Retailers today are struggling to manage demand across multiple channels while effectively controlling inventory levels. Vital to this process is the accuracy of their inventory systems. Cycle counting is the main technique used to curb inventory record inaccuracy (IRI), but it offers only a static perspective. This article provides clear evidence why retailers need to adopt a more dynamic perspective on their inventory picture.

Inventory expenses for firms in the United States have become vast. An estimated $1.5 trillion is being invested in inventory on a yearly basis, with 82 percent of the total in the manufacturing, wholesale and retail sectors. In the retail sector, mixed retailers—that is, retailers that have multiple channels to market—today are scrambling to manage these inventories in the face of still-stagnating sales across multiple channels, both traditional retail (that is, brick-and-mortar) and direct (internet-based). A typical approach has been to offer complex product assortments to meet localized consumer demand, while trying to keep a handle on their available inventory levels.

The advent of the Internet as a supporting tool for online sales has only intensified the challenge. To cite one example, buying behavior has changed greatly as a result of consumers utilizing the direct channel to verify product availability and assortment—for example, for subsequent in-store visits leading to purchases through the retail channel. This places extra emphasis on mixed retailers to maintain accurate records of their inventory and high-
Overlooked
lights the dilemma of determining which product assortment to make available in particular channels. A related, though less well understood, challenge involves dealing with inventory record inaccuracy (IRI). Coping with—or trying to mitigate—IRI will become increasingly important as multi-channel retailers rush to increase the availability of their inventory across both their traditional retail channels and their newer, direct channels.

This raises the question as to whether mixed retailers should separately allocate inventory to serve individual channels or centralize inventory to satisfy overall demand irrespective of channel. A related question is what are the IRI implications of each course of action? Mixed retailers commonly separate their inventories across channels to maximize product availability for consumers. By allocating inventories exclusively at their brick-and-mortar channel, they ensure that Internet sales do not interfere with in-store product availability. This strategy, however, prevents retailers from realizing inventory efficiencies that can result from centralizing inventories across their channels. Such efficiencies have a huge potential for reducing carrying costs for safety stocks as well as on costs necessary to monitor and control inventory levels and their accuracy.

Retailers also have utilized technology to automate various critical systems ranging from ordering to forecasting to planning and replenishment. All of these tools utilize “system” inventory records to determine sets of parameters that optimize inventory control, affecting both operational and financial decisions. Further related to technology, radio frequency identification (RFID) technology has seen a rise in popularity in the retail space. Yet RFID still remains an expensive option and is not yet feasible for all firms.

In short, the ability to accurately determine how much inventory is on hand has taken on an even more critical role than before. Without such accuracy, firms bounce between the opposing risks of holding more inventory than is necessary or alternatively running out of inventory and not being able to meet customer demand. This has made IRI a relevant—though often underappreciated—issue for many firms across diverse industries, from retailing to defense.

**Shortfalls of Cycle Counting**

In their attempts to address and control the opposing risks of excess inventory vs. out of stocks, most retailers and manufacturers use some form of cycle counting, generally either by stock-keeping unit (SKU) or by location. In the case of multi-channel retailers the company’s aim is to ensure acceptable levels of accuracy with their on-hand inventory (see Exhibit 1). Done correctly, cycle counting is accompanied by an ongoing root-cause analysis for source of errors leading to a continuous improvement approach that ultimately eliminates or significantly reduces the frequency of such cycle counting. Cycle counting is, however, a static, predominantly financially-oriented, and periodically repeated measurement approach based on an ABC product classification.

Despite the fact that cycle counting has existed for over 30 years, there have been no significant improvements or breakthroughs in mitigating inventory record inaccuracy associated with this technique. Our main concern with cycle counting is that it overlooks the issue of physical product availability between counts; that is, what is happening on a dynamic basis in terms of product availability. Between cycle “counts”—the timing of which varies on average from one month to six months depending on the approach chosen—firms strive to maintain availability without holding excess inventory.

The cycle counting approach is based on accuracy measures that can be significantly out of date and may contain major errors. This could unnecessarily increase inventory or expose the firm to stock-outs. Such lack of visibility during counts creates potential shortfalls in product availability, not to mention the adverse impact on the organization’s forecasting, planning and re-ordering processes. The reality is that firms do not understand the true impact of errors on their inventory records; as a
result, they respond simply by holding more inventory at a higher cost than is potentially necessary.

**Inventory Record Inaccuracy Abounds**

With firms still relying mainly on cycle counting to keep records accurate, both practitioners and academics have given special attention to IRI in retail settings—where out of stocks cause great concern. In particular, research has focused on the causes and consequences of IRI at a store level. To illustrate the scope of the problem, one study of a large retailer revealed that 65 percent of the 375,000 stock keeping unit (SKU) records were incorrect.6

Further, recent anecdotal evidence indicates that IRI in the distribution center is still a major issue. In a large electronics retailer, for instance, researchers found that prior to the opening of a new retail store, 25 percent of the SKUs were already inaccurate, suggesting that the likely source of these errors emanated from the retailer’s DC.7

Inventory record inaccuracy remains a pervasive and largely unexplored issue across industries spanning different supply chain echelons. Of IRI at a store level. To illustrate the scope of the problem, one study of a large retailer revealed that 65 percent of the 375,000 stock keeping unit (SKU) records were incorrect.6

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Inventory record inaccuracy remains a pervasive and largely unexplored issue across industries spanning different supply chain echelons. Not surprisingly, the consequences of data inaccuracy are poorly understood not only at physical retail store settings, but also at distribution centers and beyond. IRI can generate different outcomes, as summarized in Exhibit 2. If the system inventory record (SIR) is higher than the actual physical inventory on hand (meaning a positive balance), then this gives rise to a situation referred to as “freezing.” If this situation is not detected and corrected, then subject to the magnitude of the error relative to the re-order point level maintained by a firm, the SKU will become “frozen” once its stock is depleted because the SIR will show a positive balance of items in inventory.

In a DC setting, this situation will persist only until an order for the depleted inventory arrives and the “zero” physical inventory state is detected. In a brick-and-mortar or an online retail setting, this situation becomes more damaging. As there is no physical inventory, customers cannot purchase the item. The fact that no customers are purchasing the item leads to a potentially dangerous scenario. With no sales for the product occurring, then over time the product’s forecast is downwardly adjusted before being ultimately de-listed.

When the SIR is lower than the actual physical inventory on hand—signifying a negative balance—a situation referred to as “inflating.” In such cases, the SIR will decline until the re-order point level to replenish the inventory is reached. At this point in time, an automatic replenishment order is prematurely generated. At face value, this is a more desirable outcome than freezing. The reason: most companies would prefer IRI manifesting itself as excess inventory as opposed to the risk of being out-of-stock. In a direct channel, however, this can be reflected in lower levels of inventory availability that do not correspond to the true amounts of inventory in storage.

**The Pilot Study**

Understanding IRI as a supply chain phenomenon required us to first undertake an exploratory pilot study. Specifically, we investigated the inventory policy and practices in the DC of a national pet retailer (name withheld at company’s request) to (1) better understand the issues associated with sustained periods of counting and (2) to gain insights into day-to-day variability of inventory records.
By counting inventory for only seven consecutive days, the pilot study revealed significant evidence of very dramatic variability between overages and shortages across a sample of 30 SKUs (see Exhibit 3). This sample comprised 10 SKUs that were selected from each of the three main types of storage locations—fast-moving, bulk and module picks.

On one hand, the fast-moving products, such as canned cat and dog foods, did not suffer from any IRI. Slower-moving, bulky and module items, on the other hand, exhibited significant variability (between overages and shortages) over the counting period. Across the 20 SKUs in the bulk and module categories, we also noted a clear tendency for there to be more inventory actually on hand than the system inventory record indicated. If this were to continue throughout the year, the company would be holding more inventory than needed and paying holding costs above and beyond what was necessary.

Potentially more worrisome than the excess inventory is the volatility of records accuracy for some of the individual SKUs. Some have records that “bounce” from accuracy to excess inventory and back again; other SKUs swing from excess inventory to shortage and back again. This variability was not explained by any transactions (such as receipts, put-a-ways or order picking), even though we corrected for any process delays in terms of how quickly, for example, product received from suppliers was credited to the system inventory record. This leaves us to consider the system as inherently unstable.

**Main Research: Multichannel DC**

To examine systemic conditions underlying IRI in a multichannel distribution center, we needed to find a retailer who serviced such channels from the same facility. So we next studied an apparel retailer with annual sales in 2008 of approximately $200 million. This retailer operates a national distribution center that serves both a traditional (brick-and-mortar) retail channel and a direct (internet-based) channel. From a total of approximately 12,000 SKUs, we isolated those that were common to both channels. We ranked these common SKUs by sales volume (in units) in 2008 within each product category to identify fast, medium, and slow-moving items. We then selected the two fastest-selling and the two slowest-selling products. This left us with 27 SKUs, including an item selection of the three most popular product colors and sizes.

To assess IRI, we tracked the physical inventory on hand for the 27 SKUs at the DC for both the retail and the direct channels. Simultaneously, we contrasted this information against the data in the retailer's SIR. In tracking the retailer’s physical inventory, we counted the num-

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**EXHIBIT 3**

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**NB:** % = Percentage Difference Between SIR and Actual Physical Count
ber of items in storage for each channel every day over a period of ten consecutive business days. (We did not count the inventory during the weekend because the DC operated only from Monday to Friday.) The ten business days correspond to two calendar weeks in September of 2008. These two weeks were chosen because we wanted to examine IRI conditions without the interference of seasonality in demand for the retailer’s products.

For each selected SKU, on every day of counting, the SIR balance and SKU locations for both channels were downloaded from the DC’s warehouse management system (WMS). Additional data on product receipts, daily orders, returns and any (auditing) adjustments also was collected on a daily basis for both channels. The data on prices, product popularity in the market, and inventory review policies was collected from the retailer’s records during the period when we collected data on the SKUs inventories. It is important to note that the retailer followed continuous review policies for all the SKUs in our study. These policies were based on a min-max approach for reordering and replenishing each SKU’s inventory. When inventory reached a predetermined minimum level, the retailer reordered the inventory amount necessary to take the level back to a preset maximum.

**Results Show Dynamic IRI Variability**

The results of the research reveal significant dynamic IRI variability for both retail and direct channels. Specifically, SKU records move from being accurate, to having positive and negative divergence from the actual physical counts (that is, freezing and inflating)—all within the 10-day counting period. The research reveals some counterintuitive results, compared to previous studies. These findings support our assertion that IRI presents different challenges depending on channel structure and the company’s position in the supply chain, corroborating the assertion that IRI should be investigated in settings other than retail stores.

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**EXHIBIT 4**

*Inventory Records Accuracy by Price and SKU*

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<th><strong>Lowest $4</strong></th>
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**Legend:**
- **Accurate**
- **Excess**
- **Shortage**
- **Seasonal Out-of-Stock**
It’s important to underscore that the errors found in both channels could not be explained by any transactions (receipts, put-aways or order picking). Again, this held true even with our correcting for any process delays such as how quickly product received from suppliers was credited to the system inventory record or how quickly returns were credited back to the system inventory record.

**Impact of Item Price on IRI**

We expected to see fewer inaccuracies at the higher end of the price range of the SKUs, figuring that order pickers should be more cognizant of being accurate with high priced items. Instead, as shown in Exhibit 4, we found most inaccuracies at both the high and low-ends of price range in the direct channel and more inaccuracies at the mid-low end of price range in the retail channel.

A program that effectively addresses IRI should aim to minimize inaccuracies for high value items because this is where the higher margins typically lie. One possible approach is to use incentives to focus the attention of managers and employees on operational activities related to these high value items. However, such incentives must be balanced with the multitude of competing objectives in terms of maintaining and increasing sales of these high-value items and inventory management. Where high value (margin) items are concerned, it may be better to hold higher levels of inventory rather than to focus too much on reducing IRI across these particular SKUs.

Shrinkage—thief in particular—may also be a significant factor for higher priced items, which in turn leads to higher levels of IRI. Most retailers have focused on loss prevention in their retail stores; they need to pay the same level of attention to shrinkage in the direct channel.

The overarching concern here, however, is that the IRI errors are occurring at both the high and low price ends of the products in the direct channel. This suggests...
that some other possibly counter-intuitive issues are in play. This is something that will be explored in the next stages of this ongoing research.

**Impact of Sales Velocity on SKU IRI**

We would expect that the more transactions associated with a product, the more opportunities there are for inventory records to become inaccurate. However, as we can see in Exhibit 5, there is considerable inaccuracy irrespective of the number of transactions in the direct channel. Unlike in the previous pilot study that we undertook, we saw many instances of IRI, especially in the slower moving items. This was not an encouraging finding. And while the research revealed no obvious patterns across the 27 SKUs, we noted a slightly higher level of inaccuracy in the direct channel. This may be explained by the high number of transactions in this channel than compared to the retail channel. Further worth noting in Exhibit 5 are the many instances where SKU records experienced conditions of accuracy, shortage and overage—all in the space of ten days.

**Impact of Inventory Review and Replenishment Policy on IRI**

Frequency of inventory review has been found to negatively correlate with inventory record inaccuracy. The reason: discrepancies are easier to spot when inventory reorders are being placed, or when inventory is being physically replenished. Inventory review policies in which reorder points are close to the maximum levels carried in stock (that is, a small min/max gap) will require frequent reviews. This is because the depletion of inventories will cross the inventories’ reorder point threshold more frequently as the difference between the maximum inven-
tory levels carried and the inventory reorder points narrows.

An increase in the gap between the inventory reorder point and the upper inventory level will lower this frequency. Accordingly, we would expect that a reduction in the review frequency will increase both the magnitude of IRI and the amount of time record inaccuracies will persist for the SKU. Accordingly, Exhibit 6 shows that an increasingly narrower min/max gap will lower the magnitude of IRI in the direct channel, thus broadening the difference that exists in IRI between channels in a mixed retailer.

**Impact of Frequency and Magnitude**

Overall, our research results show that the SKUs in the direct (Internet-based) channel are much more frequently inaccurate than in the traditional channel. Specifically, the frequency of discrepancies between SIR and physical inventory in the direct channel was 58.1 percent, compared to 30.7 percent in the brick-and-mortar channel.

In terms of magnitude of errors, SKUs in the brick-and-mortar channel, while less frequently at error, have a higher magnitude of error. The average magnitude of discrepancy between SIR and physical inventory is 31 units vs. 3 units for the direct Internet-based channel. We also observed considerable volatility in both channels throughout the 10 counting days, further suggesting a significant degree of system instability.

What is behind these differences in frequency and magnitude across the direct and retail channels? So far as the differences in frequency are concerned, the direct channel incurs many more transactions (albeit small in size) than the retail channel. This sheer frequency of transactions appears to account for the heightened frequency of IRI. Although the direct channel takes on the appearance of a nervous or “agitated” state, it is relatively more stable than the retail channel.

As for the differences in magnitude, the retail channel incurs considerably fewer—but significantly larger—transactions than the direct channel. These comparatively larger transactions appear to account for the heightened magnitude of IRI. While the brick-and-mortar retail channel is stable for periods of time, it is actually more volatile when IRI occurs because of the magnitude involved.

**Managerial Implications**

The managerial implications and lessons learned from this research are far reaching. Some of the most important include the following:

- The research shows that direct internet-based channels may have more frequent errors than brick-and-mortar channels, but at lower levels of magnitude. This strongly suggests that managers need to develop spe-

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**A program that effectively addresses IRI should aim to minimize inaccuracies** for high value items because this is where the higher margins typically lie.
cific control plans to more consistently track inventory levels and changes in their records over time for their online channels. These plans should include mechanisms to enable adjustments in the records to reflect current inventory conditions. This capability is especially important for those items that are part of brick-and-mortar channels where mismatches in the magnitude of accuracy in inventory records are prone to be high.

- The research also shows that cycle counting, the main method currently used to manage and control the accuracy of inventory records, cannot capture the dynamic and often volatile nature of inventory record inaccuracy in a DC setting. This shortfall typically triggers premature ordering, leading to excess inventory. To ensure records accuracy, cycle counts need to be supplemented with continuous inventory audits that keep track of variations in stock levels to prevent premature or unnecessary inventory replenishments. Cycle counts also can miss the occurrence of interim stock-outs during the times when inventories are not being audited. The use of continuous review periods to track IRI during extended time windows can identify these occurrences and help uncover their root causes.

- The research reveals that managers need to address the issue of process “lags—that is, the time delays between physical actions and updating of systems records that may be amplifying, or even diminishing, the existence and magnitude of some of the errors behind the inaccuracies. Ideally, the warehouse management system (WMS) should be able to handle this situation. But based on evidence from this research, the pilot research, and other anecdotal evidence, it’s not happening. This represents an opportunity for WMS providers, especially in view of the increasing demand for real-time visibility of inventory.

The options on how to treat inventory record inaccuracy are stark. If firms choose not to address the dynamic aspects of IRI, they expose themselves to numerous inefficiencies—reordering too much or too little, losing customer goodwill because of phantom stock-outs, continuing to operate under high levels of uncertainty, and more. If firms do choose to address the dynamic aspects of IRI, their efforts may take the form of adopting incentive programs, deploying a new WMS, implementing continuous improvement programs, redesigning DC layout, and so forth. It is critical to recognize that with such initiatives come trade-offs: The resulting increased availability, improved customer service and overall improved inventory management, requires an investment. It could be the addition of new or more proficient personnel; an upgraded or entirely new WMS; a new set of operating processes.

Perhaps most important for managers to keep in mind, any successful initiative to improve inventory record accuracy will entail a major culture change and will require the wholehearted support and involvement of top management.

**Endnotes:**

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