Stephen J. Hoch, Xavier Drèze, & Mary E. Purk

EDLP, Hi-Lo, and Margin Arithmetic

The authors examine the viability of an "everyday low price" (EDLP) strategy in the supermarket grocery industry. In two series of field experiments in 26 product categories conducted in an 86-store grocery chain, they find that a 10% EDLP category price decrease led to a 3% sales volume increase, whereas a 10% Hi-Lo price increase led to a 3% sales decrease. Because consumer demand did not respond much to changes in everyday price, they found large differences in profitability. An EDLP policy reduced profits by 18%, and Hi-Lo pricing increased profits by 15%. In a third study, the authors increase the frequency of shallow price deals in the context of higher everyday prices and find a 3% increase in unit volume and a 4% increase in profit. Finally, they draw a conceptual distinction between "value pricing" at the back door and EDLP pricing at the front door.

Retail formats come and go with changes in consumer tastes, lifestyles, and trends in demography and the economy. Recently it is the "everyday low price" (EDLP) format that has experienced rapid growth and media popularity. The prototypical description of an EDLP pricing policy is as follows: The retailer charges a constant, lower everyday price with no temporary price discounts. These constant everyday prices at the EDLP outlet eliminate week-to-week price uncertainty and represent a contrast to the "Hi-Lo" pricing of promotion-oriented competitors. The Hi-Lo retailer charges higher prices on an everyday basis but then runs frequent promotions in which prices are temporarily lowered below the EDLP level.[1] Discounters like Wal-Mart have led the EDLP wave and successfully encroached on the turf of supermarkets and department and drug stores by advertising that their everyday prices are "*always* the lowest" to be found. Warehouse club operations like Sam's, Costco, and others also have grown rapidly by pursuing limited assortment and limited service EDLP price strategies while using well-known brand names as a draw. Nonretail industries have adopted versions of EDLP, notably the airlines (Southwest) and automobile manufacturers (Saturn).

Some grocery supermarket retailers also have implemented various forms of the EDLP concept including Food Lion, Winn-Dixie, Cub Foods, and Omni, among others. There are big differences in EDLP penetration across geographical markets, EDLP being more prevalent in Southern areas (Birmingham, AL, 78%; New Orleans, 61%) and less popular in Northeastern areas (Upstate New York, <5%; Boston, 16%) (Partch 1992). Moreover, some supermarket retailers have adopted EDLP on a more limited level, what sometimes has been labeled category-level EDLP. Here, they institute EDLP on a focal category like soft drinks or diapers in an attempt to build traffic and stave off competition from alternative retail formats.

Various rationales for adopting EDLP have been advanced. First, it has been argued that heavy price promotion has eroded consumer confidence in the credibility of everyday shelf prices (Ortmeyer, Quelch, and Salmon 1991). With an EDLP approach, it may be possible to restore price credibility. Because EDLP is simple and consistent, it may be easier to communicate to consumers and therefore to increase the chances of establishing a low price image through advertising. It also reduces managerial costs because it is easy to implement by simply matching or beating the most aggressive local competition. This assumes, of course, that the retailer has an appropriate cost structure in place.

Second, EDLP often is assumed to lower operating costs. These lower costs can be achieved in three primary ways: (1) reduced service and assortment, (2) reduced inventory and warehouse handling costs due to steady and more predictable demand, and (3) lower in-store labor costs because of less frequent changeovers in special displays. Warehouse operators gain additional cost savings due to less expensive locations and nonunionized labor. Lattin and Ortmeyer (1991) argue that EDLP also can reduce advertising expenses; for example, Wal-Mart feature advertises in newspapers on a monthly basis, whereas many of their competitors do promotional advertising 52 weeks a year.

In spite of these apparent advantages, most retailers have not adopted EDLP. According to a recent survey of the top 50 U.S. retail markets, 26% of supermarket retailers are pursing some form of EDLP (Partch 1992). This means that the remaining 74% are Hi-Lo promotion-oriented operators. The question is why. The dominant theory is that retailers can price discriminate between consumers that vary in price sensitivity, one of the most basic and long-standing principles in economics (Pigou 1920). Hi-Lo pricing allows the retailer to discriminate between informed and uninformed consumers (Varian 1980). When heavy users of a product

[1]As we show subsequently, this prototype is not representative of how most food retailers actually practice EDLP.

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category also have higher inventory holding costs, retailers can use temporary price cuts to effectively charge them higher average prices (Blattberg, Eppen, and Lieberman 1981; Jeuland and Narasimhan 1985). With a Hi-Lo policy, retailers can attract price-sensitive switchers with promotions to build store traffic while store-loyal consumers buy merchandise both on deal and at higher everyday prices (Narasimhan 1988). Temporary price discounts also can lead to category expansion when consumption rates are more flexible (e.g., ready-to-eat cereal as compared with bath tissue). Many Hi-Lo retailers also believe that aggressive temporary price reductions help to sustain a low-price value image.

In this article we examine the viability of an EDLP pricing strategy in the supermarket grocery industry. The article addresses four questions:

1. *What is EDLP in practice?* A comprehensive study (Information Resources, Inc. 1993) has found that although EDLP stores maintain lower prices on an everyday basis, they sell about the same amount of product on deal as Hi-Lo operators. This suggests that the nonpromotion prototype described previously is not representative of how EDLP actually is executed in the field. Self-avowed EDLP chains do engage in promotional pricing, and in fact some engage in as much promotional activity as the Hi-Lo chains.
2. *How well does EDLP work?* We report the results of two comprehensive field experiments in which everyday prices were varied systematically on over 7500 items in 26 categories. We did not test the idealized nonpromotion EDLP prototype described at the outset but instead attempted to create test conditions that more closely matched actual practice. We found that 10% across-the-board price cuts do not drive volume sufficiently to overcome decreases in profit margins. In fact, gross profits were over 35% greater when employing a Hi-Lo versus an EDLP strategy.
3. *What does it take to make EDLP work?* We offer a simple framework for calculating the magnitude of the volume increases that EDLP would have to produce to break even profitwise. We also consider the profit implications of decreases in operating costs that might accompany a move to EDLP. This makes it easier to evaluate the likelihood that EDLP would pay out in an implementation in which competitive conditions and historical precedent might differ from the market we studied.
4. *When and how should EDLP be employed?* We consider how the size of a retailer's installed base of consumers can affect the viability of EDLP. We also distinguish between a "value pricing" strategy at the wholesale level (i.e., the "back door" of the store) and EDLP pricing at the retailer's "front door" (where consumers actually shop).

What Is EDLP in Practice?

In March 1993, Information Resources, Inc. (IRI) completed a study of EDLP pricing in supermarkets utilizing their nationwide InfoScan syndicated database. Although a pure EDLP strategy implies low everyday prices with no temporary price promotion activity, IRI found that "true" EDLP rarely exists. Instead, it takes on many forms: chainwide, storewide, and categorywide. Because there are many hybrids, EDLP is best seen as a continuum. IRI compared the extremes: the 12% most EDLP-like stores versus the 20% most promotion-oriented (Hi-Lo) operators in their geographically diverse 3000-store sample. Representative EDLP operators included Cub, Food Lion, Lucky, Omni, and Winn-Dixie. Hi-Lo operators included A&P, Dominick's, Jewel, Safeway, and Von's. Among many other findings, three interesting facts surfaced about EDLP in practice:

1. EDLP store prices are on average 9% below Hi-Lo stores. EDLP store prices were 11% below on an everyday basis and 6% below on a promotion basis.
2. EDLP stores sell just as much merchandise on deal as Hi-Lo operators. 26% of overall store volume is sold with some form of merchandising support in EDLP stores, whereas 24% of volume is sold with merchandising support in Hi-Lo stores.
3. Percentage price reductions are less deep in EDLP stores. Discounts off everyday prices offer greater savings (percentagewise) in Hi-Lo stores, about 33% more.

In our experience, these facts do not always match up with the stylized "no-promotion EDLP" prototype that many industry observers maintain, a prototype that is much more consistent with warehouse clubs than with EDLP food retailers. Game theoretic analyses (Lal and Rao 1993; Lattin and Ortmeyer 1991) also have assumed that an EDLP strategy is characterized by constant prices (no temporary price deals) that are in between the Hi-Lo operator's regular and deal prices. This "pure" EDLP strategy is an interesting concept in theory but apparently is not pursued widely in practice. Even Food Lion, an acknowledged EDLP limited assortment chain with over 1000 outlets, offers hundreds of temporary price reductions each week. We designed our empirical implementation of EDLP to match the three characteristics listed previously: lower everyday prices, the same level of promotional activity as the Hi-Lo stores, and smaller price discounts off regular price on a percentage basis. One important limitation to our studies is that we did not widely advertise the existence of lower everyday prices.

How Well Does EDLP Work?

For EDLP to increase volume substantially, a prerequisite for success given lower gross margins, the strategy must create a low-price image in the mind of the consumer. A change in price image is required to induce at least some consumers to switch stores. We partition the determinants of price image into three components: a pure price effect, a pure advertising effect, and an interaction of actual prices and image advertising (cf. Hoch and Deighton 1989). It is easy to imagine that a reduction in prices without advertising support might not be enough to change price image, at least in the short run. Moreover, any positive benefits from price advertising not backed up by lower actual prices would seem to be difficult to sustain in the long run. As such, lower everyday prices may be a necessary but not sufficient condition for EDLP success.

So how well does EDLP work? The answer to this question is that it depends. Sears Roebuck could not make EDLP work, possibly because it did not convince the American

TABLE 1
Detailed Results From the Everyday Pricing Experiments

Study 1

Product Category	Category-Level Price Change ±[b]	Percentage Change From Control Stores			
		Hi-Lo Stores		EDLP Stores	
		Units	Profit	Units	Profit
Analgesics	10	+1	+20	+5	-55
Bath tissue	6	+1	+11	-1	-11
Beer	6	-7[a]	+10	+1	-9
Canned seafood	6	-6[a]	-5	-3	-11
Canned soup	14	-3	+70	na	na
Cereal—hot	10	-2	+30	+5	-35
Cereal—RTE	10	-1	+19	+2	-29
Cheese	8	-1	+2	+3	-11
Cigarettes	10	+3	+9	+3	-1
Crackers—snack	10	-5	+17	-1	-28
Dish detergent	6	-3	+9	+2	-20
Front-end candy	13	-3	+16	+1	-11
Frozen entrees	11	-8[a]	+1	+10	-11
Frozen juice	10	-3[a]	+11	+4	-18
Laundry soap	6	-3[a]	+18	+4	-17
Oral care	7	-3	+13	+3	-14
Paper towels	6	-7[a]	+ 1	0	-10
Refrigerated juice	8	0	+11	+3	-6
Soft drinks	24	na[a]	na	+10	-22
Averages	10%	-3%	+15%	+3%	-18%

na = not applicable
[a]unit differences between the three pricing conditions statistically significant $p < .10$.
[b]prices were increased in Hi-Lo Stores and decreased in EDLP stores.

public of its commitment to the pricing strategy after so many years of aggressive weekly promotional activity. Wal-Mart and some of the warehouse clubs, however, follow an EDLP approach and are successful. Their prices are generally lower than local competition and they are admired for their efficient logistic and operating systems. There are many factors that influence the success of any retail strategy. So we ask a different, more specific question here—how viable is it for an established grocery retailer with a substantial installed base of customers to move to an EDLP pricing strategy? Because we could not experimentally manipulate price image advertising (all stores are located in the same media market), we focus solely on the pure price effect, which will tell us how large the advertising component must be for EDLP to be a profitable strategy.

As part of a multiyear project focusing on data-driven micro-marketing, we conducted two large-scale studies to compare the performance of EDLP with Hi-Lo pricing. The Micro-Marketing project is a joint venture between the University of Chicago Graduate School of Business, Dominick's Finer Foods (which has a 20% share of metropolitan Chicago grocery sales), and 20 leading packaged goods companies. The project mission is to utilize marketing information technology to improve decision making at retail and better lever existing promotional expenditures. Micro-marketing seeks to identify the wants and needs of the local marketplace and then customize strategies at the store level to exploit trading area differences in consumers and competition. One of the objectives was to evaluate the viability of everyday pricing on the basis of micro-market differences in price elasticities (Hoch et al. 1995). In addition, a variety of promotional experiments was conducted.

In two separate series of tests we evaluated the performance of EDLP versus Hi-Lo category pricing. The relevant details follow.

Study 1

Test product categories. We used 19 product categories, accounting for about 25% of store sales, for the tests. The categories were diverse (see Table 1); there were high-volume, high-velocity categories (e.g., soft drinks) as well as slower movers (e.g., hot cereal). Some categories offered the retailer high gross profit margins (cigarettes) and others low margins (canned soup). In some categories, consumers can modulate their rate of consumption (refrigerated juice) and in others, consumption rate is fixed (bath tissue). Finally, the main retail competitor varied by category, from supermarkets (cheese) to drug stores (analgesics) to mass merchant discounters (detergents). Everyday prices were changed on over 5000 stock keeping units (SKUs). The participating retailer conducts comprehensive competitive price audits each week, so we were able to monitor the everyday prices of other retailers in the market as well. Retail competitors did not respond with corresponding price changes during the test period. Lack of competitive reaction was not unexpected because competitors would have had to execute price changes on a store-by-store basis.

Everyday pricing conditions. All 86 stores in the Dominick's chain were involved in the test. Stores were assigned randomly to three pricing conditions on a category

by category basis. In control stores, all everyday, nonpromotional prices were kept at preexisting levels. Price increases and decreases were symmetric around existing control store levels. In EDLP stores, prices of each brand in a product category were decreased by a constant factor, ranging from 6% in bath tissue to 24% in soft drinks. On average, EDLP store prices were decreased by 10% across all 19 categories. In Hi-Lo stores, prices of each brand in a category were increased by the same factor, on average a 10% increase across all the categories. These category-level increases and decreases maintained the relative price levels of brands within a category, so substitution patterns between brands were not likely to change during the test. Because the competition did not react to these price changes, this meant that Hi-Lo stores offered prices significantly above the competition, resulting in adverse price comparisons. Contemporaneously, EDLP stores benefited from more favorable price comparisons.

Although everyday prices for individual product categories varied from store to store, the price of a complete market-basket of goods across all 19 categories remained unchanged for each store during the test period. This is because for any particular store, prices were raised in some categories and lowered in others. Our rationale for this design was to ensure that we could obtain a pure read on the effect of everyday prices for each category without possible contamination due to the prices of other categories. At the point in time the study was conducted, retailers and manufacturers were very interested in better understanding the viability of EDLP on a category-by-category basis. Clearly, it is important to understand storewide price effects, a phenomenon that we investigate in Study 2 with another series of experiments, but we believe that the current design was a necessary first step to understanding everyday pricing.

Pricing test duration. The tests ran for a minimum of 16 weeks. We settled on this test length to balance out two competing concerns. First, 16 weeks provided sufficient opportunity to learn about prices through multiple (at least two) category purchases even in the less frequently purchased health and beauty aid categories. Second, because a majority of consumers cross-shop multiple retailers, they at least had the opportunity to learn of price differences. At the same time, 16 weeks is short enough so that lack of experimental control does not become a problem. We had access to 170 weeks of historical data. As a sales baseline, we computed average weekly sales and profits for each store for the 26 weeks immediately preceding the initiation of the test period. In categories with large seasonal effects (e.g,. canned soup), we utilized the same 16-week time period in the prior year.

Temporary promotional activity. Promotions occurred as they would in the normal course of business. About one-third of unit volume was sold with some form of promotional support: temporary shelf price reductions, feature advertising, and/or in-store display. The average price reduction across categories was about 15% below control store prices. This level of promotion intensity was consistent with the retailer's preexisting policy in the test categories.

Promotional prices were equivalent across everyday price conditions. That is, when an item went on deal, prices in all stores dropped down to the same price point. This policy resulted in a greater percentage of savings in Hi-Lo stores compared with EDLP stores. For example, assume that the everyday price was $1.99 in control stores, compared with $2.19 in Hi-Lo and $1.79 in EDLP stores. If the item went on deal for $1.49, this results in a 25% savings in control stores versus 32% and 17% savings in Hi-Lo and EDLP stores, respectively.

Although average everyday shelf prices were increased or decreased 10% during our tests, the fact that one-third of volume was sold at a constant dollar deal depth in all stores meant that effective out-the-door prices differed from control prices by only 7% up or down.[2]

Test implementation. Everyday and promotional price changes were made using existing scanner technology, along with shelf tags. This ensured a high-quality implementation of the pricing tests.

Does our study constitute a reasonable test of the effectiveness of EDLP versus Hi-Lo pricing at retail? There are several similarities between our operationalization of EDLP versus Hi-Lo and the IRI study previously mentioned. First, everyday prices are 20% lower in our EDLP stores compared with 11% in IRI's sample of stores. Second, the extent of promotional activity was equivalent in the Hi-Lo and EDLP stores in both our study and IRI's sample. And finally, because promotional prices in all stores in the chain went down to the same price point, deal depth in Hi-Lo stores was significantly greater than in EDLP stores on a percentage basis. This last point also mimics IRI's findings on deal depth.

The main difference between our study and EDLP in practice is that we instituted EDLP on a category-by-category basis. This precluded any additive effects of lower prices that might accumulate across categories, and it prevented broad-scale advertising of EDLP to the public.[3] These differences could be important because though consumers may not be very aware of individual product prices, they may be more likely to notice changes in their overall grocery bills. It is also the case that these findings occurred in the Chicago market, where 60% of the market is driven by Hi-Lo operators, though there are several well-known EDLP supermarket chains in the area (Cub Foods, Omni) along with KMart, Target, Wal-Mart, and several warehouse clubs. It is important to keep these similarities and differences in mind when interpreting the results. This first study therefore

[2]The calculation works as follows. Assume that one-third is sold on deal and two-thirds at regular prices. Consider the difference between EDLP and control store average prices of a product sold in control stores every day for $1.00. With an average 15% promotional price reduction off control prices and a 10% everyday price cut in the EDLP stores, the average price is a simple weighted average of deal and everyday prices. That is,

$$\frac{\text{EDLP average price}}{\text{Control average price}} = \frac{(1/3 * \$.85 + 2/3 * \$.90)}{(1/3 * \$.85 + 2/3 * \$1.00)} = \frac{.883}{.950} = .93.$$

[3]It should be pointed out, however, that in-store signage (e.g., "Check Out Our Everyday Low Prices on 6-Packs") was utilized in several categories with no appreciable differences in the results.

is viewed best as a test of the viability of category-level EDLP.

Results

For each store, we calculated performance measures for unit volume, dollar sales, and dollar profit. Percentage changes in weekly store performance were calculated as follows: (average test performance – average historical performance)/(average historical performance). All findings were indexed to the control stores, which are set to a base of 100 and then subjected to an analysis of variance (Figure 1).

Changes in unit volume. Across-the-board everyday prices were increased 10% in Hi-Lo stores and decreased 10% in EDLP stores compared with control stores. Ten percent higher Hi-Lo everyday prices led to a 3% decrease in unit volume on average. Ten percent lower EDLP prices led to a 3% increase in unit volume. This pattern of results was very consistent across categories and also held up over the entire test period (i.e., there was no suggestion of learning). Table 1 presents more detailed results for individual product categories. It shows percentage changes in unit sales and dollar profit for the Hi-Lo and EDLP stores compared with the control stores that again were indexed to 100. Changes in everyday price produced statistically significant ($p < .10$) changes in unit sales for 7 of the 19 categories. A test combining F-tests (Rosenthal 1991) across all 19 categories indicated that the ± 3% change in unit sales was statistically significant ($p < .001$). A more important issue, however, is the economic significance of these changes in unit sales.

Consumers showed little sensitivity to categorywide changes in everyday prices, an average elasticity of about –.4 (3% Δ units/ 7% Δ net prices).[4] There are several possible reasons for this, some of which we address subsequently. We do not believe, however, that the length of the test is a likely candidate. Although 16 weeks is not long term, it also is not short term. And in fact, in most of the categories the test prices remained in effect much longer. We found that the results remained unchanged over periods of more than 40 weeks and in no case did we observe a shift in the basic pattern. It is possible that store switching might take more time to emerge, but after three-quarters of a year, one would expect to detect larger effects on sales if store switching is a major factor.

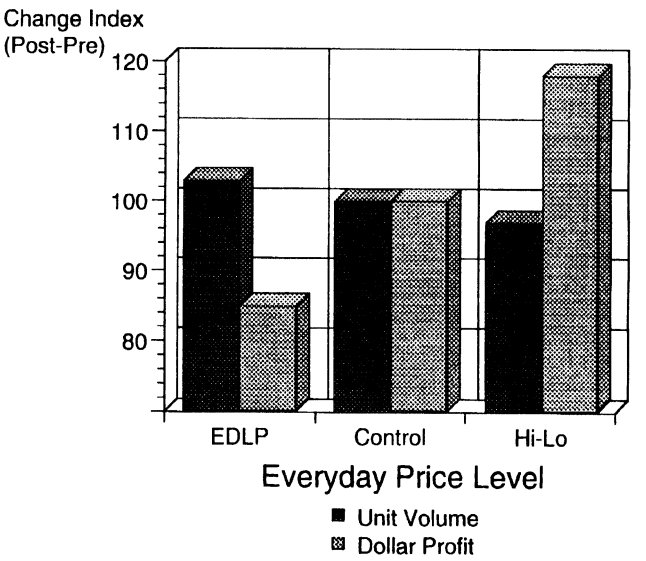
Changes in dollar profits. The gross profit results are from the retailer's perspective and are computed using the retailer's marginal costs based on an average cost accounting system. We found that 10% higher Hi-Lo prices led to a 15% increase in profitability, on average. On the other hand, 10% lower EDLP prices led to an 18% decrease in profits. Profit results were statistically significant in all 19 categories.

These results are dramatic and ex ante surprising. Consumer demand appears remarkably insensitive to changes in everyday prices: 10% changes in everyday price resulted in 3% changes in unit sales. It is possible, however, that the price changes were not large enough to be noticed by most consumers, especially in light of all the week-to-week promotional activity. Research has shown that many consumers do not possess accurate price knowledge (Dickson and Sawyer 1990). At the same time, however, the 20% price difference between Hi-Lo and EDLP stores is not trivial, at least in the eyes of the manufacturers and retailer who participated in the study and in light of the 9% difference found in the IRI study. Moreover, such price changes had a huge impact on profitability. We also found that consumers responded identically to price increases and decreases. On the basis of prior research on reference prices (e.g., Thaler 1985) and our assessment of prevailing retailer intuitions, we expected that consumers might react more strongly when faced with price increases (viewed as an out-of-pocket loss) compared with price decreases (viewed as a potential gain). We found no evidence of asymmetric response to increasing and decreasing everyday prices.

The bottom line is that EDLP did not drive volume sufficiently to compensate for lower profit margins. As shown in Table 1, EDLP led to decreased profitability in every category (18 out of 18), and a Hi-Lo pricing strategy led to increased profits in 17 out of 18 categories. There are several instances in which differences in profitability between Hi-Lo and EDLP are remarkably large, including analgesics (75%), canned soup (70%), and hot cereal (65%). In the cases of analgesics and hot cereal, the large differences in performance appear to be mainly caused by very low demand elasticities with respect to everyday price. In the case of canned soup, in which we only raised prices, the large profit effect also was driven by the fact that the category had been priced as a loss leader (meaning low retailer profit margins) prior to the test.

FIGURE 1
Pricing Experiment Results

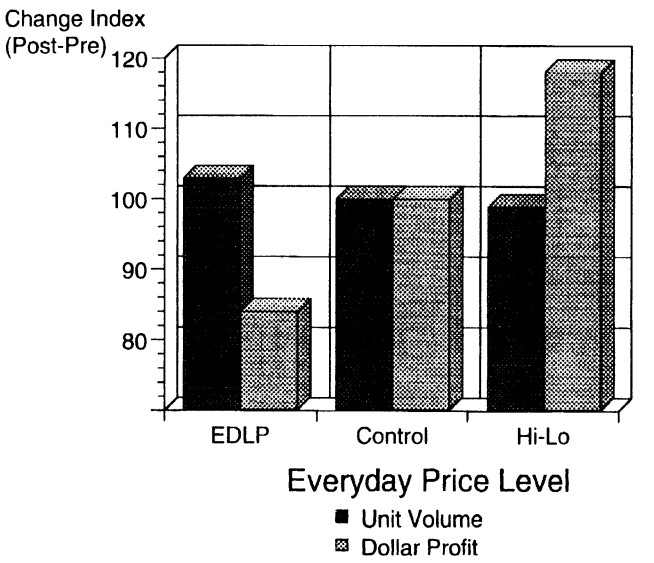
Study 1



[4]Using historical data from the same retailer and many of the same categories, Hoch and colleagues (1994) estimated an average category constant elasticity of –1.06.

FIGURE 2
Pricing Experiment Results

Study 2



Study 2

We conducted a second everyday pricing study approximately eight months later. We had two objectives: We wanted to replicate our initial study to ensure that our findings were robust; but more importantly, we wanted to address one of the limitations of the first study. With our category-by-category randomization procedure, the average price of any individual store's total market basket of goods did not differ between the pre- and post-test periods. As such, we may have limited the size of the pure price effect on overall price image, which in turn might influence store switching behavior.

Test product categories. The pricing tests were conducted in 26 product categories accounting for about one-third of store sales. Additional categories were added to those involved in the initial study. We added several large health and beauty aid categories (e.g., hair care and grooming products). Everyday prices were changed on over 7500 items. And as in the first phase, we observed no everyday price response by retail competitors.

Everyday pricing conditions. As in the first study, all 86 stores in the Dominick's chain were involved in the test. The major procedural difference in Study 2 was that we randomly assigned each store to the same everyday pricing condition consistently across categories. Of the participating stores, 29 adopted EDLP pricing in all 26 categories, 29 control stores maintained existing retail pricing, and 28 stores adopted Hi-Lo pricing. The average price change across all categories was about 9%. Because the 26 categories represent one-third of store volume, this means that storewide prices were on average 3% lower in EDLP stores and 3% higher in Hi-Lo stores during the test. Clearly, this study constitutes a stronger experimental implementation of changes in store-level everyday prices. We do acknowledge, however, that the strongest test would involve price changes on more products and consumer advertising of the store policy, both features of a real-world EDLP program that are not achievable in a controlled test.

Pricing test duration. Because of the large number of everyday price changes that the retailer had to execute, rollouts were staggered over a one-month period. For analysis purposes, we used a 16-week period after price changes had been made in all 26 categories. To control for store size and other idiosyncratic factors, we utilized the same 26-week sales baselines as in Study 1. Temporary promotional activity was similar to that during the first study, with about 30% of volume sold on deal and an average price reduction of 15%.

Results. For each store, we calculated performance measures for unit volume, dollar sales, and dollar profit in a manner similar to the first study. All findings were then indexed to the control stores, which are set to a base of 100. As can be seen in Figure 2, the bar chart appears virtually identical to the Figure 1 results for Study 1. A 9% change in everyday prices produced a 3% increase in unit sales in the EDLP stores compared with a 2% decrease in unit sales in Hi-Lo stores. Changes in unit volume were statistically different ($p < .10$) in 9 out of 26 categories. Because consumer demand was insensitive to the price changes, profits decreased by 18% with EDLP pricing, and they increased by 17% with Hi-Lo pricing. Significant differences in profits were observed in all 26 categories.

Summary of the Experiments

In both studies, changes in everyday prices had a small impact on sales volume. In contrast, these price changes produced substantial differences in category profitability. The difference in category profits between EDLP and Hi-Lo pricing were over 32% in Study 1 and over 35% in Study 2. These are not small differences. In Study 2, we went back and examined the effect of these pricing changes on two other store-level performance indicators: customer count, that is, the average number of customers visiting the store each week, and dollar sales of all remaining nontest categories. We found no significant differences between the everyday pricing conditions, and if anything Hi-Lo stores showed slightly more positive changes in customer count during the test period. Moreover, dollar sales of nontest categories were within .5% of each other, suggesting no spillover from the test categories, either positive or negative.

We do not imply that a store's overall price level is not related to the store choice decision in the long run. If we had maintained test prices for one to two years, it seems likely that price eventually would have a more noticeable impact on volume and store traffic. As an example, a retailer who raises prices across the board (our Hi-Lo condition) opens up the possibility that a competitor might begin to advertise the price disparities that exist. The more important question, however, is how large the magnitude of the price-store choice relationship must be to justify an across-the-board cut in everyday retail prices.

What Does It Take to Make EDLP Work?

To our knowledge, our two studies provide the first and only comparison of EDLP versus Hi-Lo everyday pricing utilizing tightly controlled experimental procedures. And although our design ensures high internal validity, an important question is how far (if at all) we should generalize our results. We already have mentioned the limitations of our study. In Study 1, we changed prices on a categorywide, not storewide, basis, though we remedied this limitation in Study 2 by changing one-third of the store's prices and observed identical results. We also could not advertise the EDLP price decreases to the public because of a noncontained media market, so the potential for chain-level price image effects (leading to store switching) clearly is limited. Moreover, the structure of competition in the Chicago market makes it problematic to project to other markets with different competitive structures.

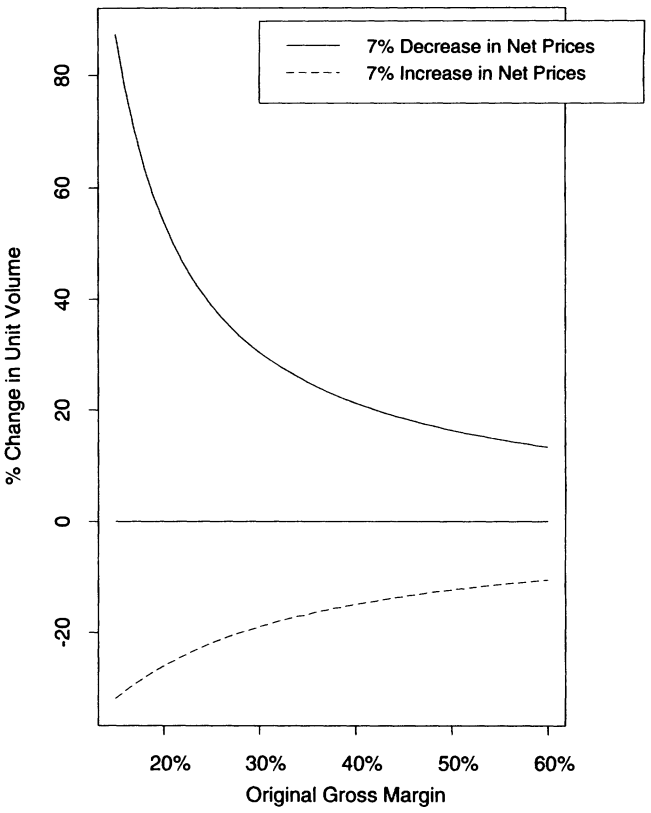
We do feel reasonably confident that our results are relevant to the decision about whether to pursue EDLP on a category-by-category basis because that is exactly what our two studies investigated. Assuming that the retailer's goal is increased profitability, it is a bad idea for a full-service supermarket to try to compete with more efficient lower-cost alternative formats by lowering their everyday prices on selected high-volume categories like detergent, soft drinks, and diapers. Lower prices on selected categories do not bring new consumers into the store (who in turn might buy other regularly priced merchandise) at a fast enough rate to compensate for the lower profit margins.[5]

We take a different approach, however, to evaluate the generalizability of our findings for store- and chain-level implementations of EDLP. We pose the following thought experiment: Imagine the best possible implementation of EDLP—a great chainwide advertising campaign, a longer time horizon for a new price image to form, and a conducive competitive environment. How much do you believe that sales would increase in this instance? Although we do not know with certainty, it is our belief that sales increases would be substantially greater under these conditions. The more important question, however, is whether these sales increases would be large enough to maintain or build dollar profits for the retailer. In other words, what kind of volume increases are needed to make EDLP work?

Margin Arithmetic

Understanding the economics of EDLP requires some very simple *margin arithmetic* to answer the question, "Given a particular change in everyday prices, what is the attendant change in volume necessary to maintain profits at the same level as before the price change?" The answer depends on two factors: (1) the retailer's original gross profit margin and (2) the level of everyday price change. The calculation is as follows:

FIGURE 3
Break-Even Volume Change Analysis for an EDLP or Hi-Lo Pricing Strategy



$$\text{(1)} \qquad \text{Breakeven Change in Volume} = \frac{-\delta}{\pi + \delta}$$

where

π = original gross profit margin (percentage) and
δ = net change in everyday prices (percentage).

(See Appendix A for derivation details). The top half of Figure 3 illustrates the needed market response for an EDLP strategy to "work" given the 7% decrease in net prices we observed in our study. The bottom half of Figure 3 provides the same market response information for the case of a 7% net Hi-Lo price increase.

Margins in the typical supermarket average around 25% (*Supermarket Business* 1993). Given an original margin of 25%, Figure 3 shows that unit sales would have to increase over 39% to make the same dollar profit after a 7% net reduction in everyday prices. Stores experienced a 2%–3% increase in our tests, an order of magnitude lower than necessary to break even profitwise. At higher margins, sales increases do not have to be so great. For example, if margins start at 40%, sales volume must increase 21%; and at 50%, sales volume must increase 16%. With the exception of a few general merchandise lines of business, there are few categories offering such high margins. At lower margins, sales

[5]It is possible that category-level EDLP might work if backed by a successful advertising campaign. We would argue, however, that it is difficult to establish and maintain a consistent price image for the chain if the retailer is sending mixed advertising messages. An exception might occur for "stand-alone" departments that are clearly separable from the rest of the store. For example, some stores appear to pursue successfully some form of EDLP only on prescription drugs for loss leader purposes.

volume must respond even more dramatically to decreases in everyday prices. For example, at 15% gross margins, typical for the high-velocity ready-to-eat breakfast cereal category and other categories viewed as loss leaders, a retailer would need to generate a volume increase of over 87% to break even with EDLP. Most retail experts find it difficult to imagine such large sales increases no matter how well EDLP is implemented.

Figure 3 also illustrates the break-even decreases in sales volume for a Hi-Lo everyday price increase. It shows that consumer demand would have to be much more price sensitive than was the case in our studies for a Hi-Lo price increase to reduce dollar profits. With an original gross margin of 25%, unit sales must decrease 22%, more than six times the amount in our study. At a 15% margin, unit sales would have to drop over 32% before the retailer begins to forgo dollar profits. Such massive store defections are possible but they seem quite unlikely, at least in the short to intermediate term.

We have found that retailers and manufacturers have asymmetric attitudes about raising and lowering prices. They express more concern about the deleterious market share effects that might accompany a price increase than they do about the potential negative implications of lower percent gross margins. In other words, retailers act as if they would rather set prices below the monopoly price than above it (Simester 1994). A natural question to ask is why retailers would choose to operate in the inelastic region of the demand curve. We have no definitive answer but can offer a few possibilities. First is lack of knowledge. Without systematic price experimentation and expertise in analyzing large scanner databases, retailers may not know exactly how price sensitive consumers really are. Moreover, with the vigilant price matching by competitors that characterizes most local markets, there are few opportunities to observe long-term store switching that does or does not take place. Second, retailers may focus more on increasing market share in the short run because of a belief (true or false) that higher market share will lead to greater profits in the long term. This story makes sense if store switching costs are fairly high because (1) it will be extremely expensive to attract back a customer who has defected and (2) the returns on investments in market share will accrue to the retailer for years in the future.

How and When Should EDLP Be Employed?

We do not argue that EDLP is not a viable retail strategy. Clearly it can be, as is evidenced by the success of Wal-Mart and others. We do believe, however, that it is important to understand when and how to use EDLP. Our pricing studies show that using EDLP on a category-by-category basis to stave off alternative format competition does not work well. If a retailer is going to make EDLP work, it probably has to be on a chainwide basis so as to benefit from overall store price image. Because the price alone does not drive volume, our results isolate how large the advertising component of EDLP must be for the retailer to gain profits—in the case at hand, a 36% increase. In executing any pricing strategy, firms must consider the likely impact on two customer sectors: their installed base of current users and nonusers who represent potential opportunity for growth.

Installed Base Versus Opportunity

For a retailer, the installed base consists of consumers already shopping at one of their locations, a particular $store_i$, either as a primary shopping outlet where they buy a majority of their groceries or as a secondary source of supply. The installed base shops a particular store because of a multitude of factors. Consumer surveys of retail patronage repeatedly have found that location/convenience is the most important factor, followed in order of mention by low prices, assortment, courteous service, good-quality merchandise, and fresh meat (Arnold, Oum, and Tigert 1983). These results show remarkable stability across time despite changes in economic conditions, suggesting that the strategic value of price should be evaluated as one part of a larger portfolio of attributes.

The main opportunity for a retailer comes from potential consumers who currently shop at a competitive chain $store_j$ but could shop at $store_i$ given the appropriate retail mix of price and other attributes. If EDLP functions as an effective economic signal, certain consumers may shift shopping outlets. The profit potential of EDLP depends in large part, however, on the ratio of installed base to new opportunity. The greater the installed base, the more difficult it will be to make EDLP pay out. Why? Because EDLP requires forgoing significant profit dollars from the installed base in search of new opportunity. In our pricing experiments described previously, we saw that an across-the-board 10% EDLP price reduction (7% net) required a 39% increase in unit volume to maintain current levels of dollar profits. One way to do this is to get the installed base to increase its consumption rate by more than one-third. This may be possible in expandable categories like snack foods but is not likely for most grocery categories. Another way to think about this is that EDLP would need to bring in new business at a rate of approximately one new customer for every three members of the installed base. If the installed base is small, which would be the case for a small firm or a firm entering a new market, this may be more easily accomplished.

Using price discounting (everyday and promotional) to attract customers is cheaper when a retailer has few loyal customers (Simester 1994). But if the Hi-Lo retailer already has substantial market share, sufficient opportunity will be much more difficult to generate no matter how effectively EDLP is communicated. Repositioning is always risky and expensive, and using price as the currency for repositioning may be even more difficult because of the direct and immediate impact on margins. Apparently, not enough consumers consider low price an important enough attribute by itself to compensate for all the other attributes that bring them into a particular retail location.

So far, we have focused solely on the revenue side in evaluating the viability of the everyday price changes accompanying a move to EDLP or Hi-Lo. Many retail observers and proponents of EDLP argue that there are important cost savings associated with moving away from a promotion-oriented merchandising strategy to EDLP. We con-

cur that retailers pursuing less promotion-intense strategies will incur lower costs because of warehouse and in-store efficiencies. It is important, however, to distinguish between the impact of EDLP on two aspects of retail operations: the "back door" and the "front door." Recent industry discussion of EDLP presents a confusing picture.

Back Door Operations

Back door operations involve a logistical partnership between manufacturer and retailer. The main goals here are (1) smoothing of the manufacturer's production process and (2) reductions in inventory, warehouse, and handling costs for both the manufacturer and the retailer. Policies that improve the efficiency of the manufacturer-retailer relationship seem to be a worthwhile investment. Recent industrywide initiatives such as efficient consumer response (ECR), which promotes greater reliance on electronic data interchange (EDI) and scanner-driven continuous replenishment, will help to take costs out of the channel.[6] Manufacturers and retailers that are not capable of instituting these logistical efficiencies will lose an important competitive advantage in the years to come because large players like Wal-Mart, KMart, and Procter & Gamble already have made major investments in information technology.

One food industry practice making it difficult to implement ECR is trade dealing. In the last decade, trade promotion has grown from about 33% of the total promotion budget to 45% in 1992, mainly at the expense of media advertising (Donnelley Marketing 1993). Buzzell, Quelch, and Salmon (1990) conducted a highly influential study of packaged goods retailing, in which they argue that the very high level of trade dealing between manufacturers, retailers, and wholesalers was adding substantial costs to the distribution system without providing tangible benefits. They calculated that trade dealing increased costs by 1.15%–2.0% of retail sales, excluding added administrative costs. Buzzell, Quelch, and Salmon maintain that these costs are eventually passed on to consumers in the form of higher retail prices.

Most of these costs are incurred from forward buying and diverting activities by large retailers and wholesalers. Armed with sophisticated buying models, retailers and wholesalers are able to arbitrage the wide fluctuations in wholesale prices that accompany periodic trade dealing, often buying anywhere from 10 to 20 times the inventory that normally could be sold. Not only does such heavy forward buying result in production discontinuities for manufacturers, especially during nationwide promotions, it also increases inventory holding costs for all parties. Moreover, it affords opportunities for retailers to offer very aggressive price deals to consumers (e.g., 50% off) in an effort to get rid of excess inventory quickly. Some manufacturers, notably P&G, believe that such steep discounting at retail can harm brand equity and decrease loyalty. Although it is difficult to imagine how aggressive sales promotion could increase loyalty, there is no definitive empirical evidence that promotion decreases loyalty; in fact, the most recent evidence suggests that promotion induces brand switching but has little effect on loyalty (Davis, Inman, and McAlister 1992; Ehrenberg 1988; Neslin and Shoemaker 1989).

Buzzell, Quelch, and Salmon (1990, p. 147) advocate a manufacturer to retailer pricing policy called "everyday low purchase price," (EDLPP), in which the "retailer arranges to buy product from the manufacturer on an as-needed basis at a weighted average price reflecting both the proportion of merchandise bought on a deal basis and the proportion bought at the regular price." This EDLPP policy is remarkably similar to P&G's current "Value Pricing" strategy to the retail trade. Although the jury is still out as to the value of this policy, it is easy to enumerate the benefits that might accrue to manufacturers and retailers by smoothing out back door prices. Manufacturers can limit massive forward buying, which in turn thwarts diverting and reduces high inventory carrying costs for both parties. Manufacturers have more control over their flow of goods and can utilize production facilities more efficiently. Moreover, value pricing combined with "pay-for-performance" promotion programs—for example, trade discounts based on scanned units or category development funds based on a percentage of annual sales volume—can produce higher pass-through of wholesale cost decreases to the ultimate consumer. It probably is beneficial to manufacturers if retailers focus on merchandising and spend less time on trying to play the forward buying arbitrage game. However, retailers and wholesalers who have been earning a substantial portion of their income from arbitrage actually may be worse off. There is some evidence that EDLPP may increase the effective cost of goods, placing greater pressure on profit margins that are already very low (Orgel 1993).

Operating cost arithmetic. Let us assume that the retailer wishes to be no worse off profitwise after the move to EDLP. How much would operating costs, that is, all costs over and above the cost of goods sold, have to decrease to maintain preexisting dollar profits? The answer depends on four other factors:

π = the original percent gross margin,

γ = per unit operating costs as a percentage of the original price,

δ = the net percent change in everyday prices, and

ϕ = the percent change in unit volume.

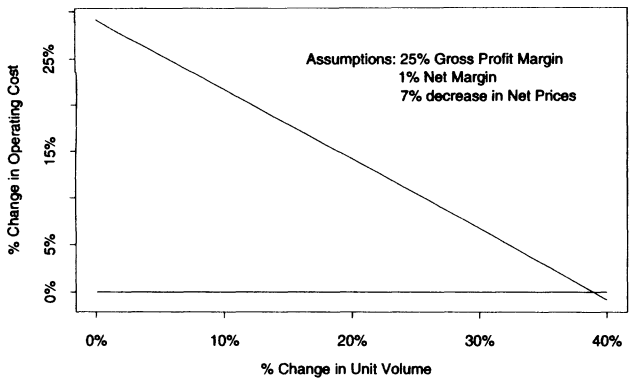
The breakeven change in operating costs is then

$$(2)\quad \text{Breakeven Change in Operating Costs} = \frac{(\pi + \delta)(1 + \phi) - \pi}{\gamma}.$$

Assuming an initial gross margin $\pi = 25\%$, operating costs as a percentage of the original price of $\gamma = 24\%$ (i.e., a net profit margin before the price change equal to 1% of sales), and a net price decrease $\delta = -7\%$, Figure 4 plots the needed change in operating costs as a function of different changes in unit volume. (The derivation is in Appendix A.) With a volume increase of 39%, no decrease in operating costs is required for an EDLP strategy to deliver breakeven profits. This 39% increase in volume exactly matches the situation laid out in Figure 3. With lower volume increases, however, costs must be reduced quite dramatically. For ex-

[6]ECR is an ambitious cooperative effort by the food industry (Food Marketing Institute) to improve, among other things, coordination between manufacturers and retailers in an effort to reduce costs and increase efficiency.

FIGURE 4
Break-Even Cost Reduction Analysis for an EDLP Pricing Strategy



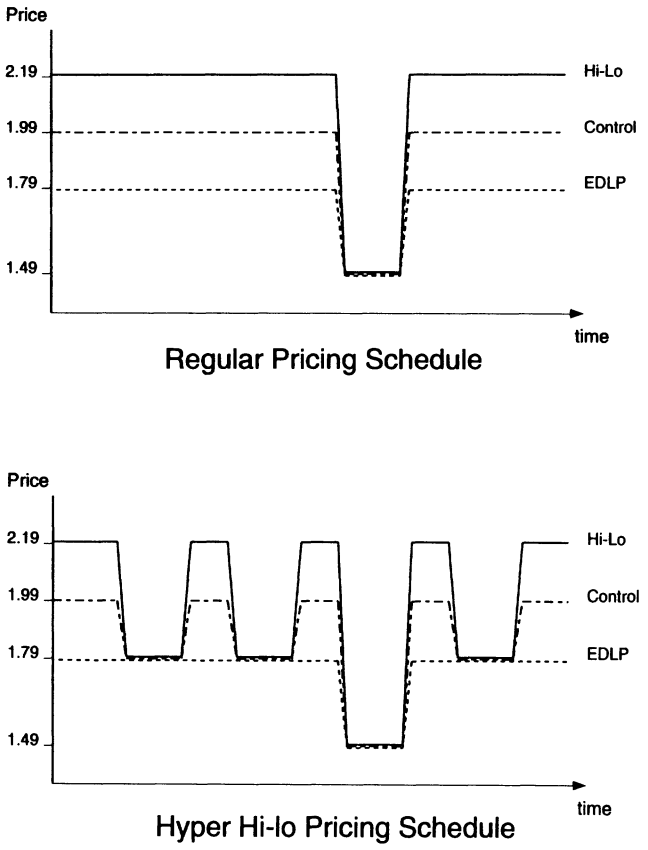
ample, with the 3% volume increase observed in our study, EDLP would need to be accompanied by a 27% decrease in operating costs. With a 20% increase in volume, operating costs need to be reduced by over 14%, not an insignificant amount, especially given the fact that only about half of a typical retailer's operating costs are fixed and half variable.

A breakdown of the typical retailer's operating costs reveals that some costs are compressible and some are not. ECR and EDLP can reduce warehouse, shipping, and inventory holding costs, but these usually make up less than 3%–4% of total revenue (and 13%–17% of operating costs). Labor costs (salary and benefits), on the other hand, are less compressible, at least in the short run. Wal-Mart is considered a state-of-the-art retailer in terms of efficient logistics and information capabilities, but its biggest cost advantage is labor. It has a nonunionized, short tenure labor force that by industry estimates is about 50% less expensive per retail dollar than their supermarket competitors (Mandel 1991). Because labor expenses make up more than 50% of a supermarket's operating costs, it is difficult to imagine how front door EDLP, even when coupled with EDLPP and ECR, could reduce costs enough to make the operating cost arithmetic pay out.

Front Door Merchandising

Our position is that value pricing at the back door does not require EDLP pricing at the front door; that is, EDLPP ≠ EDLP. And this is where confusion in the media and the trade has arisen. Most media accounts of P&G's new pricing policy have referred to it as EDLP, not value pricing or even EDLPP. As mentioned previously, however, the ratio of installed base to opportunity may not warrant a change in retailer strategy from Hi-Lo to EDLP. When a manufacturer and retailer agree on an EDLPP wholesale pricing relationship, this does not imply that a retailer necessarily should drop everyday prices at the consumer level immediately. Although lower wholesale prices would give a retailer room to reduce everyday consumer prices while protecting gross profit margins, our study suggests that it may not be in the best interests of the retailer to pass through 100% of these wholesale price cuts. In fact, they may be better off maintaining higher margins and using wholesale cost savings to

FIGURE 5
Increasing Promotion Frequency Using Hyper Hi-Lo Pricing



fund more aggressive promotional activity internally, in essence a "hyper" version of Hi-Lo pricing.

This was the topic of inquiry in our third study. Here we examined the performance of stores that move to higher everyday prices and at the same time increase the frequency of shallow price deals (compare the top and bottom halves of Figure 5). The basic idea was to examine whether it was possible to utilize greater promotional activity to reduce the small market share/unit volume losses that accompanied higher everyday prices and at the same time hold onto some or all of the profit increases.

Study 3

During the everyday pricing experiments in Study 2, we added an additional promotional pricing manipulation to the basic EDLP, control, and Hi-Lo design. In half (n = 14) of the Hi-Lo stores and half (n = 14) of the control stores, we systematically increased the frequency of shallow price deals as portrayed in the bottom half of Figure 5. We called this pricing strategy "Hyper Hi-Lo." The other Hi-Lo and control stores maintained a regular (lower) level of temporary price promotion as shown in the top half of Figure 5. Random assignment to the regular or Hyper Hi-Lo condition was determined separately for each category.

Each week the responsible category manager would select one to five items to place on deal in addition to the large

number of promotions taking place across the entire chain. The items were selected so as not to be too competitive with other chainwide promotions in a category. These items then were merchandized as "Bonus Buys" (with appropriate signage) along with approximately 2000 other items that the chain regularly promotes week in and week out. Each of the individual Hyper Hi-Lo items was price promoted down to regular EDLP price levels for one week. The price course for an individual item is shown in Figure 5. During the next week, another item(s) was promoted. These items received standard bonus buy signage, which consisted of a simple 3.5-inch by 2.5-inch shelf tag, the lower half of which said "BONUS BUY" in white letters on a red background.

Results. The basic experimental design was a 2 (Hyper Hi-Lo versus regular promotion pricing) × 2 (everyday pricing condition [Hi-Lo and control]). EDLP stores were excluded from the analysis because they always had the low price. To test the effectiveness of this pricing strategy, we compared changes in total category unit volume and dollar profits in the Hyper Hi-Lo stores with those in the regular stores over a 16-week test period. The test was implemented in 18 categories. The results appear in Table 2, collapsing across the control and Hi-Lo everyday pricing conditions. Overall, Hyper Hi-Lo pricing increased unit volume by 3.2%. The magnitude of the increase was not large but it was consistent, occurring in all 18 categories with $p < .10$ in 7 of 18 individual categories. Combining across the 18 categories, this increase in volume is statistically significant ($p < .001$) and, more importantly, economically significant. To put this result in proper perspective, we should note that this Hyper Hi-Lo sales increase was larger than the corresponding 2.1% sales decrease that accompanied a move to Hi-Lo everyday pricing. Hyper Hi-Lo pricing also produced a 4.1% increase in dollar profits ($p < .001$). The effect of Hyper Hi-Lo pricing did not depend on (i.e., interact with) the everyday pricing condition in which it was implemented, which is a bit surprising because the percentage deal depth in Hi-Lo stores was twice as big as in the control stores.

These are important results because they suggest that it is possible for a retailer to retain the increased profits accruing to higher everyday prices and at the same time maintain unit sales levels and market share by systematically increasing the frequency of shallow price discounts. We do not argue that such a pricing strategy is the best alternative for all retailers but simply that it is a viable option depending on market position.

Summary. In our view, front door strategies should be designed primarily to improve in-store interactions with the consumer. This may involve attempts to increase novelty and excitement through creative weekly promotional activity. In a typical supermarket, 20%–25% of the business is driven by fresh meat and produce. The seasonal nature of these two commodity groups produces a highly variable retail environment, a condition that will remain so for the foreseeable future despite rapid advances in biotechnology. Front door merchandising and pricing in a Hi-Lo market does not necessarily sabotage the value of a net pricing back door policy. True, it is a more difficult problem to solve because the retailer and manufacturer must improve their ability to forecast a more volatile sales pattern at retail. But the promotion spikes at retail caused by consumer purchase acceleration are much smaller (3 to 5 times regular sales on average) than those induced by trade forward buying (10 to 20 times average sales) (Blattberg and Neslin 1990). A single, uniform solution of back *and* front door EDLP may not be in the best interests of either manufacturer or retailer.

TABLE 2
Detailed Results from the Hyper Hi–Lo Experiments

Product Category	Category–Level Price Change±	Percent Change Hyper Hi–Lo Compared With Regular Pricing	
		Units	Profit
Analgesics	10	+6.6[a]	+3.8
Bath tissue	8	+7.1[a]	+9.3[a]
Canned seafood	10	+4.2[a]	+3.9
Canned soup	7	.4	+2.5
Cereal—hot	10	+.9	+4.6[a]
Cereal—RTE	7	+2.7	+5.8[a]
Cheese	10	+1.6	+1.1
Cookies	10	+2.9	+8.1[a]
Crackers—snack	10	+4.3[a]	+5.4[a]
Dish detergent	7	+2.7	+4.9
Fabric softener	10	+2.3	+.9
Front-end candy	13	+4.4[a]	+5.1[a]
Frozen Entrees	10	+.6	−.1
Frozen Juice	10	+2.0	+5.9[a]
Laundry soap	10	+4.3[a]	+5.8[a]
Oral care	7	+5.0[a]	+.4
Paper towels	10	+3.2	+4.1
Refrigerated juice	10	+1.3	+1.0
Averages	9.4%	+3.2%	+4.1%

[a]unit differences between the three pricing conditions statistically significant p < .10.

Conclusion

Retail diversity is a reality. Although some retailers have made EDLP work, other merchants like Von's Pavilion, Fresh Fields, Smith's, and Gelson's have been successful in moving upscale, providing high-quality, full-service, value-added grocery environments. Manufacturers must learn to manage a portfolio of retail formats, each with different segments of customers. We found that EDLP gave a small (3% increase in units) win to manufacturers. At the same time, EDLP represented a big loss for the retailer (18% decrease in profits). Attempts to impose front door EDLP on all retailers is probably counterproductive because eventually the manufacturer will have to pay for retailers' lost profits. Instead, manufacturers would be better served focusing on improved back door solutions and let the retailer take care of the front door. Together these two strategies—more targeted micro-market merchandising and promotions on the front end combined with improved logistics on the back end—are defensible competitive strategies. Price is not a defensible point of differentiation for a firm unless it already has the appropriate operating cost structure in place. Major airlines like American apparently have recognized this issue, because they abandoned the idea of imitating the low-cost,

low-service strategy that has been so successful for Southwest Airlines (O'Brien 1993). Retailers can be profitable charging low prices, but only when they have low costs. Price alone will not drive a business even during tough economic times.

Appendix A

This appendix provides derivations of margin arithmetic and operating cost arithmetic. Given a change in policy, breakeven occurs when net profits are equal before and after the policy change, that is,

$$(A1) \quad (p - c)\, q - fq = [p(1 + \delta) - c)q(1 + \phi)] - fq(1 + \lambda),$$

where p = price, c = cost of goods, f = per unit operating costs, δ = % change in price, ϕ = % change in unit volume, and λ = % change in operating costs. For present purposes we assume that all operating costs are fixed, that is, no component of operating costs increases with increases in sales volume. When some operating costs actually are variable, our formulations provide conservative lower bounds on the volume increases and cost decreases that are required to make a move to EDLP pay out for the retailer.

If we divide both sides of Equation A1 by pq and substitute $\pi = (p - c)/p$ = gross profit margin and $\gamma = f/p$ = per unit operating costs as a % of the original price, we are left with

$$(A2) \quad \pi - \gamma = (\pi + \delta)(1 + \phi) - \gamma(1 + \lambda).$$

Arithmetic Derivation

For the simple formulation shown in Equation 1, we want to calculate the break-even change in volume, ϕ, assuming that the everyday price change has no impact on operating costs, that is, $\lambda = 0$. Then Equation A2 reduces to

$$\pi = (\pi + \delta)(1 + \phi)$$

or

$$(A3) \quad \phi = \frac{-\delta}{\pi + \delta}.$$

Operating Cost Arithmetic Derivation

Calculation of the break-even change in operating costs, λ, as shown in Equation 2, comes by rearranging the terms in Equation A2:

$$\gamma(1 + \lambda) - \gamma = (\pi + \delta)(1 + \phi) - \pi$$

or

$$(A4) \quad \lambda = \frac{(\pi + \delta)(1 + \phi) - \pi}{\gamma}.$$

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