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UPC Scanner Pricing Systems: Are They Accurate?

The author empirically examines the efficiency of scanner checkout systems by calculating the rates of underrings and overrings occurring in stores employing scanner systems. Actual purchases were used to calculate error rates across three shopping trips to each of 15 stores. The results reveal that both underring and overring rates are significantly higher than retailers' expectations. Though these rates are equivalent across regular-priced purchases, they systematically favor the retailer for purchases of advertised specials and items on end-of-aisle displays. The author discusses the implications of these findings for retailers, consumers, researchers, and public policymakers.

Scanner technology has been a regular part of consumers' shopping experiences for over 15 years. Today, 93% of mass merchandisers and 94% of supermarkets employ scanner systems (*Chain Store Age Executive* 1990). The utilization of scanner technology has been quite advantageous for retailers. For example, documentation indicates that scanners have proven to increase retailer profitability by 4–5% net before tax (*Chain Store Age Executive* 1978). "Hard" savings (e.g., decreased labor costs) account for about half of this increase and "soft" savings (e.g, improved inventory management) account for the other half. However, these figures assume that the profits accrued to retailers reflect agreement between displayed prices and consumer charges. Deviations from this assumption could affect profitability upward when prices charged exceed prices displayed (overrings), and downward when prices charged fall below displayed prices (underrings).

Scanners provide academics and retailers with huge quantities of data that have been used as the basis for studying consumers' buying patterns and how marketing variables impact these shopping patterns (e.g., Guadagni and Little 1983; Inman, McAlister, and Hoyer 1990). Both behavioral and quantitative scholars have learned about customers' shopping habits using scanner information. Behaviorally, the rich data sources provided by this technology have enabled researchers to have a better understanding of heuristics used in consumer choice (e.g., Simonson and Winer 1992). Pricing inaccuracy can limit the usefulness of consumers' heuristics, such as the value of a discounted price, in decision-making (Goodstein, Escalas, and Kassarjian 1993). Quantitative modeling using the data has enabled academics and managers to have a better understanding of how promotions affect consumer purchase behavior (e.g., Gupta 1991), as well as how product displays, such as end-of-aisle gondolas, affect the probability that consumers purchase a featured item (e.g., Guadagni and Little 1983). The existence of overrings and underrings could affect the validity of these findings when based on dollar market shares (cf. Sethuraman and Tellis 1991), because these shares could be biased by the errors. Examining the nature of scanner errors is consistent with the call of marketing scientists to examine their data at the micro level (e.g., Hauser and Wernerfelt 1990; Urbany and Dickson 1991; Winer 1986) and of experimental researchers to combine scanner findings with behavioral rationales (McIntyre and Bender 1986; Simonson and Winer 1992).

Consumers were promised that the advent of scanner technology would guarantee more accurate pricing, price deflation, faster checkout, and more detailed and accurate receipts (Pommer, Berkowitz, and Walton 1980). Scanner systems have been correlated with reductions in checkout times and more accurate receipts—that is, correctly reflecting prices stored in the retailer's central computer. However, the accuracy of prices that consumers are charged by retailers has remained relatively unexamined since the widespread adoption of scanner systems (Garland 1992). Price is an important cue in consumers' comparison shopping, reference prices, and determination of product satisfaction (Zeithaml 1982). Charging consumers prices that differ from those marked on shelves or featured in ads makes price a less useful cue for evaluating which items to purchase.

Other consumer research suggests that the issue of pricing accuracy is heightened for promotional items because promotions lead to "special" price inferences, even when items are not marked down (Dickson and Sawyer 1990; Inman, McAlister, and Hoyer 1990). For example, retail promotions (e.g., advertised price reductions, end-of-aisle displays) have a significant positive influence on consumer sales, yet consumers have very poor recall of the prices

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charged at the point of purchase (Dickson and Sawyer 1990; McIntyre and Bender 1986; Zeithaml 1982). Furthermore, consumers are unlikely to remember advertised prices and instead rely on point of purchase price displays as their reference (Dickson and Sawyer 1986). On the basis of these studies, consumerists conclude that retailers can abuse customers by not lowering actual prices on promotional items at the point of purchase, even though they promote these lower prices. Retail trade associations assure customers that such abuses do not take place. For example, Edie Meleski of the Food Marketing Institute (an international trade group representing 1500 food companies) believes that store policies such as giving consumers free items when they find an overcharge act as disincentives for stores to cheat, because cheating actually would decrease profitability over the long run (O'Connell 1993). Consumerists counterargue this claim by citing research indicating that very few consumers notice when they are being mischarged, especially when item prices are nonexistent (cf. Langrehr and Robinson 1979). This debate has been the focus of several recent public policy inquiries (Green 1991; O'Connell 1993).

Given the relative importance of scanner pricing accuracy for retailers, academics, consumers, and public policymakers, it is surprising that academic research for the most part has ignored this issue. Scanner accuracy is critically linked to retail pricing and profit policies, potential biases in academic findings based on scanner data, efficiency of consumer heuristics based on price cues, and legal action by public policymakers interested in consumer welfare. Clearly the implications of such an inquiry would relate to all these groups, regardless of the outcome. This study addresses this gap by examining the error rates in retail stores adopting scanner systems, and places specific emphasis on the area of promotional items.

History of Scanner Adoption

In 1971 the Grocery Industry's Ad Hoc Committee on Universal Product Coding (UPC) was formed by the nation's six major grocery associations. This committee recommended to grocers that they adopt the UPC scanning system because it "provides a standardized method for identifying products according to the name of the manufacturer and product 'type' (by size and weight)" (California Assembly Office of Research 1977, p. 8). A subcommittee then recommended that (1) the industry adopt a single, common code; (2) the code consist of numeric digits divided into two groups, one identifying the manufacturer and one the particular product; and (3) the associated code be in a standard, machine-readable format. This recommendation was adopted in 1973 and yielded the now familiar series of thin and bold vertical lines accompanied by numerics directly below.

The UPC system was projected to save retailers 1–2% of costs from improved checkstand productivity, elimination of item pricing, reduced workforce, and elimination of intentional and unintentional misrings. Improved efficiency in the areas of automatic (re)ordering, improved shelf space allocation, improved sales analysis, and better item tracking promised additional savings of 2–3%. Customers also would benefit because adoption would produce faster and more accurate checkouts, slower rises in prices, and more detailed customer receipts. Many of these promises have proven true (see Cutler and Rowe 1990 for a review), though the issue of pricing accuracy has not been addressed.

By 1990, grocers, general retailers, and department stores virtually all had converted to scanner pricing and checkout (*Chain Store Age Executive* 1990). Most systems employed by retailers use laser scanners built into checkstands (hand-held scanners in department stores) as the major scanning device. This means that clerks do not read the prices; they simply pass them over the optical scanner. Item prices corresponding to the UPC code are reported to the register via in-store microprocessor, minicomputer, or on-line central computer for some chains. All information related to the transaction is contained in the computer, which records the sale and marks the unit out of inventory (Cutler and Rowe 1990).

The introduction of UPC coding and scanner checkout alleviated the need for retailers to mark prices individually on each unit of inventory. Instead, prices were marked on the shelves housing the inventory, resulting in substantial savings in labor costs for the retailer (Garland 1992) and the promise of fewer pricing errors (Cutler and Rowe 1990). Consumers and consumerists, however, reacted strongly to this change in the fear that inconsistencies would exist between the shelf labels and the prices stored in the computer. Furthermore, they were concerned that consumers would be unable to remember the prices posted on shelf labels when they went to the store checkout stand (Gylling 1976).

The industry reacted to these complaints by stressing the advantages that consumers were obtaining from the system, but never directly tested consumers' concerns over pricing accuracy. Even industry studies found that consumers had questions about item price removal and shelf tag accuracy (e.g., Gylling 1976; Lucky Stores 1975). An industry-sponsored survey, referred to as the Michigan State University Study (1976), found that scanners had met their promise in terms of checkout speed. The study also concluded that UPC systems correlated with lower price awareness and less comparison shopping by consumers, relative to conventional systems using item pricing. This is not unexpected because customers in stores using item-pricing systems could check their baskets to confirm prices. Yet, this result also was found in surveys in which item prices were not available for immediate recall (Harris and Mills 1980, 1982; McIntyre and Bender 1986).

Legislative research also addressed consumers' concerns. For example, the California Assembly Office of Research (1977) concluded that the grocery industry had failed to acknowledge consumers' concerns over item price removal. Item price removal, they feared, put severe stress on consumers' capacity to remember price information (cf. Bettman 1979). Given that the average shopping trip consists of approximately 30 items, it becomes nearly impossible to compare shelf and checkout prices and to catch er-

rors. Retailers, however, emphasized the fact that customers preferred shopping in stores using the scanner systems. Langher and Robinson (1979) echo this sentiment and find that 64% of shoppers believe scanning provides for a more efficient shopping environment. However, though they also find that 15% of shoppers believe scanning provides for more accurate pricing, 20% actually mention that scanning could lead to inaccurate pricing. Yet, other research concludes that availability of item prices does not necessarily improve pricing accuracy. In fact, shoppers indicate that the improvements in checkout time outweigh the disadvantages of item price removal (Dickson and Sawyer 1986).

The Consumer Federation of America states that pricing errors are a national problem, which has been on the increase since the widespread adoption of UPC technology. The consumerists maintain that these errors in fact could be acts of deception rather than simple mistakes (Bartholomew 1992; *Chain Store Age Executive* 1976). Some academics agree: "Mistakes and deception can still occur with scanning but the key point is that they are less likely to be *identified*" (Cutler and Rowe 1990, p. 166). Industry and some legal experts believe, however, that the issue is less likely related to fraud than issues of negligence by management (Bartholomew 1992).

The Consumers' Perspective

As adoption of scanner systems increased, retailers maintained that the system was benefiting consumers; however, only one report conducted by nonindustry researchers had surveyed actual consumers for their opinions of the systems, and the results of this inquiry were mixed (MSU Study 1976). When researchers noted this gap, they began to survey consumers systematically for their reactions to item price removal. For example, Langrehr and Robinson (1979) explored consumers' reactions to scanner adoption and item price removal. They found that though consumers surveyed mentioned that scanner systems reduced checkout time and provided a more accurate and informative receipt, almost 85% of respondents did not examine their receipts for information or accuracy. Many respondents believed not only that scanners provided no real advantages to consumers, but that they actually presented serious disadvantages to consumers because of inconsistencies between shelf prices and the price charged on the receipt. Langrehr and Robinson conclude that studies investigating where these errors occur and whether these inconsistencies favor the retailer or the customer are warranted.

Subsequent survey research confirmed these earlier opinions: (1) consumers believe that checkout service has improved, (2) receipts are more detailed but largely unused, and (3) consumers question whether item price removal will put them at a disadvantage (e.g., Harris and Mills 1980, 1982; Langrehr and Langrehr 1983). One survey found that the question of pricing accuracy was heightened for promotional items because promotions tended to increase store traffic and sales (Pommer, Berkowitz, and Walton 1980). Discussions in these papers suggest that retailers develop strategies to remove fears of consumer deception, yet none of these studies empirically test the pricing accuracy of stores employing scanner systems.

The New Jersey Division of Consumer Affairs found that overrings occurred twice as often as underrings and cost consumers three times more than they were saving on underrings (Danco 1983), though it is not clear whether the state randomly selected items for their study. In a recent media-sponsored investigation, O'Connell (1993) concludes that 30% of grocery stores overcharge. Within these stores, consumers are overcharged, on average, on one out of every ten items purchased. Similarly, the City of New York found that when errors occur, they are ten times more likely to be an overcharge than an undercharge (Green 1991). In contrast, the Food Marketing Institute cites two studies that indicate that scanner errors occur less than 3% of the time (New York State Food Merchants Institute 1991; Virginia Department of Agriculture and Consumer Services 1990).

Two academic investigations have examined error rates in stores employing UPC scanner systems. Welch and Massey (1988) examine the accuracy of scanner checkout by making 205 shopping trips across six grocery chains. Errors were defined as a shopping trip in which a shelf tag price disagreed with the price on the register receipt. Of the 58 "errors" they found, overrings occurred significantly more often than underrings. By analyzing their data at the shopping trip level, it is likely that Welch and Massey bias error rates downward because more errors can take place at the item level (Goodstein, Escalas, and Kassarjian 1993). It is also not clear whether items were selected randomly for purchase in this study or if promotions such as advertised specials or end-of-aisle specials were investigated. These specials were of particular concern to consumers in the survey addressing item price removal (Pommer, Berkowitz, and Walton 1980).

In another study, Garland (1992) investigates price accuracy in New Zealand supermarkets by purchasing over 18,000 bar-coded items. Purchases were made in both scanner and nonscanner stores. Overall, discrepancies (shelf price less receipt price not equal to zero) were found on 4.29% of items purchased. Undercharges were found on 2.39% of purchases and overcharges on 1.65%, with other types of errors accounting for the remainder. He also found that overall rates of error increase significantly for sale goods relative to regular-priced goods. The question of whether error is due to scanning, however, is not addressed because Garland pools his data without regard for a store's pricing technology.

So, overall results are mixed. The academic studies have limitations that restrict their generalizability and implications. The nonacademic studies simply disagree. Consumerists cite studies indicating alarming error rates and the industry cites studies with lower rates of misrings. Unfortunately, both sides may be biased on the outcome. For example, the two studies conducted during the same time period in New York draw opposite conclusions. On the basis of these shortcomings, an unbiased empirical investigation appears warranted.

The Retailers' Perspective

Retailers clearly have benefited from the adoption of scanner equipment. For example, scanning greatly simplifies pricing for the company in that price changes are handled by simply changing the computer and shelf tags. Scanner maker NCR Corporation estimates that most retailers make between 1500 and 3000 price changes a week. The elimination of item pricing labor on these changes have netted retailers substantial profits (Cutler and Rowe 1990). The technology also has enabled retailers to make promotions available to consumers more regularly because price changes are handled more efficiently. In fact, recent trends in retailing indicate unprecedented growth in the use of temporary price reductions (Currim and Schneider 1991). Assuring pricing accuracy on these promotions is clearly the aim of the industry, according to the Food Marketing Institute (O'Connell 1993). Consumer research also finds that accurate pricing positively influences consumer choice (Moore and Olshavsky 1989).

Public debates and inquiries into pricing accuracy make the retailer look guilty and cast doubts regarding the honesty of the entire industry (e.g., Bartholomew 1992; O'Connell 1993; ABC's "PrimeTime Live" 1993). A typical response from retailers is that "the inspections didn't take undercharges into account" (e.g., O'Connell 1993). However, balancing underring and overring errors does not benefit the retailer; in fact they could lose on both ends. Legal actions against the retailers are required by law to include only overrings (Cutler and Rowe 1990), and publicity of price deception harms consumer loyalty (Grewal and Compeau 1992). When underrings occur they can erode profits directly; one study finds that this type of error has not been eliminated by scanner adoption (Garland 1992).

Therefore, though documentation indicates that scanners have increased retailer profitability, pricing errors must be considered before drawing a bottom line conclusion. Retailers appear to desire accurate pricing, though consumerists argue this point. Overrings mean legal problems and consumer distrust; underrings mean decreased profitability. The question of interest then is, How do we resolve the differences between consumers' charges and retailers' assurances? The answer to this question involves investigation of the actual error rates in stores using scanner systems; however, error rates have remained relatively unexamined in the academic literature (Garland 1992).

Retailers' rates of undercharging and overcharging across the store should be equal and lower than before the adoption of scanner systems. This should hold true for regular priced items, advertised sale items, and items displayed on the end of the aisles (Kassarjian, Goodstein, and Escalas 1992). If overrings exceed underrings or overrings are occurring more often with promotional items than with regular-priced items, then consumers' concerns are warranted and retailers risk losing customer loyalty (Urbany, Madden, and Dickson 1989). If underrings exceed overrings, then retailers should examine the efficiency with which they use this sophisticated technology because they could be losing profits.

Hypotheses

Most of the research addressing consumers' concerns about scanner systems has been survey based. Opinions about possible deception and errors have been the dominant dependent variable in survey studies; however, error rates are best measured by examining actual purchases. Though consumers' opinions provide an important signal to retailers, only those customers actually purchasing goods are relevant for testing whether these opinions are empirically valid (cf. Garland 1992).

For retailers, underring rates historically have averaged approximately .7% among regular-priced, nonadvertised items before the installation of scanner systems (Welch and Massey 1988). Overrings would be expected to be a similar fraction of sales (Kassarjian, Goodstein, and Escalas 1992). Higher error rates for overrings could be viewed as a deceptive practice, whereas a higher percentage of underrings could be cause for retailer concern. One of the major reasons for adopting scanner systems was the elimination of both errors, and industry periodicals imply that underring errors have been reduced substantially in stores adopting scanner systems (*Chain Store Age Executive* 1978).

By definition, no temporary price changes are made on regular-priced, nonfeatured goods during a retailer's sale week. When price changes do occur, that is, on promotional items, it is more likely that mischarges are found (Garland 1992; Welch and Massey 1988). Retailers claim that it is often hard to key in all price changes on the opening day of a sale week, though this delay should not affect error rates for regular-priced goods. That is, error rates for regular-priced goods should be independent of the fact that retailers update their computer systems after the start of a sale week (Bartholomew 1992). Therefore, from the retailers' perspective we expect the following:

H_{1a}: The rate of underrings for regular-priced, nonadvertised items will be less than .7% in stores employing scanner systems.

H_{1b}: The rate of overrings for regular-priced, nonadvertised items will be equal to the rate of underrings for regular-priced, nonadvertised items in stores employing scanner systems.

H_{1c}: The rate of overrings and underrings for regular-priced, nonadvertised items will be constant over a sale week in stores employing scanner systems.

Though regular-priced items provide a good base rate of in-store error, consumerists were more concerned about increased error rates for promoted items (e.g., Pommer, Berkowitz, and Walton 1980). One common method of promotion for stores employing scanner systems is weekly advertising featuring price discounts on many items found in the store. Advertised promotions (price discounts) increase both traffic into a store (Kumar and Leone 1988) and the volume of sales for an item (Sethuraman and Tellis 1991). These promotions, however, require that the prices stored in a retailer's computer system be reduced. Failure to do so would increase the rate of overrings. Though not allowed legally by the Federal Trade Commission, it is possible that stores have not updated their computers by the opening of the sale day; in that case, however, we would expect the

rate of overrings to be reduced by the end of the sale week (Goodstein, Escala, and Kassarjian 1993; O'Connell 1993).

Consumerists argue that because customers do not remember advertised prices (e.g., Dickson and Sawyer 1990), they are unable to call overcharges to the attention of retailers. Thus, deception can result and lead to consumer mistrust (e.g., Harris and Mills 1980) and even legal action (O'Connell 1993; Trager 1992a). Consumerists predict error rates to favor the retailer, especially if these errors are unidentifiable (Cutler and Rowe 1990). Conversely, retailers acting fairly would expect that error rates for advertised specials should occur no more often than they do for regular-priced goods. Because promotions usually represent lower profit margins, mischarges have an even greater effect on profits and are less likely to occur (O'Connell 1993). Therefore, from the retailers' perspective we expect the following:

H_{2a}: The rate of underrings for advertised, price-reduced items and regular-priced, nonadvertised items will be equal in stores employing scanner systems.

H_{2b}: The rate of overrings for advertised, price-reduced items and regular-priced, nonadvertised items will be equal in stores employing scanner systems.

H_{2c}: The rate of overrings and underrings for advertised, price-reduced items will be equal in stores employing scanner systems.

H_{2d}: The rate of overrings for advertised, price-reduced items will decline over the course of the sale week in stores employing scanner systems.

Another commonly used method of promotion in stores using scanner systems is the end-of-aisle display. When accompanied by price reductions, these promotions lead to significant sales increases (Blattberg, Eppen, and Lieberman 1981; Dodson, Tybout, and Sternthal 1978; Guadagni and Little 1983). Recent research indicates that even in the absence of price reductions, feature displays lead to increased sales (Inman, McAlister, and Hoyer 1990). End-of-aisle displays signal a "special deal" to consumers, even though an item may not have been reduced in price. Because end-of-aisle displays are not necessarily advertised, conservatively we can assume that volume increases can be attributed to in-store customers rather than higher store traffic. As was the case with advertised specials, consumerists believe that end-of-aisle promotions can result in consumers paying prices above the amounts shown on in-store signs. This opportunity stems from the fact that though consumers can recall whether an item was displayed specially, they cannot remember its special price (Dickson and Sawyer 1990; Zeithaml 1982). Consumerists say that this can lead to misrings by retailers, though retailers expect that no more errors occur with these items than with regular-priced items. On the basis of retailers' claims and the fact that not all end-of-aisle display items required price reductions, we expect the following:

H_{3a}: The rate of underrings for nonadvertised items featured on end-of-aisle displays and regular-priced, nonadvertised items on the main aisles will be equal in stores employing scanner systems.

H_{3b}: The rate of overrings for nonadvertised items featured on end-of-aisle displays and regular-priced, nonadvertised items on the main aisles will be equal in stores employing scanner systems.

H_{3c}: The rate of overrings and underrings for nonadvertised items featured on end-of-aisle displays will be equal in stores employing scanner systems.

H_{3d}: The rate of overrings for nonadvertised items featured on end-of-aisle displays will decline over the course of the sale week in stores employing scanner systems.

Methodology

The hypotheses were tested in a quasi-experiment examining the type and magnitude of register errors made in stores employing scanner systems. Data were collected by trained personnel following a product shopping procedure that ensured random selection of advertised, end-of-aisle, and regular-priced items. The shoppers frequented five outlets for each of three retail chains exclusively using UPC scanner checkout systems (two supermarkets and a general merchandiser).

Selection of Stores

The State Department of Weights and Measures selected three large chains of retail stores from one political subdivision—a county in California. To avoid potential bias due to chain selection, H_{2a-b} and H_{3a-b} are tested relative to error rates for regular-priced goods from the same chains. In addition, "chain" is included as a covariate in the analysis and tests *within* a product class (i.e., H_{1c}, H_{2c-d}, and H_{3c-d}) will not be affected by chain selection.

Two of the retail chains used are among the largest supermarket retailers in the United States and the sales leaders in the county. Within the test area, the first chain had 20 outlets and the second had 13. The average supermarket within these chains carries between 30,000 and 50,000 different items, though some carry as many as 75,000 products. The third retailer is a chain with 15 general merchandise stores in the county. The chain carries approximately 40,000 to 50,000 individual items per store. Using a table of random numbers, 5 stores from each chain were selected for a total of 15 stores (10 supermarkets and 5 general merchandise stores).

Selection of Products

Three groups of products were included in the study, all of which were bar coded with the UPC symbol. The first group was made up of those products that were advertised in the local paper as being at a special price for a week. The second group was not advertised in the newspapers but was featured in the stores on end-of-aisle displays. The third was made up of the regular-priced, nonadvertised products selected from the main aisles within the store. A total of 30 items (10 from each group) was purchased on each trip because this was the size of the average market basket in the state (California Assembly Office of Research 1977).

To select the assortment of advertised specials to be purchased from the supermarkets, a copy of the local newspaper was obtained on the first morning of the study and

every advertised item consecutively numbered. Using the Rand table of random numbers, ten separate lists of 30 advertised items were generated (one for each of the five stores of the two supermarket chains). Each shopper was given one list and assigned a particular store from which he or she was to buy the first ten items that were available for purchase. The list of ten purchased items was then turned over to a second shopper, who repurchased the same ten items (or less if an item was out of stock) in the middle of the sale week; this procedure was repeated on the last day of the sale.

A similar procedure was used to select nonadvertised items specially displayed on the end of the supermarket aisles. Aisles were numbered consecutively in the stores, and shoppers were given a list of random numbers from which to select an aisle. If this number was even, an item was selected from the front of an aisle; if odd, from the rear. A second random number procedure was used to select an item if the display contained multiple brands or sizes. This procedure continued until ten different end-of-aisle items that had not been in the store's ad were selected. The same ten items were repurchased by subsequent shoppers in a store unless an item was out of stock or no longer on the end-of-aisle display.

To select the regular-priced items for purchase we used a 700-page computer printout listing all products (by brand, size, and weight) sold in a similar grocery chain not included in the study. From that tome, 300 pages were selected randomly and one item chosen randomly from each page. Again using the Rand table of random numbers, ten separate lists of 30 products were generated. Each shopper was given a list randomly assigned to his or her store. The shopper was to buy the first ten items from the list, provided the item was available for purchase, was not advertised, and was not displayed at the end of an aisle. The list of ten items purchased was turned over to subsequent shoppers who repurchased the items later in the week. On average, each shopper purchased $77 worth of supermarket products per visit. His or her cart contained ten advertised sale items, ten end-of-aisle display items, and ten regular-priced items.

The procedure in the general merchandise store was similar, modified according to the particular layout of those stores. We did not have a listing of all available products; hence, a procedure was developed to choose the regular-priced items by randomly selecting aisles and racks in the store, and from each rack randomly selecting a product. However, extremely bulky items (over 20 kilograms) and extremely expensive items (over $50) were omitted systematically. Again, each shopper purchased 30 products; 10 advertised sale items, 10 from end-of-aisle displays, and 10 regular-priced items. Total basket costs were, on average, $134 per visit. As with supermarkets, original lists of items purchased were passed on to the next shopper in that store.

Selection of Shopping Days

With all three chains, advertised sales occur weekly and last for seven days until the new sale week begins. Three time periods were selected to check prices: the initial morning of the sale week, approximately two hours after store opening; the middle of the sale week, on the afternoon of the fourth day; and early evening of the last day of the sale week. A different shopper purchased the items from a specific store on each day.

Procedure

Data were collected by trained personnel who were taught how to follow the procedures. Shoppers attended two training sessions and one field test before actually conducting the experiment. All shoppers had received a score of 100% in a mock shopping trip.

On the first trip to a store, shoppers began by selecting the first ten available items from their advertised sale list. After completing this task, they followed the random number procedure until ten items had been selected from end-of-aisle displays. Finally, the first ten available regular-priced items were selected from their list (or from the procedure outlined in the case of the general merchandiser). The procedure required shoppers to select each item in order, which enabled us to predict accurately what should have been in each basket. A second shopper verified these purchases later in the day, and there was 100% accuracy across stores and shoppers.

In addition to selecting and purchasing the appropriate items, shoppers also filled out a worksheet as they made their way through the store. On this worksheet they recorded the name and location of the store, the time they entered the store, a description of each item selected, whether it was a featured item (i.e., advertised or on an end-of-aisle display), and its shelf price. After purchasing the items, shoppers went back to the worksheet and recorded the price actually charged for each item. The worksheet and original receipt were turned in to the author.

A copy of the receipt then was given to the shopper assigned the same store on the next purchase date. The receipt made up their shopping list, though it sometimes resulted in fewer than 30 items purchased if an item was out of stock. The shoppers also completed the worksheets and turned in their original receipts. Because of out-of-stock items and the removal of items from end-of-aisle displays, a total of 1234 items were purchased and analyzed. These items were kept by the county for distribution.

Dependent Measures

The dependent measures in this study are straightforward. An underring is defined as a case in which the price charged for (1) a regular-priced item is less than its shelf price, (2) an advertised special is less than its featured price in the newspaper advertisement, or (3) an item on an end-of-aisle display is less than its featured price. Similarly, an overring is defined as a case in which the price charged for (1) a regular-priced item is more than its shelf price, (2) an advertised special is more than its featured price in the paper, or (3) an item on an end-of-aisle display is more than its featured price.

Results

Though three chains were used in the data collection, the pattern of results was similar across chains. On the basis of this observation, the chains were pooled in the analysis to draw conclusions about scanner technology across stores rather than within particular chains. A covariate was included in all subsequent analyses to account for chain effects before concluding about the variables of interest. Separate analyses were run for overrings and underrings and the results between and within each category are summarized in Tables 1 and 2, respectively. Of the 1234 items purchased, misrings (overrings plus underrings) occurred for 111 items (8.99%).

The ANCOVA revealed two major findings from these data. Misrings differed significantly depending on whether items were regular priced, advertised specials, or end-of-aisle features. Specifically, overrings were more prevalent for promoted items than for regular-priced items (Regular = 3.58%, Advertised = 7.25%, End-Aisle = 6.02%; $F[2,1223] = 2.99$, $p < .05$). Similarly, the rate of undercharging differed marginally across regular and promoted items (Regular = 4.77%, Advertised = 1.75%, End-Aisle = 3.61%; $F[2,1223] = 2.76$, $p < .06$). Counter to H_{2d}, date of purchase had no significant effect on the rate of overrings ($F[2,1223] < 1$, n.s.), a fact that should alert retailers and consumers because apparently mistakes are not being corrected during the week. The date of purchase did marginally affect underring rates (Day 1 = 4.77%, Day 2 = 3.11%, Day 3 = 2.10%; $F[2,1223] = 2.31$, $p < .10$), showing an improvement over the sale week. There were no significant interactions between category of product offerings (i.e., advertised specials, items on end-of-aisle displays, and regular-priced offerings) and date of purchase ($F[4,1223] < 1$, n.s.).

Contrasts were analyzed between and within each category of product offerings to test the individual propositions developed in the hypotheses. Winer (1971, p. 384) suggests that "specific comparisons that are built into the design or suggested by the theoretical basis for the experiment can and should be made individually, regardless of the outcome of the corresponding F tests." Therefore, the fact that differences in undercharging were only marginally accounted for ($p < .06$) by category of product offering does not affect the rationale for testing for differences between error rates on regular-priced versus advertised or end-of-aisle promotional items. Tests of the effect of date of purchase were tested using a "linear trend" comparison to see if error rates improved over the course of the sale week. The micro level analyses are presented by category, using tests of equal proportions for each planned comparison.

Regular-Priced, Nonadvertised Items

H_{1a} predicted that underring rates in scanner stores would be lower than they were before the adoption of scanner technology (.7%; cf. Welch and Massey 1988). Analysis revealed that the rate of underrings actually had increased significantly over historical rates (Underring = 4.77%; $z = 3.91$, $p < .001$); therefore, H_{1a} is rejected. Though underrings were quite prevalent, the test of equal proportions indicated that the rate of overrings was equally high for items in this category (Overring = 3.58%; $z < 1$, n.s.), supporting H_{1b}. Finally, the rates of error (underrings and overrings) were constant across the sale week ($F[1,1223] < 1$), supporting H_{1c}.

Though the rates of underrings and overrings were significantly higher than historical trends, the analysis revealed no systematic bias toward one type of error over the other. Errors, in terms of mischarges among regular-priced, nonadvertised items, therefore seem to be related to adoption of the scanner system rather than any bias by retailers (cf. Welch and Massey 1988).

TABLE 1
Overcharge and Undercharge Differences Between Categories of Goods

	Regular Priced	Advertised Special	p-value
	(419)	(400)	
% Under	4.77	1.75	.001
% Over	3.58	7.25	.01

	Regular Priced	End-Aisle Special	p-value
	(419)	(415)	
% Under	4.77	3.61	n.s.
% Over	3.58	6.02	.05

TABLE 2
Overcharge and Undercharge Differences Within Categories of Goods

	% Under	% Over	p-value
Regular Priced (419)	4.77	3.58	n.s.
Advertised Special (400)	1.75	7.25	.001
End-Aisle Special (415)	3.61	6.02	.06

Reduced-Priced, Advertised Items

H_{2a-d} predicted that the pattern of misrings across advertised specials and regular-priced goods will be equivalent. One exception was the expectation that overring rates would decline over the course of the sale week because retailers would update their sale prices into the scanner system. These hypotheses were not supported by the data. In particular, the rate of underrings was significantly less for advertised specials than it was for regular-priced goods (Regular = 4.77%, Advertised = 1.75%; $z = 4.61$, $p < .001$), failing to support H_{2a}. Analogously, the percentage of overrings was significantly higher when items were advertised than when they were regular priced (Regular = 3.58%, Advertised = 7.25%; $z = 2.33$, $p < .01$); therefore H_{2b} is not supported.

Analysis within the category of advertised sale specials also failed to support the hypotheses. For example, these data supported that retailers are significantly more likely to commit an overring error than an underring error (Underring = 1.75%, Overring = 7.25%; $z = 4.63$, $p < .001$), leading to the rejection of H_{2c}. Furthermore, retailers' claims that these error rates are simply a function of delayed timing and will decline over the week (H_{2d}) are not supported ($F[1,396] < 1$, n.s.). Interestingly for retailers, undercharg-

ing rates also did not decline over the course of the sale week ($F[1,396] < 1$, n.s.).

Overall, advertised sale specials could result in consumers paying prices above those featured in the newspapers. Overrings occurred more often for advertised items than for regular-priced items, and overring rates exceeded underring rates within this category of goods. Advertised goods performed better than regular-priced goods in terms of underrings, but retailers could be losing in the long run from reductions in loyalty related to overrings. Retailers and consumers should be alerted by the fact that all four hypotheses reveal that error rates in this category significantly favor the retailer over the consumer. In addition, the insignificant effect of date of purchase in the analysis suggests that sale prices not entered into scanner systems by the opening sale day are unlikely to be updated by the end of the sale week.

End-of-Aisle Display Items

H_{3a-d} predicted that the pattern of misrings across items on end-of-aisle displays and regular-priced goods would be equivalent. It also was predicted that the rate of overrings would decline over the course of the sale week because items featured on end-of-aisle displays are often accompanied by a price reduction. The pattern of results does not support these hypotheses. In particular, the rate of underrings was not significantly different between end-of-aisle items and regular-priced goods (Regular = 4.77%, End-Aisle = 3.61%; $z = 1.28$, n.s.), supporting H_{3a}. However, the overring results suggest a different conclusion. Overrings were higher for items on the end-of-aisle displays compared with those at regular price (Regular = 3.58%, End-Aisle = 6.02%; $z = 1.65$, $p < .05$), failing to support H_{3b}.

Tests within the category of end-of-aisle specials also failed to support the hypotheses. For example, the analysis revealed that retail errors for this type of promotion are more likely to be an overring than an underring (Underring = 3.61%, Overring = 6.02%; $z = 1.63$, $p < .06$), failing to support H_{3c}. Retailers' claim that these error rates are simply a function of delayed timing again are not supported ($F[1,411] < 1$, n.s.), and H_{3d} is rejected. Interestingly, underrings declined marginally over the sale week (Day 1 = 5.37%, Day 2 = 3.52%, Day 3 = 1.61%; $F[1,411] = 2.75$, $p < .10$).

Summarizing across these hypotheses, it appears that error rates among end-of-aisle items tend toward benefiting the retailer more often than the consumer. Three of the four propositions point to advantages for the stores. Consumerists' concerns that end-of-aisle specials could lead consumers to pay more for items than displayed on signs seem to be warranted. Retailers' contention that price changes would be updated later in the sale week received little support because date of purchase had no significant effect on overring rates. In addition, many items on end-of-aisle displays do not even require price changes to be entered into store computers (Inman, McAlister, and Hoyer 1990). Underring rates decreased over the sale week, yet the percentage of underrings is high enough to warrant retailers' attention.

Discussion

In total, errors average 1.57% of the shelf price. Though both underrings and overrings are represented, they are discussed separately because the presence of the former does not excuse the latter. Retailers and consumers should be concerned because both underrings and overrings have implications for each audience. Underrings may indicate that consumers gain in the short run, overrings mean that they are paying more for items than they should. One industry executive pointed out that many underrings occur simply because shelf labels have not been changed, and that consumers are not actually saving money at all. This fact is important considering (1) consumers already believe they are paying too much on their food bills (Margolius 1982), (2) price is the primary competitive variable in the industry (Urbany, Dickson, and Key 1990), (3) retailers operate on low margins (O'Connell 1993), and (4) overrings mean loss of consumer trust and possible legal action (Trager 1992b).

Before concluding that the results found in this study reflect those of all retailers using scanner systems, however, note that this study was based on examining 15 stores (three chains) within one California county. Given the sample, the results indicate that scanner systems have resulted in significant numbers of overrings and underrings. These rates are high compared with estimates made by experts before the advent of scanner systems. Though overrings and underrings were statistically equivalent for regular-priced items, the rate of errors indicate that scanner systems are less efficient than traditional item-pricing procedures. Part of the increase in errors may be accounted for by the fact that stores now carry more items and price discounting is more prevalent. However, this study provides academic data to supplement the industry and government reports described previously. The results are also similar to those found in the study conducted by Welch and Massey (1988) within the Dallas/Fort Worth metropolitan area, adding to the generalizability of the findings. Interestingly, these authors also conclude that the number of errors tend to favor the retailer rather than the consumer.

Retailers and consumers should be concerned by the pattern of results found for promotional items (advertised specials and end-of-aisle displays). Given the significant number of price changes that must be made weekly within a store, it is likely that error rates will be higher for promoted versus nonpromoted goods. This is supported by the data; however, the pattern of errors consistently favors the retailer over the consumer and supports consumerists' concerns developed almost 20 years ago. Advertised discounts were not delivered to consumers more than 7% of the time. Furthermore, overrings occurred more than four times as often as underrings within this category. Similarly, consumers are more likely to overpay versus underpay for an item appearing on an end-of-aisle display. Within this category, consumers are overcharged 1.67 times more often than they are undercharged for an item. Arguments that the correct charges are entered later in the sale week were not supported; the date of purchase had no effect on the number of misrings.

One may question whether these errors are noted and therefore whether they affect consumer behavior. Research suggests that consumers may have a zone of indifference around a price, meaning that slight deviations from a reference price go unnoticed (Krishnamurthi, Mazumdar, and Raj 1992). Given that shelf (advertised) prices are recognized as good models of reference prices (Urbany and Dickson 1991), consumers in these stores were unlikely to detect misrings at the point of purchase (1.57% deviation on average). Thus, not only do consumers fail to remember actual prices (Dickson and Sawyer 1990), they also fail to notice errors when the price charged is close to, but not equal to, the correct price.

Yet if consumers do suspect that they are charged an amount different from the listed price, then one might expect that the price cue becomes less valued in their decision making. For example, research suggests that a proportion of the consumer population is "vigilant" and notices even small deviations in price (e.g., Le Boutillier, Le Boutillier, and Neslin 1992; Urbany, Dickson, and Key 1990). From this perspective, the results support the discounting of discounts literature (e.g., Krishna, Currim, and Shoemaker 1991; Gupta and Cooper 1992; Zaichkowsky and Sadlowsky 1991); that is, consumers' beliefs that a retailer promising a 20% reduction on an item is delivering a discount of less than 20%. Zaichkowsky and Sadlowsky suggest this phenomenon may be due to the frequency of price promotions. Gupta and Cooper relate this tendency to the depth of the discount and type of brand being advertised. Krishna, Currim, and Shoemaker integrate vigilance and discounting by identifying consumer groups more and less sensitive to price changes. The present study supports the assertion that consumers, acting rationally, could dismiss discounts because they do not always receive them. Over time this segment may become suspicious of price claims made in newspaper advertisements. This interpretation is consistent with prospect theory (e.g., Thaler 1985), which states that losses (overcharges) are overweighted versus gains (undercharges), even though both exist in our context. A direct test of this proposition is warranted for further research because it could explain how consumers "unlearn" the value of a discounted price.

Implications

For retailers, this study implies that scanner systems could be used more efficiently than they are currently. The high rate of underrings may cost retailers significant dollars off the bottom line. For example, each underring error in the grocery stores averaged 83.4 cents. Overrings are raising consumer mistrust and legal pressure to give consumers redress and recourse. In this study, grocery overrings averaged 24.3 cents. Though some industry personnel say that the two balance out over the long run, such a viewpoint is shortsighted. Consumerists and public policymakers explicitly state that undercharges are irrelevant to their cases. Industry personnel indicate that this error may represent simply a delay in changing shelf tags, in which case there is no profit loss to the store. In either case, sloppy management policies that cost the store money (underrings) are not an issue; instead advertising and promoting specials and then not delivering them are the basis for their cases (O'Connell 1993). Therefore, overcharges harm retailers through the loss of consumer loyalty and negative publicity. Retailers also could lose directly on underrings from the bottom line. Thus, both types of error warrant attention and correction. Industry evidence shows that assuring customers of better price accuracy by focusing on this problem translates to loyalty and profitability (WKRC Television News 1993).

This is not to suggest that scanners are not beneficial to retailers and consumers in other ways. Inventory management and cost savings have been realized by stores employing these systems. However, retailers should be more concerned over the accuracy of their input systems, because error rates found here are more than six times worse than they were before scanner adoption. Consumers may be enjoying faster checkout times and more accurate receipts, yet the question of pricing accuracy remains.

Those interested in public policy and consumer protection do not believe that underring errors or amounts are germane to their concerns. They focus instead only on situations in which the consumer is disadvantaged, that is, overrings (95-cent average for the three chains included in the study). The State of Connecticut has suggested that the high error rates in scanner stores warrants legal action. In response, the state enacted a law requiring stores either to retain item pricing or switch to electronic shelving systems that are connected to the store's computer (O'Connell 1993). The rationale behind this decision is that item pricing would allow consumers a better opportunity to verify the prices they are charged against those on the items. However, Dickson and Sawyer (1986) find that a return to item pricing does not lead automatically to better price recall. Furthermore, item pricing also might result in higher prices to consumers due to increased labor costs in the stores. Instead, refocusing management attention on the problem or installing electronic shelving may be new avenues to investigate because both these methods retain the advantages that scanner pricing systems have afforded retailers and consumers.

It may be desirable for government agencies to compare error rates between price-marked items (e.g., meats) and bar-coded items within a store. If rates are equal, sloppy management may explain why. If rates are higher for bar-coded items, then the problem may be caused by system operations and/or deceptive practices. The results found in this study lend support to the rationale used for government actions and may suggest that public policymakers reexamine "price in advertising" issues (cf. Biswas and Blair 1991). Perhaps making advertising agencies partially responsible for deceptive advertising (e.g., promoting a price that is not delivered by the store) would lead these agencies to check stores' scanner accuracy. In other words, another legal entity would have an incentive to assure customers of accurate pricing because of the risk of fines and possible legal proceedings.

The key to resolving this issue is to maintain as many of the advantages scanner systems offer retailers and consumers while improving scanner accuracy. Returning to

item pricing has limitations, whereas electronic shelving, increased monitoring, and legal (dis)incentives have merit. Other possible solutions suggested by industry personnel and academic researchers include requiring stores to post a printout of scanner prices for featured items next to the display of the store's flyer advertising these featured items. This policy would assure consumers that markdown prices have been entered into the computer system at the time the sale begins, but does not provide a check of nonfeatured items. Installing scanners at various locations throughout the store (other than the register) so that consumers can verify prices easily might overcome this limitation. This solution would increase the probability that errors are pointed out to the retailer because consumers will not be holding up the rest of the line at the checkout stand (ABC's "PrimeTime Live" 1993). Other legal remedies, such as increased enforcement of current laws and stiffer fines, also have been suggested. These laws are seen as a bottom-line incentive to assure accurate pricing.

For academics, the findings call into question the validity of much of our scanner research. Though it is clear that many marketing variables affect sales, market share, and profitability, the magnitude of these effects may be biased (e.g., Sethuraman and Tellis 1991; Tellis 1988). Our study indicates that reliance on dollar shares can bias promotional effects in an upward manner. If a good promoted at $1.00 is sold at the regular price of $1.25, then models using dollar shares will reflect a 25% increase that was not due to the promotion. Unit share, on the other hand, will reflect only that the promotion had an effect on the number of purchases, not the overcharging bias. Unit market share estimates could provide more reliable assessments of promotional effects because unit shares do not change when an item is either overcharged or undercharged. In addition, this research may indicate why promotional effects seem to be declining (e.g., discounting of discounts).

In conclusion, during the 1970s and 1980s, retailers were promised by industry committees that the adoption of scanner technology would guarantee better service and more accurate pricing. Retailers, in turn, made these same promises to their customers. Surveys indicate that service has improved (e.g, Gilly and Zeithaml 1985; Pommer, Berkowitz, and Walton 1980), yet retailers and consumers must ask, At what cost? Misrings are higher than expected, and the rate of overrings versus underrings appears to benefit retailers more often than consumers.

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