dynamic Pricing

Background

Merchandise pricing has a major impact on consumer purchase behavior. Thus, when a retailer sets a price for merchandise, they generally seek to strike a reasonable balance between profit maximization and the retention of customer loyalty. Another consideration is that most customers prefer fixed prices to ensure that they are being treated equally (i.e., fairly). Consequently, other than in support of a sale or promotion, retailers have generally been reluctant to change prices in response to changing conditions. Yet as merchants become more adept at leveraging analytics, and stores become more digitized to remain competitive with online rivals, dynamic pricing (DP) will become a retail reality.[46]

Variable pricing, as distinguished from DP, is not a new concept. It is defined as the practice of charging different prices for the same merchandise in different markets at the same time. Large retailers, such as Home Depot, use variable pricing, such as markdowns of products in a region, rather than chainwide. Land-based retailers for various reasons, on the other hand, are not currently implementing dynamic pricing. Not only is there a concern for potential customer resistance, but also few can currently implement such a strategy operationally. DP refers to the construct whereby prices are instantly adjusted in a store based on location, current demand, weather, competitor pricing (including online), and inventory levels and age, among other factors.

Data Sets

Data sets may include: POS/Transactional/Product (data for sales, price and demand analysis); Store (which would consider factors such as store traffic, weather conditions, customer demographics, and competitive pricing, for example); Mobile App. (for customer interactivity); and Inventory Systems/RFID (on-hand, age, and location and levels of inventory).

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[42] It was shown that social media feeds can be effective indicators of real-world performance, "Predicting the Future with Social Media," *IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology*, 2010.

[43] Estimate of influenza distributions based on search keywords related to the topic influenza were found two weeks quicker than other systems, "Social Web Mining and Exploitation for Serious Applications: Techno-Social Predictive Analytics and Related Technologies for Public Health, Environmental and National Security Surveillance," C*omputer Methods and Programs in Biomedicine,* 2010.

[44] "The Usage of Social Media Text Data for the Demand Forecasting in the Fashion Industry, Fashion Sales Forecasting and the Predictive Power of Online," *Dynamics in Logistics, Fourth International Conference*, 2014.

[45] A related research point is that a positive correlation between social media (electronic word of mouth) and sales has been demonstrated. See "The Effect of Electronic Word of Mouth on Sales: A Meta-Analytic Review of Platform, Product, and Metric Factors," *Journal of Marketing Research,* 2015.

[46] It should be kept in mind that Dynamic Pricing may not add value to all categories of merchandise (i.e., women's high-end dresses), nor is its use consistent with all retailer brands.

Process

Correlations between the data sets and the chosen merchandise are required. It is suggested to start with a limited set of inputs, and later expand that to include other information as confidence is gained in the process and with the outcomes.

The following Figure 3 illustrates an approach.[47] Assume that the product chosen for testing is a very popular and high-volume athletic shoe being sold at a chain of sporting goods stores. The dependent variable is item sales. Independent variables considered for purposes of this example include: price, demand (calculated as a function of the velocity of sales by day/time), store (data, such as customer traffic in the area the merchandise is located), and inventory (on-hand by age, size, and color). Here, price changes are considered in relationship between the variables (demand, traffic, and inventory). The impact on sales produced is an estimate of the elasticity of the price changes. As correlations between sales and the independent variables are determined, the retailer can make price changes to meet its goals.

Figure 3. Dynamic Pricing Model Example

This application considers changes in end user demand based on price changes in relation to various inputs. Data relationships will drive price variances based on conditions. Then, when the conditions present themselves, prices can be adjusted. As an illustration, it may be found that if snow is present in the region, heavy customer traffic around replenishment items, such as milk or diapers, decreases customer price sensitivity, resulting in the ability to increase prices without a negative impact on demand.

RFID data plays several critical roles. These include measures of on-hand inventory (accuracy) and the location of that inventory. In addition, RFID data provides accurate information related to the age of inventory, which may facilitate price changes.

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[47] For purposes of this illustration, it is presumed that the retailer can process data and display price changes in real time.

Rationale

DP is not unknown to or unaccepted by consumers. For example, the transportation service Uber uses "surge" pricing to raise prices during periods of peak demand. Companies in the airline, hotel, and car rental industries have long incorporated DP because charging fixed prices fails to effectively reflect disparities in demand, competition, seasonality, and/or the cost of operations – all without customer resistance. As stores continue to digitize, and in-store, price comparison-shopping continues to exert pressure on retailers, DP will become a retail reality, as it has in these other industries.

From an operational standpoint, most retailers today lack the ability to quickly change prices at the shelf in reaction to such changing conditions. Moreover, frequent price changes also require the coordination of various operations, such as ensuring that the correct merchandise is on hand and in place, and shelf edge pricing is adjusted. This situation is changing, however, as stores become more digitized to remain relevant. Pertinent to this Working Paper, this shift likely will include communication platforms such as digital shelf signage, such as that being deployed by Kroger,[48] and shelf-to-mobile device interactivity. This will enable instant changes of displayed prices, adjust merchandise placement on a shelf (as verified by RFID), and display related promotional messages. Prices will then adjust based on demand and inventory levels. A further application illustration is if local weather conditions are forecasting extremely hot temperatures, a retailer with excess bottled water inventory may choose to lower prices to quickly reduce stock. On the other hand, if store traffic is strong and sales of water are steady, they may determine to raise prices. Another example is if a grocer finds that certain meat or produce items are getting close to expiration (as determined by item-level RFID). In that scenario, price reductions may stimulate demand and avoid the prospect of markdowns and/or the disposal of expired items.

We are mindful that adoption of a retail DP strategy is not without risk. One interesting study found, for example, that customer perceptions of the fairness of such price changes are "influenced by both the magnitude of the price difference and the perception of the price as a gain or a loss." That same study suggested "to alleviate perceived unfairness, retailers may consider providing reasons for price differences."[49] Further research finds that the traditional notion of variable pricing is gaining popularity.[50]

Central to the success of a DP strategy is the analytics behind which price changes are communicated to a digital device. Consideration also needs to be given to the fact that consumers may need time to adjust to DP. Thus, a digitally advanced retailer may want to slowly introduce the concept to loyalty cardholders, app users, etc. The display of competitive pricing, i.e., the same item price on Amazon, may also ease the consumer transition to DP. Ultimately, as consumers become better-informed shoppers, retailers will need to respond more actively on pricing.

C. Fitting Room Utilization and Conversion

Background

An accurate assessment of fitting room activity has been limited for various reasons. With analytics, informed decisions can be made regarding the allocation of store space and the optimization of customer service staffing levels. In addition, conversion and merchandising decisions can be influenced.

Data Sets

Relevant data sets may include: Customer, Store, POS/Transactional/Product, and Inventory Systems/ RFID.

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[48] See: http://www.cincinnati.com/story/money/2015/10/02/next-shelves-giving-cues-kroger/73218252/.

[49] "Customers' Asymmetrical Responses to Variable Pricing," *Journal of Revenue and Pricing Management*, 2014.

[50] "Emerging Trends in Retail Pricing Practice: Implications for Research," *Journal of Retailing*, 2004.

Process

Unlike the extensive analytic modeling and test-and-learn approach required to implement demand forecasting and merchandise trends applications, as well as to implement a dynamic pricing program as addressed above, the requirements here are more straightforward. Notwithstanding, an ability to collect and review a large amount of information will still be required.

Fitting room space allocation is a function of tracking customers. This is accomplished by analyzing customer movement into the area by day by hour. For a new store, the question of the proper square footage (i.e., the number of fitting rooms) can be established. For an existing store, flex fitting rooms may be a solution to serve customers during peak traffic periods; which are later collapsed and closed for merchandise display during non-peak periods.

Staffing levels, to aid in restocking and customer service, can also be fine-tuned by considering customer and merchandise movement into and out of fitting rooms. One such case would be to alert an associate to collect and restock merchandise from the fitting room area when a predetermined number of items or set dollar amount of merchandise is detected. Merchandise in the area would be sensed and identified by RFID. The information can then be processed, and rules-based programming could alert a store associate via text message, for example. An extension of this is to summon seasoned associates to proceed to a dressing room if certain high-end merchandise is detected. For example, if a $1,000 dress (which is identifiable by size and color by RFID) is taken into a fitting room, a representative can be notified to proceed to the area to answer questions, be alerted to bring a matching scarf or jacket to aid in upselling functions, etc. Correlations between the dress and related purchases made would need to be run in the background to assist the associate in the upsell task.

Tracking merchandise that is taken into a fitting room can yield some interesting category level observations. This would require an analysis of merchandise location, provided by RFID, and sales data. As an illustration, customers who buy a type of shirt may also be found to have considered, but not purchased, a certain type of pant. Thus, insights into substitutes and complementary products can be made. Another example would be whether merchandise placement and visual presentation have an impact on items being tried on. Try-on to sales ratios can also be undertaken to render insights into product assortment. These types of insights can influence both reorder levels and influence promotional activities that can impact conversion rates.

D. In-Store Marketing

Background

Various customer-facing communication technologies, such as iBeacons and digital shelf-edge devices, as well as mobile apps, have been advanced as tools for personalized customer marketing. However, various shopper and operational insights need to be considered to trigger messages that should be communicated.

For instance, is the merchandise promoted in stock? Is it located where it should be and where is the merchandise in relation to the customer? These practical questions need to be considered as part of a message personalization tactic. Without such insights, the practical application of these delivery devices may be limited. Conversely, the influence of targeted messages can be enhanced with additional insights. That is, their relevance can be improved with the consideration of additional information.

Data Sets

Relevant data sets may include: Customer, Inventory Systems/ RFID, and Store.

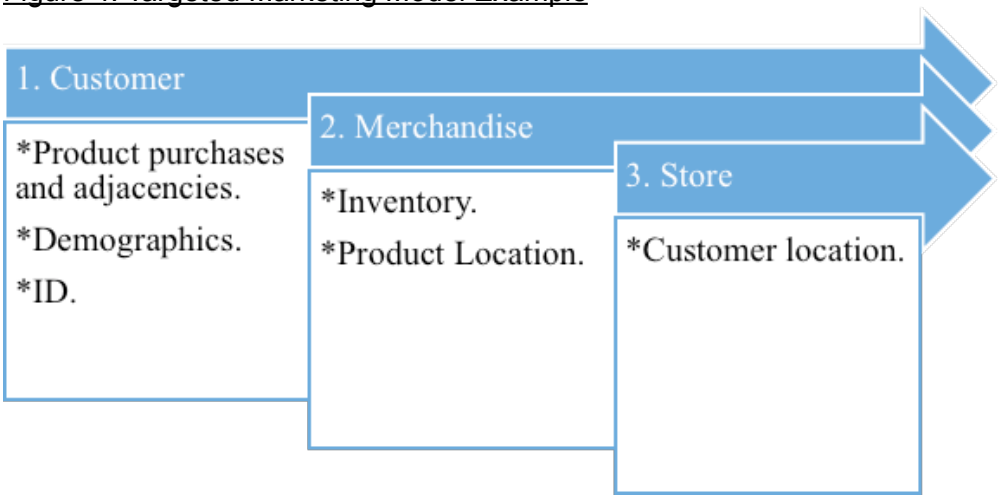
Process

Customized digital marketing, whether the message is delivered via text, digital screen, iBeacon, app, etc. must start with a behavioral understanding of that customer to avoid delivering worthless communication that annoys them. This starts with the use of CRM/loyalty data to determine purchase history, demographic

information, etc. The availability, attributes, and location of relevant merchandise should also be known. Ensuring that the merchandise is both on hand and in a specific location is critical to customer satisfaction and impacting basket size. This information can be generated by item-level RFID data. Where in the store to deliver that message, in turn, is determined by customer location information. A model to accomplish this will require an understanding of the relationships between the various data points.

The following Figure 4 illustrates an approach.[51] Assume here that a high-volume replenishment product is chosen for testing, such as laundry detergent at a mass merchandiser. First, customer-level files need to be considered. This can include CRM/Loyalty data on laundry detergent purchase frequency, brand, and associated product purchases. Demographic data, in lieu of or in addition to CRM/Loyalty data, may also be factored in (i.e., gender, age). Finally, an ID linkage of that customer to the delivery medium, such as a digital shelf-edge sign, needs to be established, principally via loyalty or app registration. The second set of data considered revolves around the product inventory and location. Finally, knowledge of the location where product and customer intersect will determine the optimal time and place to deliver a message. The model outcome, as refined and perfected, is stimulating customer demand by the delivery of relevant and timely messages. As correlations between the messages' impact on sales and the independent variables are determined, the retailer can fine-tune its targeted message strategy.

Figure 4. Targeted Marketing Model Example



Rationale

The concept of location-based marketing is not new. Point of purchase (POP) advertising has been in existence for a long time, historically delivering static messages placed in proximity to the promoted product. Research has found that traditional POP advertising "significantly affects consumer attitudes, attention and purchase intention."[52] More recent studies of internet and mobile interaction find that the key to perceptions of value/message use is the consumer's ability to receive unique and tailored communications.[53]

[51] For purposes of this illustration, it is again presumed that the retailer can process data and distribute messages in real time.

[52] "The Effects of Location-Based Services on Consumer Purchase Intention at Point of Purchase," *European Journal of Marketing,* 2015.

[53] See, i.e., "Interactivity and Persuasion: Influencing Attitudes with Information and Involvement", *Journal of Interactive Advertising*, 2005, and "Determinants of Perceived Web Site Interactivity," *Journal of Marketing*, 2008.

E. Merchandise Placement

Background

The study of consumer shopping paths and interactions can aid in merchandise placement in a store (and the related delivery of targeted messages as discussed above). Traditional measurement instruments, such as traffic counting and video recording, have various limitations in this regard. In the case of traffic counting, its utility is generally limited to counting customers at an entrance and not at various points in a store. Video, while generally accurate, is cost-prohibitive in terms of store and systemwide deployment. That is, video tends not to be relied upon for continuous feedback of customer traffic data throughout a store. In general, Wi-Fi and, to a lesser extent, apps provide a less expensive and broader funnel of customer traffic data.

Data Sets

Relevant data sets include: Customer Traffic, Inventory Systems/RFID, and POS/ Transactional/Product.

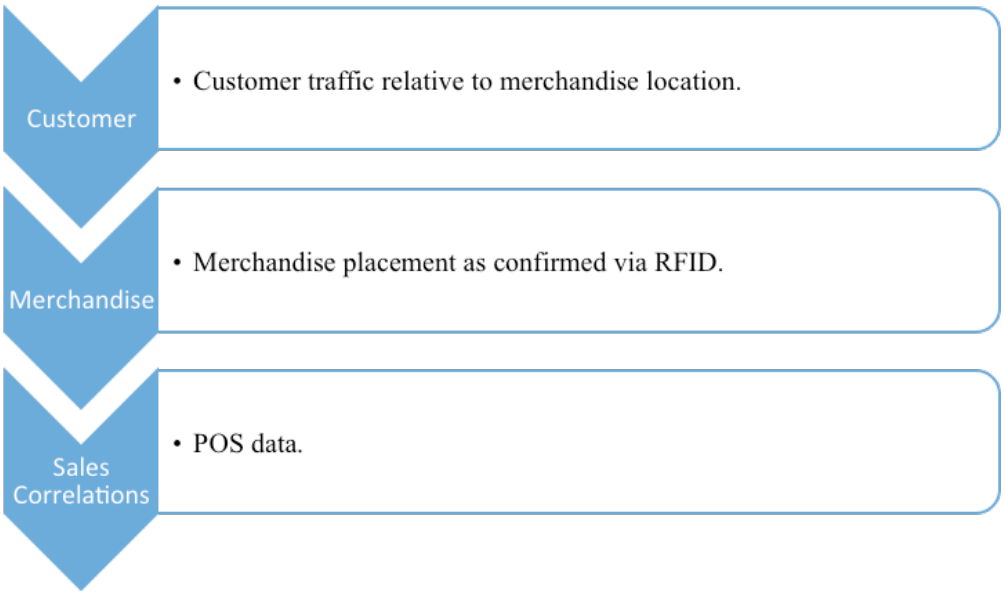
Process

Modeling here is predicated on two use cases, as further detailed below. The first is merchandise placement in a store in response to customer traffic flows. The second is testing display effectiveness. In both cases, assuming the data is live, real-time analytics can be undertaken to continually optimize placement.

In the first example, traffic flow is referenced against merchandise placement to determine optimal placement predicated upon sales data (see Figure 5 below). Not only can this be useful for initial store set-up, but it also can be used to customize different outcomes in dissimilar markets and stores. For example, the intersection of customers and merchandise can be very different in Dallas than it is in Chicago. Expanding upon this, merchandise can be moved during the day, for certain retailers, to adjust to different shoppers displaying differing behaviors. Assume, for example, that in an apparel store it is determined that different traffic and merchandise intersections occur during a day, as it is found that in the morning, more traffic is detected around sweaters, and in the afternoon, more customers tend to look for jackets. With this information, store associates can strategically locate merchandise in response. POS data will determine what placements are optimal. In addition, RFID and POS data can further be analyzed to isolate purchase patterns to enhance collateral merchandise placement.

In the second use case, customer traffic, inventory location, and POS data are again analyzed to determine optimal display placement in a store. Here we are referencing which merchandise is put on a display in combination with other items for maximum impact. For example, at the entrance to an electronics retailer's store, several computers, headphones, cellphones, etc. are positioned on a display. Analyzing the available information can yield insights into whether customers are drawn to the display and ultimately make a purchase. Merchandise display combinations can also result in a different impact on behavior. Therefore, merchandise displayed can be altered continuously to determine the optimal items to display together to impact traffic and sales.

Figure 5. Merchandise Placement Model Example



Rationale

Historically, merchandise placement has been grounded on factors such as historical sales, static determinations of shopping patterns, planograms that consider shelf optimization, product turn and margin, as well as the visual appeal of merchandise placement. More advanced retailers have implemented optimization methods for shelf space management. Our focus here, on the other hand, is to demonstrate a method by which the relationship between customers and merchandise can be enhanced continually to impact behavior. This would, as well, take the concept of localization to a new level. That is, it would enable a retailer to move from a cluster approach to one based on format, assortment, space allocations, or segments, i.e., from one based on personas, to a highly individualized, store-by-store approach.

V. Conclusion

This Working Paper has two objectives. The first is to present detailed findings of the benefits associated with RFID technology at a major department store. To our knowledge, this is the most extensive set of data made available on the quantifiable attributes associated with RFID at a retail store. Our second objective is to demonstrate how RFID-generated data can be integrated with other information to provide retail business insights.

As RFID has many additional use cases beyond those presented here, it is hoped that this research will serve as the foundation for additional work. For example, the use of RFID to check the validity of the receipt of vendor shipments at a store or warehouse is an area of interest. Further, an evaluation of the vendor benefits of item-level source tagging is of significance. The use of RFID data in combination with other information is also a topic to be explored in additional research. Finally, implementing these integrated analytic applications, and reporting best practices and results, are also areas worthy of further investigation.