Economic Evaluation of Shelf-Space Management in Grocery Stores

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ABSTRACT

Recently, many commodity groups have shifted promotion expenditures from generic advertising to non-advertising activities such as in-store promotion programs. Accordingly, corresponding evaluation methods need to be developed to identify the benefits of these non-advertising programs. We develop a general framework to assess product sales performance of in-store shelf-space management programs in retail stores. The framework was applied to the evaluation of dairy case management programs in the Northwestern Hudson Valley market, New York. Simulation results on fluid milk product sales indicate that preferred product locations vary between smaller convenience stores and larger supermarket retailers. On average, the dairy case management program was estimated to improve product sales 6 to 10% at the retailer level. [Econlit subject codes: M300, Q130]

1. INTRODUCTION

U.S. farmers are assessed over $750 million annually through commodity checkoffs to fund various generic commodity promotion programs, such as generic advertising, consumer education, and product research.[1] Historically, major commodity groups (e.g., dairy,

[1]Generally, agricultural checkoff programs collect a per-unit assessment for each commodity unit marketed based on special legislation to expand the demand for the product category. For example, the dairy checkoff assesses milk producers $0.15 per hundredweight (i.e., one hundred pounds) of milk marketed for the purpose of underwriting advertising and promotion programs. Based on a 1991 survey, total agricultural checkoff revenue in the U.S. was over $750 million annually from 116 commodity promotion organizations representing 52 commodities (Lenz, Forker, & Hurst, 1991). Because the checkoff programs are intended to promote all products in the commodity category as opposed to specific brands, the effort is directed to promoting "generic" or common attributes of the products to increase total category demand.

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beef, and pork) have invested majority shares of their checkoff budgets in generic advertising. In recent years, however, relatively slow growth of checkoff revenues combined with strong increases in media advertising costs has prompted a shift in producer checkoff dollars away from advertising activities to other non-advertising demand-enhancing activities, such as in-store shelf space management programs, in the hope of better utilizing scarce checkoff dollars to achieve higher benefits to producers.

A recent example includes the American Dairy Association and Dairy Council's (ADADC) implementation of dairy case shelf-space management programs in over 600 retail grocery stores in New York State. Funded by New York farmer checkoff monies, the program is intended to increase the profile of the fluid milk beverage category, improve retail milk handling procedures, and, hopefully, increase per capita fluid milk consumption. While many previous studies focused on evaluating various promotion and advertising activities, little empirical research has been conducted on the effectiveness of shelf-space management programs at the retail level. This study develops a general framework that can be used for the analysis of economic impacts of in-store space management programs in retail stores and then applies this framework to the evaluation of a retail-level dairy case management program operated in an upstate New York market.

In general, previous studies have used two types of evaluation methods: experiments (e.g., American Dairy Association, 1967; Cox, 1970; Krueckenberg, 1969; Schmit, Kaiser, & Chung, 2004) and econometric models (e.g., Basuroy, Mantrala, & Walters, 2001; Desmet & Renaudin, 1998; Dréze, Hoch, & Purk, 1994; Rhee & Bell, 2002). The experimental method is designed to compare store performance before and after the space management programs. A potential problem of experiment methods is that it is difficult to control for various factors affecting sales other than the space management program. A simple before-and-after comparison of store sales may not adequately control for seasonal variation of store sales and effects of changes in prices, promotion programs of own and competing products, and other store environments. Even if the comparison is made between stores under experiments and controlled stores during the same period of time, it remains difficult to control for differences in store characteristics (e.g., store location, type, and size, promotion activities and services, and store traffic). The accuracy of the evaluation results from this type of study depends on the maintenance of rigid control during the test periods and across stores. It is, however, extremely difficult and costly to adequately control for differences in numerous micro- and macro-variables across different time periods and stores.

To overcome these limitations, econometric models are often suggested in the marketing literature. Many studies have found a positive relationship between sales volume and shelf space (e.g., Brown & Tucker, 1961; Dréze et al., 1994; Lee, 1959). While most of these studies assume a constant elasticity of shelf space, Curhan (1972) argues that the relationship between shelf space and sales is not uniform across products, periods, and stores. His study specifies a general equation for product space elasticity as a function of product, brand, and store-specific factors (e.g., package size, price, brand type, market share, and rate of sales) but finds that only about 1% of the variation in shelf-space elasticity is explained the independent variables in the model. Based on theses findings, Curhan (1972) concludes that simulation of merchandising effects of shelf-space reallocation on sales and profits is likely to be impractical. However, as he acknowledges, his rather disappointing results could be caused by failure to include other important independent variables and misspecification of the functional form of the estimated equation.

Lynch (1974) challenges Curhan's findings by suggesting the unexpected outcome may be attributed to simultaneous equation bias between sales and shelf-space elasticity. Lynch argues that maximizing the store profit via shelf-space rearrangement implies that the product of the gross profit per square foot of shelf space and the shelf space elasticity must be equal for all items in the same store. Therefore, if a store manager attempts to maximize store profit by equalizing gross profit per square foot, then all shelf space elasticities will also be nearly the same, which will result in the lack of variability in the dependent variable. This will obviously obscure the relationship between the shelf-space elasticities and independent variables included in the equation. In response to Lynch's comment, Curhan (1974) examined individual space elasticities and the correlation between profit contribution per square foot and item shelf space elasticity and found that the variability of intra-store space elasticity was large and the correlation coefficients were not perfectly negative. Curhan (1974) points out that Lynch's model assumes store manager's economically rational behavior; however, at the store level, the shelf space allocation is mostly dictated by operational constraints. Based on results from his analysis, Curhan concluded that his previous result is less likely to be due to the simultaneous equation bias.

Dréze et al. (1994) evaluated the impacts of increasing shelf-space size as well as better managing existing shelf-space; i.e., micro-merchandising. It is well-known that displays can be used to increase customer attention by manipulating the location of the product within a display, the area (facings) devoted to the product, product adjacencies, and aesthetic elements, such as size and color coordination and special displays (Dréze et al.; Stern, 1962). To evaluate the effect of shelf-space management, the study created location variables for each SKU (Stock Keeping Unit) by measuring the coordinates of the center of its facings on store planograms. The planogram is a blueprint of the store display case and considers shelf management and presentation of each product. Specifically, the planogram design takes into account shelf space allocation and location of each product to maximize store sales and profits. Like most previous studies, the study also assumes constant space and location elasticities, and the estimated elasticities are used to evaluate the effectiveness of shelf-space management.

Following Dréze et al. (1994), our study uses location and space data in store planograms to quantify space management efforts. However, unlike Dréze et al., we take into account various management efforts such as pricing, promotion, maintenance of planogram, cleanliness, and stock flows. To evaluate the effects of space management accurately, it is important to consider various management variables as well as the space and location variables in the model specification. The extended model is applied to the data collected from retail grocers of a New York State market.

For the evaluation, we examine changes in product sales volumes from the precategory-management baseline period to the in-program period. All sales, regular and promotional, would be included in our performance measures. Baseline sales are collected over an 8-week period prior to the case management program for each SKU. Subsequently, the case management program would last for an additional 8 weeks. An econometric model is designed to control for changes in store environments (such as price and promotion) and seasonality. An important but challenging task in developing an econometric model for our study is to quantify space management activities (e.g., change in location and space of a product) as appropriate numeric variables. Location and space variables for each SKU are generated from store planograms for the pre- and in-program time periods. The location of each SKU is measured by the coordinates of the center of its facings with the lower left corner of each dairy case being zero. Then, measurements of coordinates from each planogram are converted into inches using actual case dimensions. Product space is the amount of space allocated to each product in the dairy case and is calculated as the product dimension multiplied by the number of facings. Estimated parameters of location and space variables are used for the simulation that estimates the economic benefits of the category management program on retail sales.

2. OVERVIEW OF DAIRY CASE MANAGEMENT PROGRAM

The dairy case is the primary merchandising instrument available for grocery retailers to promote dairy and other refrigerated products. Because the space of dairy case is limited, retailers continuously face the problem as to how much space they should allocate to various products and how to determine the location of each product within the dairy case. Recently, the American Dairy Association and Dairy Council implemented the Dairy Case Management Program (DCMP) in over 600 grocery stores in the New York State milk marketing area. The DCMP is a category management program aimed at increasing milk sales at the retail level. Before the DCMP was implemented, store auditors were sent to stores to evaluate current conditions of the dairy case and planograms were produced for the preprogram period. Then, based on the evaluation of existing planograms and preprogram audit reports, new planograms were developed and provided to each store for the in-program period. The new planograms were designed to achieve three objectives: (a) increase the per capita consumption of fluid milk, (b) improve the position of milk as a high-profile beverage and fluid milk category, and (c) improve the management of milk ordering and handling.

In general, planogram design procedures followed the following protocols: (a) whole, reduced fat, and skim milk were vertically aligned with each product in its own section; (b) the store's fastest selling items were placed on the side with the highest traffic area at eye level; and (c) all size options were arranged next to each other. In addition, lactose reduced and organic milk products were integrated into the fat content sections and beverage milk products (i.e., flavored and single serve unflavored) were positioned next to other nonmilk juices when applicable. After the DCMP was implemented, dairy cases were audited each week for eight consecutive weeks and scored in terms of planogram adherence, hygiene, temperature control, and inventory, ordering, and rotation scheduling.

Why should rearranging shelf space matter? At least two explanations can be provided to answer this question. First, store-level space management decreases the probability of being out of stock because shelf space is more closely allocated proportional to the current store-level sales. Second, changes in space and location can affect consumer attention by altering the visibility of a product. A better location or increasing the number of product facings may shift consumers to higher margin items or may increase the number of unplanned purchases on a given shopping occasion. Previous studies suggest that consumer attention in the store is malleable and an important determinant of purchase behavior, and the majority of decision making occurs in the store (Dréze et al., 1994; Hoch & Deighton, 1989). Surveys of supermarket shopping behavior have found that only about one-third of purchases are planned in advance (Dagnoli, 1987),[2] and most consumers make choices very quickly after minimal search and price comparison (Dickson & Sawyer,

[2]According to the study by the Point-of-Purchase Advertising Institute, Englewood, N.J., a total of 52.6% of grocery store purchases are specifically unplanned, another 10% of consumers plan to purchase from a specific product but not a specific brand name, and nearly 3% of consumers substitute another brand when the planned purchase is not available. Taking these three figures together, about two-thirds of supermarket purchases are impulse purchases (Dagnoli, 1987).

1990; Hoyer, 1984). Underhill (1999) also reports that 60 to 70 % of grocery purchases are unplanned, and men are particularly suggestible to the entreaties of children as well as eye-catching displays (p. 101). Several Progressive Grocer articles point out that display is an important tool of sales enhancement and claim that display is a science based on knowledge of consumer attitudes, product characteristics, store traffic, and selling capacity of the store's entire area (Progressive Grocers, 1968, 1971a, 1971b). These previous studies on consumers' shopping behavior suggest that simply increasing the salience of products through better display could have significant impacts on store sales performance.

3. MODEL SPECIFICATION

To study the effect of reallocation and rearrangement of product space in the dairy case, it is important to generate numeric variables that reflect these changes. Retailers often believe that eye-level is the best option vertically while the middle position is the best horizontally. Alternatively, some prefer the edges in order to be the first or last from consumers' attention. Because no complete theory exists on this issue, we adopt a flexible specification in modeling numeric variables of location and space of each product. As discussed earlier, the location and space variables are derived from store planograms.

To generate the location variables, we measure coordinates of the center of product facings on the planogram and integrate these coordinates using a quadratic function. The quadratic function is chosen to insure the model flexibility, where the optimal position can be in the middle of the shelf or on one or both edges both horizontally and vertically. The location portion of the model can be represented as:

$$\beta_2 X_{it} + \beta_3 X_{it}^2 + \beta_4 Y_{it} + \beta_5 Y_{it}^2, \tag{1}$$

where X_{it} and Y_{it} are horizontal and vertical coordinates of i-th SKU at time t, and the β's are parameters to estimate.

For the space variable, we measure the amount of actual space allocated to each product SKU. For example, if there are three facings of a product whose package dimensions are 3 inches by 8 inches, then the product takes a total space of 72 square inches. The number of facings could have been used because of its convenience. However, the number of facings does not control for the size of each facing. One facing for a large product will not have the same effect as one facing for a small product. If other conditions are held constant, large-sized products are likely to get much more visual attention than small ones (Salvendy, 1987).

A double logarithmic functional form is adapted, where the natural logarithm of sales for each SKU is a function of the natural logarithm of price, space, and other control variables. The complete specification of our empirical model can be represented as:

$$\begin{aligned} \ln SALES_{it} &= \beta_0 + \beta_1 \ln PRICE_{it} + \beta_2 X_{it} + \beta_3 X_{it}^2 + \beta_4 Y_{it} + \beta_5 Y_{it}^2 \\ &= \beta_6 \ln SPACE_{it} + \beta_7 \ln SCORE_{it} + \sum_l \beta_1 CHAIN_{lit} \\ &\quad + \sum_m \beta_m SIZE_{mit} + \sum_n \beta_n MONTH_{nit} + \varepsilon_{it}, \end{aligned} \tag{2}$$

where *SALES* and *PRICE* are sales (in hundredweight) and price (in \$/hundredweight) for each SKU at time t; X, Y, and *SPACE* are the x- and y-coordinates and space taken by each SKU as described above, *SCORE* is the program audit score representing overall dairy case conditions, and *CHAIN*, *SIZE*, and *MONTH* are dummy variables representing retail grocery chain (chains 1–6), package size (pint, quart, half gallon, and gallon), and month of sales (May, June, July, and August), respectively. The dummy variable *CHAIN* is included to account for differences in marketing and promotion activities across retail chains assuming that each retail chain runs consistent marketing and promotion programs across its stores.[3] The dummy variable *SIZE* is added to account for differences in consumer purchasing behavior by package size (e.g., de Meza, 1988; Folkes & Matta, 2004; Granger & Billson, 1972). Monthly dummy variables are included to control for monthly or seasonal variations in sales.[4]

The double logarithmic functional form was chosen to impose bounded sales in the model. We certainly do not expect that the DCMP would increase sales indefinitely as we improve the location of milk and the number of facings in the dairy case. In addition, the double-logarithmic form provides coefficient estimates that are directly interpretable as sales elasticities. For example, in the equation specified above, β_1 is the own price elasticity, β_6 is the space elasticity (i.e. the elasticity of milk sales with respect to space allocated to each SKU), and β_7 is the score elasticity (i.e. the elasticity of milk sales with respect to audit score). The horizontal and vertical location elasticities will vary depending on location, taking account of the quadratic terms specified.[5] The effects of horizontal and vertical movements of product will be illustrated graphically via simulation analysis in the Empirical Results section.

4. DATA

Data were collected from retail grocery stores in the Northwestern Hudson Valley Market, New York that participated in the DCMP. The data include 770 SKUs from six grocery retail chains with 28 stores that participated in DCMP between July and August,

[3]Planogram design adjustments considered the objective of increasing the profile of the milk category by increasing allocations of beverage products (flavored and unflavored single serve products). Within this general objective, specific design adjustments followed first by fat content, then by package size, and finally by brand type. Each chain carried similar brands and the set of brands varied by chain. As such, the *CHAIN* dummy variable may also be capturing differences in brand sets, in addition to the chain-specific marketing and promotion effects.

[4]As pointed out by a reviewer, differences in store traffic patterns may also be important and affect case management program performance. Unfortunately, this data were not available and we assume that traffic patterns are balanced over all observations in the sample. Assuming that traffic patterns will vary across store chains and months of the year, this should be accounted for sufficiently with the respective dummy variables included in the models.

[5]One can calculate elasticities of X and Y using the following formulas:

$$\eta_x = \frac{\partial SALES}{\partial X} \cdot \frac{X}{SALES} = \frac{\dfrac{\partial \ln SALES}{\partial X}}{\dfrac{\partial \ln SALES}{\partial SALES}} \cdot \frac{X}{SALES} = (\beta_2 + 2\beta_3)X,$$

$$\eta_y = \frac{\partial SALES}{\partial Y} \cdot \frac{Y}{SALES} = \frac{\dfrac{\partial \ln SALES}{\partial Y}}{\dfrac{\partial \ln SALES}{\partial SALES}} \cdot \frac{Y}{SALES} = (\beta_4 + 2\beta_5)Y.$$

2002. In order to compare pre- and in-program performance, data were also collected for the preceding two months.

The data include monthly sales data of each SKU for four different milk packages: pint, quart, half gallon, and gallon. Because we are interested in evaluating the effects of dairy case management after controlling for pricing and other marketing effects, both price and marketing expenditure data (e.g., promotion expenditures) are required for our analysis. The price data during the program time period were based on store audit data collected from selected products. Prices were collected on eight representative fluid milk products and delineated by package size, fat content, flavor (flavored or unflavored), and brand (store or manufacturer brand) on a weekly basis from each store. While the data does not encompass all individual SKUs during the program period, we believe the data are reasonably disaggregated to represent actual store-level pricing across products with similar categorizations.

Unfortunately, prices were not collected prior to the in-store program period. One method of recovering the missing price data for the pre-program period is to extrapolate the price series using supplemental price data (if available) covering both the pre- and in-program periods from representative stores in the market area. This extrapolation assumes that the average monthly price movements of these stores are representative of all stores during the 4-month period. However, the extrapolation method could cause a measurement error problem that typically results in biased estimates (Green, 2003). Therefore, we turn to the data imputation literature to impute the missing price (e.g., Allison, 2002; Little & Rubin, 1987; Rubin, 1987; Schafer, 1997). To alleviate the measurement error problem, we reconstructed the pre-program price series using a multiple imputation procedure that produces consistent and asymptotically efficient estimates (Allison, 2002; Little & Rubin, 1987). The procedure is based on assumptions that: (a) the data is missing at random, (b) all variables have normal distributions, and (c) each variable can be represented as a linear function of all the other variables, together with a normal, homoscedastic error term. Then, for cases with missing data on x, the imputed values can be calculated as:

$$\hat{x}_i = a + \sum_j b_j y_{ij} + se_i \tag{3}$$

where a and b are intercept and coefficients of explanatory variables y_{ij}, respectively, and e and s are random error term and its standard deviation, respectively. Because a and b are not true parameters, the procedure is iterated using a Markov Chain Monte Carlo algorithm until it converges. The SAS Proc MI procedure was used to impute the preprogram price series after estimating the equation above with in-program price data. The imputation procedure implies that stores impose the same pricing strategies (including price promotion) during the pre- and in-program periods.

One can argue that the limited availability of specific store-level price data can potentially mask effects of particular price promotion programs. However, price promotions for fluid milk products are not as frequent as for other store products and response to the price promotions is limited due to the inherent perishability of the product (McLaughlin & Perosio, 1996).[6] In addition, we assume that additional price variation not reflected

[6]We checked the frequency of price promotion by product and store type during the program. Promotion frequency data indicate that price motion occurred less than one time on average for each product type across stores and most stores didn't have price promotions during the data period. For example, for supermarkets,

TABLE 1. Descriptive Statistics of Key Variables

	All stores		Convenience stores		Supermarkets	
Variable	Mean	Range	Mean	Range	Mean	Range
SALES, cwt	35.57	[1.01, 479.02]	6.08	[1.03, 59.25]	38.13	[1.01, 479.02]
PRICE, $/cwt	28.50	[20.15, 48.70]	37.63	[27.25, 48.01]	26.97	[23.01, 28.65]
X	86.44	[1.50, 266.00]	18.29	[2.00, 43.50]	92.40	[1.50, 266.00]
Y	35.63	[5.00, 67.40]	28.82	[5.50, 55.00]	36.60	[5.00, 67.40]
CASEDIM_X*	205.49	[24, 390]	44.23	[24.00, 60.00]	219.48	[144, 390]
CASEDIM_Y**	73.30	[50.00, 79.39]	59.13	[50, 71]	74.53	[52.00, 79.39]
FACINGS	3.40	[1, 10]	1.79	[1, 5]	3.49	[1, 10]
SPACE	141.84	[16.50, 409.50]	117.51	[26.79, 292.50]	143.95	[16.50, 409.50]
SCORE	17.44	[15, 20]	17.67	[15.50, 20.00]	17.42	[15, 20]

*CASEDIM_X: horizontal case dimension
**CASEDIM_Y: vertical case dimension.

in the price data should be adequately captured by the dummy variables on *CHAIN*, *SIZE*, and *MONTH*. In-store promotion expenditure data were also not available. As a proxy, we use dummy variables for each retail grocery chain assuming that each chain runs consistent marketing and promotional programs throughout its chain stores in the study area.

Recall that location and space variables were computed for each SKU from store planograms for both the pre- and in-program layouts. The effects of changing location and space allocated to a product may differ by the overall size of the dairy case. Therefore, location and space variables were normalized using both horizontal and vertical dimensions of the dairy case to provide relative location and space data comparable across stores.

By pooling 4 months of data for each of 770 unique SKUs, our data set has 3,080 observations in which 520 observations are from convenience stores and 2,560 observations are from supermarkets. Table 1 presents descriptive statistics of key variables in Equation 2. For each SKU, average monthly sales were 35.57 hundredweight with an average price of $28.50 per hundredweight. As expected, supermarket sales were over six times larger than convenience stores. Conversely, the price of milk in convenience stores was approximately 40% higher than supermarket prices reflecting a higher proportion of smaller packaged and flavored products. (See also Schmit, Kaiser, and Chung, 2004).

Location variables, *X*, *Y*, *CASEDIM_X*, and *CASEDIM_Y* indicate that supermarkets tend to use significantly bigger and wider dairy cases than convenience stores. While the horizontal case dimension for convenience stores ranges from 24 inches to 60 inches, the dimension for supermarkets ranges from 144 inches to 390 inches. As expected, the vertical dimensions are similar between the two types of stores. The average product location variables (X and Y) are approximately one-half of the respective case dimensions,

average number of price promotions for whole, 2%, 1%, skim, and chocolate milk with a gallon container were 0.25, 0.25, 0.38, and 0.94, respectively, and percentage of stores that had price promotions for these products were 0.19, 0.19, 0.31, 0.25, and 0.87, respectively. For convenience stores, average number of price promotions for 2% milk in a gallon container, 2% milk in a half gallon container, 2% milk in a quart container, and chocolate milk in a single serve 16 ounce container were 0.79, 0.58, 0.29, and 0.25, respectively, and percentage of stores that had price promotions for these products were 0.42, 0.29, 0.33, 0.25, respectively.

indicating that the number of products are relatively evenly distributed throughout the dairy case. Because supermarkets have larger cases, they can accommodate more facings of individual products to display. This is reflected in both the average number of product facings (e.g., 1.79 for convenience stores and 3.49 for supermarkets) and average product space allocated (e.g., 117.51 square inches for convenience stores and 143.95 square inches for supermarkets).

Average store audit scores were 17.44 on a scale of one to twenty. Because audit scores were not available during the pre-program period, i.e., May and June, we set initial audit scores from the first store audit report as audit scores for this period. Audit scores were quite similar between store types indicating that both store types responded equally well to the performance and operation standards established in the DCMP. Sales models are estimated for three store classes: convenience stores, supermarkets, and all stores.

5. EMPIRICAL RESULTS

The Maximum Likelihood Estimation (MLE) method was used to estimate the sales models (Equation 2). Because the data were collected from various stores, heteroscedasticity was tested on variances of the error terms using the Lagrange Multiplier (LM) test.[7] The test results indicated that regressions for all three models (convenience stores, supermarkets, and all stores) have heteroscedastic error problems. Accordingly, the heteroscedastic error problem was addressed using the MLE procedure and the final estimation results are presented in Table 2.

Overall, the models fit the data reasonably well, with estimated R-square values ranging from 0.38 to 0.41. Linear and Gompertz growth functional forms with various alternative specifications were also estimated, but R-square values and RESET test results indicated that Equation 2 is the best for the data. Coefficients of the price variable show expected negative signs and all are statistically significant at the 5% level. The estimates indicate that milk products are price elastic at convenience stores while price inelastic at supermarkets. This result may be attributed to the fact that convenience stores tend to sell higher-priced and relatively smaller sized packages, while supermarkets focus more on relatively lower-priced and relatively larger-sized packages. Note that milk price in convenience stores is 40% higher than in supermarkets (Table 1).

The space variables show expected signs and are statistically significant at the 5% level (Table 2). The coefficient of the space variable from the supermarket model indicates a 1.62 percent increase in product sales per one percent increase in product space. The lower convenience store results (0.63) is likely due, in part, to a higher proportion of smaller package-size products relative to supermarkets. Improving overall store conditions (e.g., cleanliness, ordering, stocking), as identified through store audit scores, appears important in supermarkets, while the effect was not significantly different from zero in convenience stores. This may be due, in part to the relatively larger volume and variety of products in supermarkets, combined with the fact that planogram effects are accounted for via the location and space variables. The majority of retail chain and size dummy variables are statistically significant, indicating that sales performance per SKU differ significantly across retail chains and package sizes. All monthly dummy variables are

[7]Harvey-Godfrey test was performed with *lnPRICE*, X, X^2, Y, Y^2, *lnSPACE*, and *lnSCORE* as independent variables. P-values were smaller than 0.0001 for all three regression equations.

TABLE 2. Parameter Estimates from Maximum Likelihood Estimation by Store Type

	All stores		Convenience stores		Supermarkets	
Variable	Estimate	*t*-Statistic	Estimate	*t*-Statistic	Estimate	*t*-Statistic
Intercept	12.75	10..49	8.30	2.45	2.15	0.41
lnPRICE	−1.08	−4.53	−2.29	−3.97	−0.76	−2.94
X	−0.66	−0.50	7.27	1.34	−1.67	−1.25
X^2	0.71	0.50	−6.88	−1.99	1.77	1.16
Y	2.29	1.88	7.45	1.82	1.74	1.87
Y^2	−1.47	−1.77	−3.51	−2.11	−1.01	−1.76
lnSPACE	1.55	11.02	0.63	1.97	1.62	12.24
lnSCORE	2.01	1.99	−0.09	−1.01	3.44	2.07
CHAIN1	−6.02	−22.69	−0.82	−1.73		
CHAIN2	−4.08	−8.62	1.24	1.89		
CHAIN3	−4.76	−9.41				
CHAIN4	−2.01	−8.63			−1.57	−6.54
CHAIN5	−1.23	−6.47			−1.03	−5.53
Quart	0.11	0.37	−1.31	−1.98	0.01	0.04
Half gallon	0.04	0.41	−1.19	−1.27	0.12	0.32
Gallon	1.45	4.08	−0.87	−1.87	1.81	3.91
May	−0.03	−0.18	0.92	2.38	0.40	1.75
June	−0.04	−0.31	0.70	1.89	0.41	1.70
July	0.11	0.77	0.84	2.02	0.13	0.94
No. of obs.	3,080		520		2,560	
F-statistic	5.00		6.24		65.96	
R-square	0.39		0.41		0.38	

significant from the analysis of convenience stores but only *May* and *June* are significant from supermarkets at the 10% level.

Given the magnitude of the parameter estimates of location variables, it appears that that vertical positioning is relatively more important (and statistically significant) than horizontal location. Effects of horizontal and vertical movements were statistically tested via F-tests and the results are reported in Table 3. Results from Test 1 and 2 confirm the results from Table 2 that vertical movement is more effective than horizontal relocation.

TABLE 3. Results of *F*-Test on Location Variables

	All stores	Convenience stores	Supermarkets
Test 1, H_0: $\beta_2 = \beta_3 = 0$			
F-statistic	0.13	1.07	0.79
P-value	0.88	0.34	0.45
Test 2, H_0: $\beta_4 = \beta_5 = 0$			
F-statistic	4.45	2.62	5.85
P-value	less than 0.01	0.07	less than 0.01
Test 3, H_0: $\beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$			
F-statistic	2.65	2.11	3.17
P-value	0.03	0.08	less than 0.01

Results of Test 3 suggest that rearranging products inside the dairy case can effectively increase sales, particularly in supermarkets.

The results reported in Table 2 and 3 give supporting evidence that location matters and plays an important role in increasing product sales. To be able to provide useful information for shelf-space arrangement in retail stores, we further examine how horizontal and vertical product movement affects product sales through simulation of the estimated store sales models (in Table 2). Specifically, we compute expected sales in response to changing x- and y-coordinates for horizontal and vertical movement, respectively, while maintaining values of other variables at sample means.

The graphs in Figure 1 show the effects of product movement in the dairy case, both horizontally and vertically. For the horizontal movement, mixed results were observed from convenience stores and supermarkets, as expected from the econometric results in Table 2. For convenience stores, the preferred product location was approximately centrally located (18 inches from the left),[8] while the preferred product location in supermarkets was the right edge. There is no unifying theory that can justify this result, but the mixed result may be attributed to the relative differences in the size of the dairy cases. In Table 1, the mean horizontal case dimension in convenience stores was around 44 inches, while it was 219 inches in supermarkets. When the case is relatively narrow, the midpoint may be a good location, but it may not be an ideal location to attract consumers when the case is substantially wide with a large number of products on either side. Thus, when the case is wide, the good location may be the edges, the first or last in the case.

For the vertical movement, we have consistent results from both convenience stores and supermarkets. Across all store types, the expected sales reached the highest point when the product is located around 60 inches (5 feet) high (Figure 1). In general, our results are consistent with Dréze et al. (1994). The earlier study also found no consistent results from horizontal movement, but suggested that an eye-level location was most desirable (above the knees but below 6.5 feet) from the vertical arrangement. Supplemental model estimation results with linear functional forms on the location variables were generally consistent with those in Table 2.

A final simulation of the estimated models was conducted to determine the sales impact of implementing the DCMP in participating stores. To do so, the sample was divided into two parts representing the pre- and in-program time periods and then the estimated models (Table 2) were simulated for each period. For this simulation, only the corresponding DCMP variables on location, space, and exit scores were changed between the two distinct periods, while all other variables were held constant at their overall sample means.

Simulation results indicated that the DCMP resulted in a 7.05% increase in average product milk sales at the retailer level across all stores (Table 4). Disaggregated by store type, DCMP effects indicated sales enhancement of 5.89% and 10.37% for supermarkets and convenience stores, respectively. Dréze et al. (1994) reported 4–5% and 7–11% sales increase for convenience stores and supermarkets from similar shelf-space management programs for consumer products such as toothpaste, toothbrush, cigarettes, and detergents. Hence, our results are quite comparable to Dréze et al. Estimated 95% confidence intervals indicate our results are statistically greater than zero.

[8]In Figure 1, expected sales for convenience stores are zero beyond 50 inches from the left corner for the horizontal movement. The simulation result is plausible because the maximum of horizontal location (X) and case dimension (CASEDIM_X) in convenience stores are 43.50 and 60 inches, respectively (Table 1).

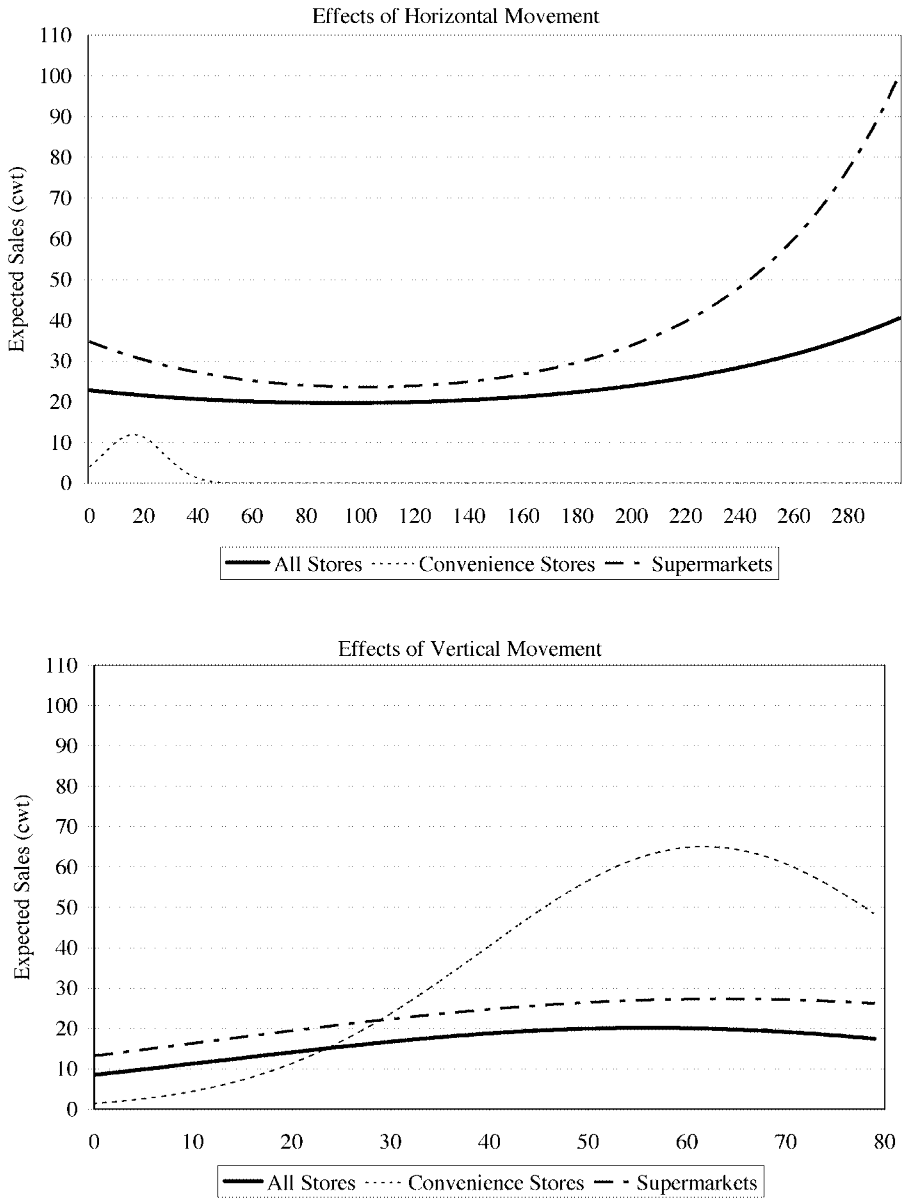

Figure 1 Effects of horizontal and vertical movement in dairy case.

TABLE 4. Effects of DCMP in Increasing Store Sales

	All stores	Convenience stores	Supermarkets
Sales increase (%)	7.05	10.37	5.89
95% Confidence interval	[4.76, 11.22]	[5.36, 16.15]	[3.88, 9.07]
Sales increase from Dréze, Hoch, and Purk (%)		7–11	4–5

6. CONCLUSIONS

An econometric methodology was developed for the evaluation of shelf-space management programs in retail stores. Product- and time-specific location and space variables were generated to determine preferred product locations for differing store types. In addition, accounting for other program-specific changes in display and management allowed for the estimation of sales enhancement directly attributable to the in-store management program. As many agricultural commodity groups have gradually shifted their generic advertising efforts to in-store promotion programs, the current study provides a useful framework for the evaluation of these types shelf-space management programs. The model was applied to the evaluation of the Dairy Case Management Program conducted at retail grocers in the Northwestern Hudson Valley Market, New York.

Three joint hypothesis tests were conducted and showed that the Dairy Case Management Program was effective at increasing average retail product sales approximately six to ten percent during the program period. In addition, location-specific model simulations were conducted to examine the relative importance of product placement both horizontally and vertically. Along the horizontal plane, centrally located products were preferred in the smaller dairy cases in convenience stores, while an edge location was preferred in the larger and more complex cases in supermarkets. Results from vertical rearrangement indicated that an eye-level location (around 5 feet high) was the most desirable in both convenience and supermarket stores. The model results can be useful in the development of retail store dairy case designs to improve shelf space management and product sales.

The evaluation results presented here should be viewed with caution as a case-study application to a relatively small market in New York State. Further exploration with additional market areas may permit the generalization of findings presented here. Given data availability, future research in this area is warranted to consider the cross-product effects of shelf-space management programs. Changing location (or space) of a product may not only affect own sales but also sales of adjacent products, and will be influenced by the level of complementary or substitute product relationships.

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