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Retailers have invested, and continue to invest, substantial amounts of money in information technology (IT). By some estimates,[1] U.S. retailers now spend close to $30 billion a year on IT, mostly to track merchandise and operations, automate transactions, and optimize inventory levels and other supply chain decisions. However, operational execution—a vital complement to planning and automation, and a key ingredient to exploiting these IT investments fully—is woefully inadequate even at leading, financially successful retailers. Drawing on substantial interaction with multiple leading retailers (and extensive operational data from two leading retailers), we show that two particular execution problems—*inaccurate inventory records* and *misplaced SKUs (Stock Keeping Units) in stores*—are significant and expensive, and they pose a serious barrier to the effective use of IT in retail operations. At the two retailers we studied in-depth, these problems reduce profits by more than 10%. More surprisingly, however, there were substantial and systematic differences in performance among stores within the same retail chain. Why is it that retail stores with the same products, similar demand profile, identical monetary incentives, and the same corporate management and IT systems perform so differently on these measures?

Consider the following execution problems:

- Inventory Record Inaccuracy—Contrary to popular belief, most retailers cannot, with any degree of precision, identify the number of units of a given item available at a store. At a leading retailer that we refer to as the

The authors would like to thank managers from Beta and Gamma Corporation who were critical to this research. We regret that we cannot name them due to the need to protect the companies' confidentiality.

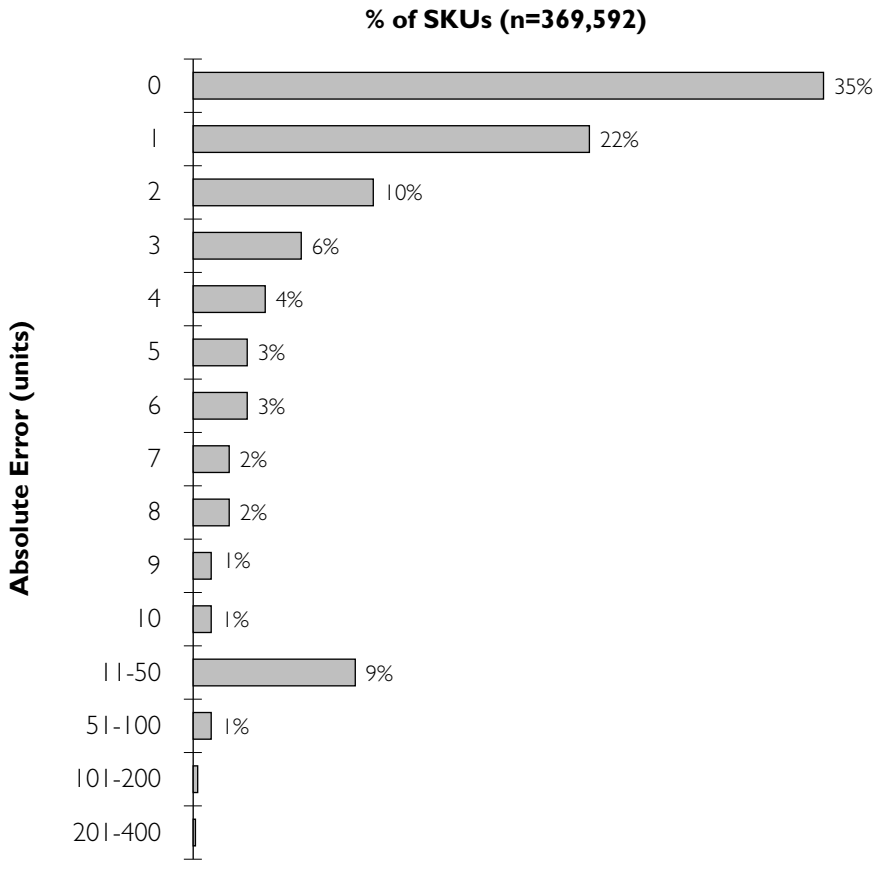
Gamma Corporation to preserve confidentiality, more than 65% of the inventory records were inaccurate at the store-SKU level (i.e., "system" inventory did not match "physical" inventory). Figure 1 shows the histogram of absolute errors (i.e., the absolute difference between system and physical inventory levels for nearly 370,000 inventory records). Moreover, the absolute difference between system and physical was on average 35% of target inventory level for each item. Gamma, we should emphasize, is a leading publicly traded retailer with hundreds of stores and billions of dollars in annual sales. The company scans *all* its sales electronically and has modern distribution centers that use information technology extensively.

Gamma is not an isolated case; this problem is common at other retailers as well. For example, a large, well-known apparel retailer found that "physical" inventory levels differed from "system" inventory by over 35% of the latter. The situation is even worse for those items whose sales are not scanned electronically. At one supermarket chain, sales of "medium tomatoes" exceeded shipments into the store by 25% because other types of tomatoes such as "organic tomatoes" or "vine ripe tomatoes," which typically cost more than "medium tomatoes," were often sold as medium tomatoes when salespeople were in a hurry.

- Misplaced SKUs—Even when inventory records are accurate, items can be hard to find at a store. At Beta Corporation, another leading retailer whose identity we cannot disclose, 16% of the items in a store could not be found by consumers who approached a sales associate for help, not (as typically assumed) because the items were out-of-stock but rather because they were misplaced in a backroom, in other storage areas, or in the wrong aisle or location. Beta, like Gamma, is a sophisticated retailer with hundreds of stores and billions of dollars in sales. Figure 2 depicts the histogram of the fraction of SKUs across 242 Beta stores that, at the time of annual audit, were not found on the sales floor even though inventory for these SKUs was available at that particular store (termed "SKUs not on floor"). That is, the *entire* store inventory for these items was in storage or receiving areas and, consequently, no units of these items were on the sales floor where they would be visible to (and thus purchasable by) consumers.

Inventory record inaccuracy and misplaced SKUs can substantially decrease retail profits due to lost sales and gross margins as well as additional labor and inventory carrying costs. By our estimates, derived in conjunction with managers from Gamma, the profit lost due to inventory record inaccuracy amounted to 10% of current profits (roughly the profit of 100 stores) at Gamma. Similarly, misplaced SKUs reduced profits by 25% at Beta (roughly the profit of 50 stores). Our estimates do not include the long-term adverse impact such execution problems could have on the firm's brand image, a major concern for senior managers at both retailers. The importance of these themes has been

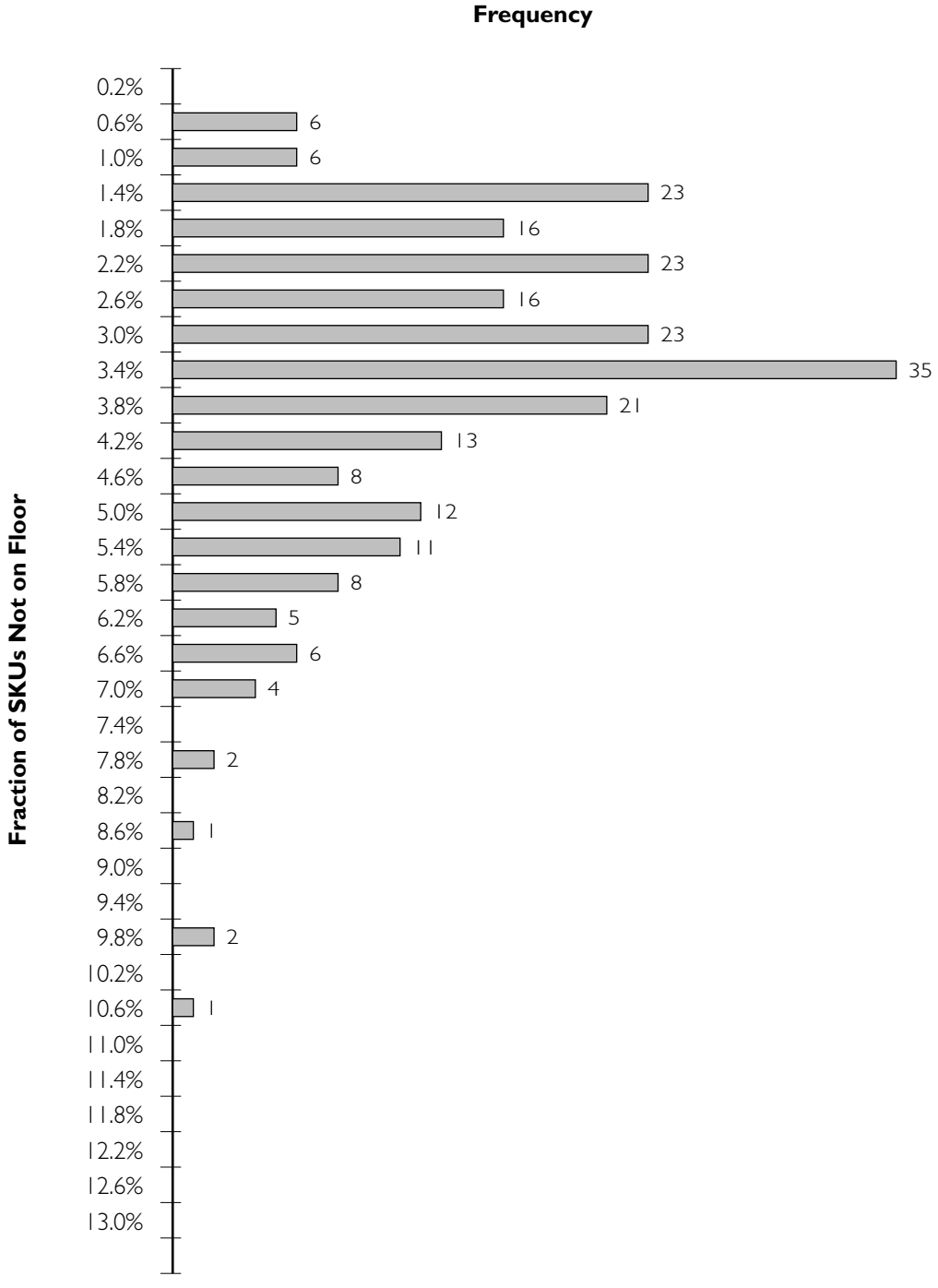
FIGURE 1. Histogram of the Absolute Value Difference Between System and Actual Inventory Measured in Units



reinforced by the personal experiences senior managers recount. At Gamma, the CEO on a store visit noted that many items in a certain category with few substitutes had stocked out. Subsequently, a limited and careful audit on 42 items that he specified at eight stores revealed that 34 of the 336 store-SKU combinations were stocked out on the shelves. However, 28 of these 34 combinations were reported as "in stock" according to the company's replenishment systems.

The impact of inventory record inaccuracy and misplaced SKUs can be severe for retailers like Gamma and Beta that rely on computerized replenishment systems for managing store inventory. At these retailers, when an out-of-stock is reported as in stock, the item may never be reordered. What's worse, when demand forecasts for that item are updated by the automatic replenishment system, the new forecast may be so low (zero, in fact), that the retailer decides to drop what is actually a popular item. At Gamma, one item at a store

FIGURE 2. Histogram for the Fraction of SKUs That Are Not Available on the Sales Floor, From a Sample of 242 Stores



where the system showed 42 units in inventory was, in reality, stocked out. The error in data caused the system not to replenish the item and because the item had not sold in months due to the stockout, reduced future demand forecast to ridiculously low levels. Similarly, with misplaced SKUs, retailers often fail to observe consumer demand accurately, and this, in turn, causes them to underestimate demand for items that were misplaced at the stores.

Moreover, the successful execution of a "bricks and clicks" strategy, presently pursued by many retailers, requires very good store-level execution. For example, many retailers now allow consumers to purchase items on the Internet and return merchandise to their stores. Similarly, some retailers have tried, and many others have considered, allowing customers to view a store's inventory on the web. Such a strategy allows consumers to verify whether an item is available at a store and even to reserve the item for future purchase without having to visit the store. However, offering such a service reliably requires inventory data to be accurate and also requires that items that are available at the store can be found easily by a consumer. Imagine the impact of a consumer verifying on the web that an item was available at a particular store and traveling to that store only to find the item stocked out because the information on the web was inaccurate or because the item had been misplaced at the store. Most retailers recognize that the cost associated with disappointing customers after promising product availability is substantial. Not surprisingly, many have shied away from offering their stores' inventory on the web for consumers to examine.

There is, however, reason to be optimistic; the incidence of these execution problems can be reduced. Our research shows that while execution is weak on average at the chains that we have studied so far, pockets of excellence are present (i.e., some stores perform better than others). Consequently, operational execution can be improved quickly and dramatically if retail managers were to create awareness of the magnitude and impact of execution problems in their supply chain and learn from those stores that are currently executing well.

What Drives Poor Execution in Retail Operations?

We discovered these execution problems by accident. A few years ago, we started studying retail supply chains and operations in a research consortium[2] that included over 30 retailers. Our goal in this consortium was primarily to understand how retailers do, and recommend how they should, forecast demand and plan inventory levels and other operational variables in the supply chain.

Our assumption in launching this research consortium was that retailers had plenty of sales and inventory data that was "clean" and easily accessible. Consequently, we were surprised when, early in our research, executives at a small retailer told us about problems relating to inventory record inaccuracy. We assumed that the problems were unique to this retailer and would not be

encountered by other retailers with more established systems. Subsequent field visits to other retailers however showed that execution problems were widespread. Over time, we were able to identify anecdotally the two execution problems described in this article at multiple retailers in food, apparel, book, music, and office product categories.

Subsequently, we launched a more intensive phase of our research based on data obtained from physical audits conducted at the store-SKU level at Beta and Gamma. Both were frequently identified by other retailers in our study as having stellar operations and systems. At Beta and Gamma, physical audits are conducted annually or semi-annually; a team of auditors visits each store and collects data on the amount and location of various SKUs. Stores are closed at the time of physical audit, hence execution problems are likely to be less prevalent during an audit than during regular store hours. For each of Beta's 242 stores, we were able to obtain the fraction of a store's assortment that had been misplaced in storage areas and hence was not available in the selling area where consumers could find and purchase them. At Gamma, we obtained "physical" and "system" inventory levels and hence errors in inventory records for roughly 10,000 SKUs at 37 stores.

Our analyses revealed a number of insights that were interesting to managers, and at least a few that were initially surprising to us. The performance of stores measured on the two execution problems identified here varied considerably. For example, average absolute error (between physical and system inventory level) ranged from 2.4 units per store-SKU at one store to 7.9 units per store-SKU at another. Similarly, with misplaced SKUs, the fraction of a store's assortment that was misplaced in storage areas ranged from 0.2% to 10%. Moreover, store performance for both measures remained consistent from one year to the next. The variation in performance among stores and the consistency of performance from one year to the next is summarized in Figures 3 and 4.

Our statistical analysis (described briefly in Appendix 1) enabled us to identify three broad categories of drivers: replenishment and sales processes at stores and distribution centers (DCs), merchandising and inventory management, and employee turnover. The stores had identical information technology and monetary incentive mechanisms and were part of the same corporate entity; consequently, these factors could not explain the differences in store performance.

Replenishment and Sales Processes at Stores and DCs

The processes followed at stores and distribution centers understandably affect the quality of execution in the stores. Consider the inventory record inaccuracy problem—it is easy to see that store processes contribute substantially to this problem. Almost all of us, when buying multiple, identically priced items at a supermarket, say a lemon yogurt and a plain yogurt, have watched the salesperson scan one item (say, the lemon yogurt) twice instead of each item separately. This apparently innocuous practice results in two discrepancies between

FIGURE 3. Consistent Performance in Inventory Accuracy Among Stores in Two Consecutive Years

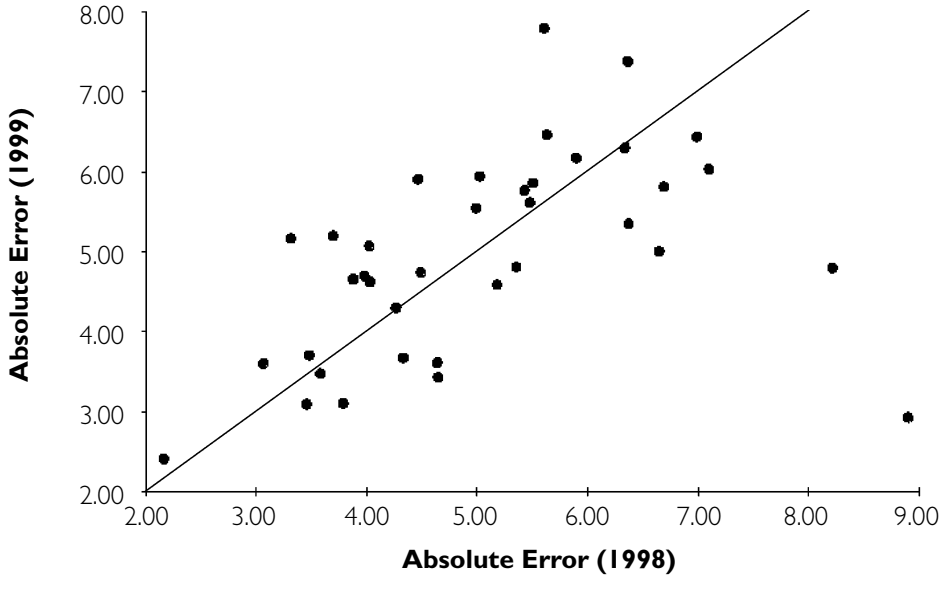
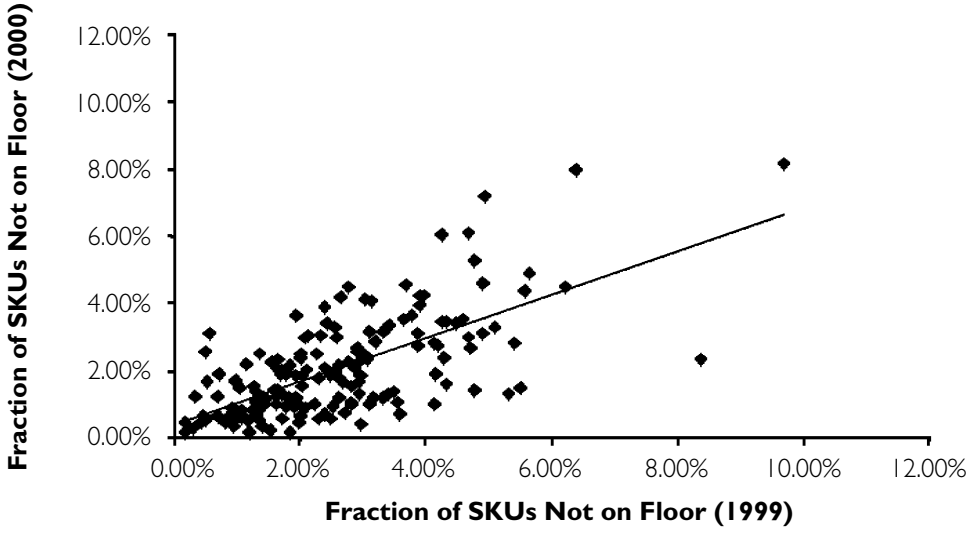


FIGURE 4. Consistent Performance in Misplaced SKUs Among Stores in Two Consecutive Years



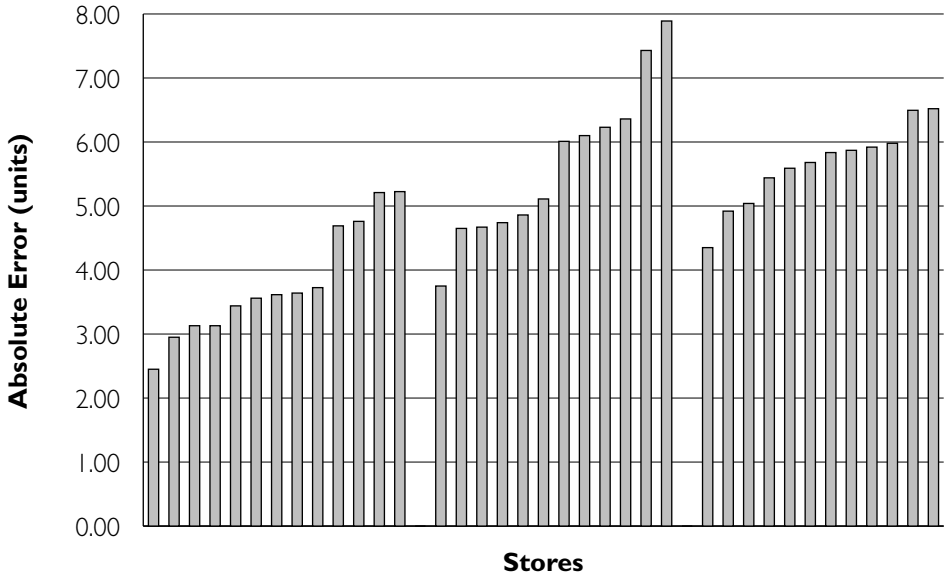
"system inventory level" and "physical inventory level." In the above example, system inventory would exceed physical inventory by one unit for plain yogurt and would be a unit short for lemon yogurt. Similarly, many of us have experienced situations where, after buying a "large" garment, we returned to the store to exchange the "large" for a "medium." It is not unusual in this circumstance for salespeople to exchange the garments without entering either transaction (i.e., the return of one item and the sale of another). Clearly, in this case the system would underestimate physical inventory for large and overestimate inventory for medium garments.

Store processes also cause the "misplaced SKUs" problem. Store sales people are often charged with moving merchandise from the storage areas to the sales floor based on sales of specific items. The task, though it appears to be simple, is rendered complex by a number of factors. One, store salespeople, who often are very busy during high-traffic periods, find it hard to replenish merchandise promptly from the storage areas. Two, most stores do not organize the inventory in their storage areas very well. Consequently, sales people may not know if merchandise that has stocked out in the selling area is even available in the storage areas. Moreover, computerized information systems that track the inventory at the stores often do not maintain separate fields to identify storage area inventory. The fact that storage areas are often dispersed over multiple locations and "SKUs not on floor" could be in any of these locations exacerbates the problem. For example, at some stores, there are storage areas above the shelves, in the basement, at the back of stores, and near the loading dock, and merchandise in each of these areas are not tracked separately.

Store design—especially the design, size, and number of backrooms and other storage areas—can also hamper execution. The importance of backroom size, for example, can be illustrated with an anecdote from Beta Corporation. While store performance was largely consistent from one year to the next, there were some anomalies. One store, for example, saw substantial deterioration in performance from 1998 to 1999. The President of Stores at Beta was not surprised at all. He pointed out that, after repeated requests, he had allowed the store to increase the capacity of its backroom at the end of 1998. Not surprisingly, as ardent proponents of JIT[3] would have predicted, the backroom had more inventory after the expansion than it had before and the store suffered from having a larger fraction of SKUs not available on the floor than it had in the past.

However, store processes only explain part of the problem. Gamma, for example, found that DC processes had much to do with inventory record inaccuracy. In early 1999, Gamma tried an experiment at one of its new stores. The company planned to open a store on a particular date and the distribution department was asked to stock merchandise in preparation for this opening. Unknown to the distribution department, however, the company postponed the opening of the store and, instead, audited every item at the store *before a single*

FIGURE 5. Average Store "Absolute Errors" Grouped by Distribution Center



customer had ever walked the store. Amazingly, system inventory levels were inaccurate for 29% of the items and the average absolute error was 25% of system inventory levels. Clearly store processes and customers could not be blamed for these errors.

The importance of DC processes is also supported by Figure 5, which shows the average error in inventory records at stores served by each of three different DCs. Notice that stores served from DC 1 tend to have far smaller errors than those served from DCs 2 and 3. We suspect that differences in DC processes explain the differences observed, even though it is possible that the differences in performance stemmed from regional differences in store management and labor (because each DC served stores in a certain geographic region). Gamma managers pointed out that, unlike the other two DCs, DC 1 had had stable management since its inception. Over time, the management team at DC1 had established procedures for a number of activities. For example, procedures for quality control, receiving inventory returned from stores, and shelving of inventory existed and were enforced.

Interestingly, merchandise received at the stores directly from the vendor tend to have much more accurate records than those shipped from even the best DC. Gamma managers believed that the superior performance obtained on vendor-direct items could be traced to two factors. First, store managers are more careful in checking shipments received directly from vendors for accuracy, partly to ensure that invoices are accurate. Expecting this, vendors probably are more

careful than DCs, who at times can be somewhat sloppy in verifying accuracy. Furthermore, Gamma Corporation, in an attempt to save on operational complexity, had issued policies whereby stores could not get credit for mis-shipped items unless the quantity of mis-shipment exceeded a certain dollar amount. Such a limit did not apply to shipments received directly from vendors. This also contributed to the increased likelihood of store managers checking vendor shipments. Second, vendor-direct shipments tend to be smaller overall and often contained fewer items. Consequently, they could be checked more easily.

Merchandising and Inventory Management

Greater variety and more store inventory lead to greater inaccuracy in inventory records and more misplaced SKUs. Our data show conclusively (i.e., with very high statistical significance) that increasing variety leads to more execution problems. Increasing variety results in multiple items at a store that are very similar to each other. Similar SKUs result in process confusion at the DC and the store. For example, it is easy for pickers at the DC to pick one SKU instead of the other by accident, especially if the SKUs, in addition to being similar, are located next to each other. Similarly, as in the yogurt example provided earlier, it is easier for salespeople at the store to scan one SKU multiple times if a consumer purchases multiple SKUs that are similar to each other.

With misplaced SKUs, it is harder for employees to identify items that are misplaced, or identify items that are in the backroom but should be on the selling floor, when there are more SKUs in a store. In a bookstore, for instance, associates find it extremely hard to identify titles that are missing from the sales floor and available in the backroom as assortment increases. As another example, one bread manufacturer described the problem of "lost facings" that his firm encountered when dealing with supermarkets that rely on manual reordering at stores. Increasing bread assortment led to associates simply forgetting to reorder some bread SKUs for a few days, which eventually led to the item being dropped from the store's assortment entirely.

Additional inventory leads to more crowded stores, and hence, makes it harder to keep track of the number of units available. It is easy to count inventory if few units are available per SKU but hard to do so accurately when each SKU has many units. Moreover, additional inventory also leads to multiple locations for the same item, which also leads to greater difficulty in counting and ensuring that items are not missing from the sales floor.

Employee Turnover

At Beta Corporation, two aspects of employee turnover were associated with the number of items that were found in the store but not on the selling floor.

Stores with higher turnover of floor employees had more items that were not on the floor. This is not surprising because, at Beta, floor employees

are typically responsible for re-shelving merchandise from the storage area to the selling floor. New floor employees understandably are less familiar with the stores' products and replenishment processes and probably make more errors in transferring items from the storage to the selling area. Moreover, as explained earlier, the inventory in the storage area is neither carefully monitored nor organized at Beta Corporation, as is true at many other retail stores. These stores rely on the employee doing replenishment to know if an item, which has sold out on the selling floor, is available in one of the storage areas. Newer employees are less likely to have this knowledge and hence could contribute to more items being in the storage area and not on the floor.

A second observation: stores where the store manager had either resigned or was fired during the year prior to the store audit had a higher percentage of misplaced items, an understandable phenomenon because a store manager's departure could be disruptive to various operations at the store.

Improving Retail Execution

Enlightened retailers, such as Beta and Gamma, are moving to improve execution in their operations. In fact, both Beta and Gamma have launched substantial initiatives with participation at the most senior levels in the organization. The executives in charge of stores and merchandising are personally involved in the projects; the CEO or Chairman is typically kept abreast of progress being made. There are three ways in which execution can be improved: through creating awareness of the problem and its impact; through counting and inspection; and by benchmarking performance *within* the retail chain to understand the drivers of poor execution and to allow poorer performers to learn from their better performing counterparts. These potential solutions and the drivers of poor execution identified in the previous section are summarized in Table 1.

Quite clearly, the execution problems described here are similar to the problems described and addressed in quality management. Not surprisingly, our prescriptions are similar to and share some characteristics with the solutions identified to improve quality in manufacturing. Similar to the observations by Deming, by Juran, and by Crosby, there is no single "magic bullet" or easy "quick fix" to overcome the problems in retail execution.[4] However, execution performance, just like manufacturing quality, can be improved.

Create Awareness of the Problem and Its Impact on the Firm's Performance

Many employees in retail companies are unaware of the extent and magnitude of these execution problems in their chains, even if they are in functions like Merchandising and Replenishment that rely on such data. Although both Gamma and Beta are among the relatively few retailers that actually track inventory quantity at the SKU level and location within the store during their

TABLE 1. Drivers of and Potential Solutions for Execution Problems

Driver of Execution Problems	Examples	Potential Solutions
Store and DC Replenishment Processes	• Errors in scanning at checkout • Items not moved from storage to shelf at appropriate time • Wrong item picked in DC • Shipments from DC not verified at store	• Create awareness of execution problems and associated costs among store and DC employees. • Inspect (via audits and sampling) accuracy of inventory records and location of SKUs in stores. • Alter processes based on employee and customer feedback and inspection results.
Merchandising and Inventory Management	• Greater variety in assortment leads to more confusion (e.g. harder to identify merchandise that has been sold and is available in storage). Easier for checkout counter clerk or picker in DC to get two very similar items confused. • Additional inventory leads to more crowding in stores. Harder to keep track of items.	• Create awareness among merchants and inventory planners. • Benchmark performance at different stores to identify how merchandising and inventory management affect execution performance.
Turnover	• New employees get confused more easily • Store managers cannot transfer, to new managers, tacit knowledge about store processes and procedures.	• Create awareness among store and human resource managers. • Benchmark performance at different stores to quantify the impact of turnover on execution.

annual audits, many managers at each firm were surprised by the shocking evidence of poor execution.

Lack of awareness is often to blame for the inaccurate scanning of merchandise, one cause of inventory record inaccuracy. Most checkout clerks do not realize the impact of their actions on the accuracy of inventory records. Perhaps more problematic in most organizations, store training and incentives motivate clerks to focus on scanning quickly rather than accurately. POS scanners should not be viewed exclusively as labor-saving devices, as has been common in the past, but rather as critical data gathering tools. As such, employees need to be aware of the importance of the data collected and how inaccuracies can have repercussions throughout the organization, and they must be trained accordingly.

Consistent with the claim that awareness can help us better manage these execution problems, the accuracy of inventory records improves with the cost of the item. That is, inventory records are more likely to be accurate for expensive

items. This is true even after controlling for other differences among expensive and inexpensive items. The reason for this finding is that store managers and employees, because of their focus on controlling inventory shrink,[5] pay more attention to managing inventory of expensive items. While this focus on expensive items is appropriate for managing shrink, it is inappropriate for managing execution. By focusing their attention on expensive items, retailers run the risk of running out of items that, though inexpensive, have high stockout costs. Gamma, for example, had identified a list of 250 "never out" items that though inexpensive were those that consumers expected the stores to have in stock.[6] However, since many of these items were inexpensive and also had high annual sales volumes, they were highly prone to inaccuracies in inventory records and, as a consequence, frequent stockouts.

In addition, creating awareness of the problem is not enough; awareness of the *impact* of the problem is also important. At Gamma for example, quantifying the lost profit due to inventory record inaccuracy was a vital step in gaining senior management commitment. Beta, on the other hand, quantified the cost associated with misplaced SKUs early in the project. Having quantified these costs, Beta managers were able to garner top-management support that led to the creation of a cross-functional team to address the problem.

Creating awareness of the problem and its impact broadly in the organization can often have immediate consequences. During the last year alone, Beta reduced the number of SKUs that are in the store but not on the selling floor by 22%, driven largely through greater awareness and training at the store level.

Count and Inspect

Frequent physical audits of stores can help in improving execution performance. At Gamma, stores that were counted twice a year had substantially lower errors.

Most retail stores conduct annual physical audits or periodic "cycle counts" where a part of the store is counted every week or month. At most stores, physical audits are performed to ensure "financial conformance." Hence, the auditors measure shrink carefully but do not track errors in inventory *at the SKU level*. For example, the auditors would conclude that there was no shrink if a store had extra units of a particular item and was short by the same number of units for another item with the same price. At many stores, system and physical inventories have not been aligned for years, even though the physical audits and cycle counts offered excellent opportunities for doing so.

To start using their inspection procedures more effectively, many companies should make some changes to their physical audit and cycle counting processes. The audit and count should be conducted at the item level, not at the dollar level alone. In other words, companies should ask their auditors to examine absolute unit differences between system and physical inventory levels.

Moreover, the absolute differences should be stored to enable the identification of stores and SKUs that are executing exceptionally well or poorly. If appropriate, auditors should also check if the items are shelved at the right location within the store. Beta Corporation, for example, was aided by the fact that the company tracked how many units of each item were available at different locations. Thus, the company tracked *how much* and *where* the item was within the store (e.g., whether an item was in the backroom or on the selling floor).

A variation of cycle counting to improve inventory record accuracy can be found at some retail chains. Employees at these companies perform a "Zero-Balance Walk" every day at their stores to identify items that are stocked out. The company verifies system inventory levels for these items and adjusts system inventory levels for those items found to be inaccurate. Beta launched an initiative to track misplaced SKUs in its stores. The stores were asked to verify if 100 randomly chosen SKUs were available at the right location. Such a sampling process is much less expensive than the audit and could be performed more frequently than the annual audit by store employees. Such routine checks, partly by increasing the awareness of the problem, can often go a long way in improving execution.

The zero-balance walk or the sampling process could also be the basis for a statistical process control ("SPC") chart that has been recommended and used widely in manufacturing.[7] Each inaccurate inventory record or misplaced SKU could be considered a "defect" in quality terms and substantial deviations from expected defect levels would be investigated and become opportunities for learning and process improvement.

Benchmark within Your Chain

Retailers can improve execution in their stores by learning from parts of their chains that are currently executing well. Our research shows that some stores within a chain execute much better, and consistently so, than other stores.

Evidence that some stores are executing well serves as powerful evidence to managers in retail companies that operational execution *can* be managed and improved. This evidence can be used to understand the drivers of poor execution and can also be used to motivate the stores that are lagging in execution.

Both Beta and Gamma shared the results of our statistical analysis widely in their organizations. Understandably, the findings generated a lot of interest not only among store managers, but also managers from merchandising and human resources whose actions were shown by our analysis to impact a store's ability to execute. Moreover, the wide dispersion within the same chain, where all the stores use the same information technology and have the same monetary incentives, makes it clear that technology and incentives are not the drivers of inter-store differences.

Immediate Steps to Improving Operational Execution in Retailing

Retailers can take the following five steps to improve operational execution immediately.

As a first step, retailers should measure performance along dimensions of operational execution that are important to their businesses. For example, retailers that are interested in improving inventory record inaccuracy should measure the absolute difference between system and actual inventory levels at the SKU level. Similarly, those that are interested in managing misplaced SKUs should measure the fraction of their stores' assortment that is misplaced within the store. Such measures, as noted earlier, can be derived from physical audits at the stores, through sampling methods, or through cycle counting procedures.

Second, these measurements should be used to create awareness of the problem. As noted earlier, it is valuable to be able to quantify the costs associated with poor execution. Managers in functions like merchandising, information technology, marketing, and human resources—whose efforts are compromised by poor execution or whose actions determine the quality of execution in retailing—are usually unaware of the magnitude, or even existence, of execution problems. Store and DC personnel, on the other hand, are often aware of execution problem but unaware of its impact on the company.

Third, the measurements should be used to set up a process for continuous process improvement. Similar to the approach taken with managing quality in manufacturing,[8] retailers should set up processes for diagnosing the causes of poor execution and identifying ways in which these causes can be overcome.

Fourth, retailers should derive advantages from the fact that they typically control hundreds or even thousands of stores, and can use the differences in processes and performance at these stores to understand how execution can be improved.

Fifth, retailers can improve performance by using operational data for decision making. It is tempting for some to argue that the execution problems reported here should logically lead us to avoid relying on POS and inventory data for inventory and supply chain planning. There are two flaws in this argument. One, not relying on such data for inventory management, as others have argued,[9] is simply infeasible in the long term, especially as leading retailers such as Beta and Gamma are improving their ability to use such data. Two, using the data can expose problems in them and hence provide the company with impetus to improve execution. Both Beta and Gamma discovered their execution problems when they attempted to use the data in their systems. Gamma, for example, found that the performance of its automatic replenishment systems was compromised because of inaccurate inventory records. Beta had invested in computerized kiosks that allowed customers to find out if a certain item was available at the store. The company began to investigate customer

complaints that items that the system showed as available at the store could often not be found. As a result, the company discovered the magnitude of misplaced SKUs in its stores.

Conclusion

It is important for retailers, at a minimum, to be aware of these problems and the potential impact they may have on profitability. Moreover, as a Beta executive pointed out, acknowledging the prevalence of weak execution would make it less embarrassing for retailers to discuss these problems in public and thus identify solutions jointly. Execution can be managed. Our data show that some stores perform better than others year after year. The drivers of these differences yield prescriptions to improve execution.

APPENDIX
Summary of Empirical Analysis

Our conclusions on the drivers of inventory record inaccuracy and misplaced SKUs are based on regression analysis, a statistical technique that allows us to explain the variation in a dependent variable using values of other variables. We use three regression models to derive our results, two applied to Gamma data (for inventory record inaccuracy) and one applied to Beta (for misplaced SKUs). More details of our technical analysis can be found in DeHoratius and Raman[10] and in Raman and Ton.[11]

We estimate the drivers of inventory record inaccuracy at the record level and at the store level. For our record level analysis, we use logistic regression to predict the probability of inventory record accuracy as a function of the cost of the recorded item, the quantity sold of that item during the past year, and whether or not the item was shipped to the store direct from the vendor or from the retail-owned distribution center. We control for differences across stores and product categories. All variables in our final model are significant at the 99.9% level.

For our store level analysis, we predict the average error in store inventory as a function of inventory density (the quantity of inventory in a particular selling floor space), the frequency of inventory audits at the store, the product variety displayed at the store, and the DC from which the store receives merchandise. We control for sales differences across stores. In our final model, inventory density and the frequency of audits are significant at the 95% level, product variety is significant at the 99% level, and the impact of the DCs from which the store received merchandise was significant at the 99.9% level.

We estimate the drivers of misplaced SKUs at the store level. We predict the fraction of items that are present in storage areas but not on the selling floor as a function of "SKU density" (the number of SKUs in a particular selling floor

space), "depth" (the quantity of inventory for each SKU), backroom size, full-time and part-time employee turnover, general manager turnover, and "training" (the number of training assistant managers at a particular store). We control for regional differences, unemployment rate, age of the store, and the period during which the audit was conducted. In our final model, part-time employee turnover is significant at the 95% level, depth is significant at the 99% level, and SKU density and general manager turnover are significant at the 99.5% level.

Notes

1. Carl Steidtmann, "The New Retail Technology," *Discount Merchandiser* (November 1999), pp. 23-24.
2. The research consortium, Consortium for Operational Excellence in Retailing (COER), is directed by Professor Marshall Fisher of the Wharton School of the University and Pennsylvania and Professor Ananth Raman of the Harvard Business School. The research is supported by the two schools and a grant from the Alfred P. Sloan Foundation.
3. John F. Krafcik, "Triumph of the Lean Production System," *Sloan Management Review*, 30 (Fall 1988): 41-52.
4. W.E. Deming, *Out of the Crisis* (Cambridge, MA: The MIT Press, 2000); P.B. Crosby, *Quality Is Free* (New York, NY: Mentor, 1980); J. M. Juran, *Juran on Leadership for Quality: An Executive Handbook* (New York, NY: The Free Press, 1989).
5. Levy and Weitz define shrink as the difference between the recorded value of inventory based on merchandise bought and received and the value of actual inventory in stores and distribution centers. Shrink is caused by employee theft, by customer shoplifting, and by merchandise being misplaced, damaged, or mispriced. Michael Levy and Barton A. Weitz, *Retailing Management* (New York, NY: Irwin/McGraw-Hill, 1998).
6. Milk at a supermarket would be an example of such a low-price but high-stock-out-cost item.
7. See Steven Nahmias, *Production and Operations Analysis* (New York, NY: Irwin/McGraw-Hill 1997).
8. For a discussion of manufacturing quality, see David Garvin, *Managing Quality* (New York, NY: The Free Press, 1988).
9. See, for example, Marshall Fisher, Ananth Raman, and Anna Sheen McClelland, "Rocket Science Retailing is Almost Here: Are you Ready?" *Harvard Business Review*, 78/4 (July/August 2000): 115-124.
10. Nicole DeHoratius and Ananth Raman, "Inventory Record Inaccuracy: An Empirical Analysis," Harvard Business School Working Paper (2001).
11. Ananth Raman and Zeynep Ton, "An Empirical Analysis of the Magnitude and Drivers of Misplaced SKUs in Retailing," Harvard Business School Working Paper (2001).