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ESTIMATION OF WEEKLY SALES FORECASTING EQUATIONS FOR SUPERMARKETS

by

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Abstract

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Weekly total and departmental sales forecasting equations were specified and estimated for 10 supermarkets. Nearness to payday, holidays and number of grocery specials were significantly related to total store sales. Several variables were statistically significant in meat and produce sales equations but not in the total store sales equations.

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Retail food store sales demonstrate substantial short-run variability due to changing competitive conditions, promotional programs and consumer demand. Sales variation of 10% or more from the first to the last week of a month is not unusual while day-to-day variation within a week often exceeds 50%. Costs of food retailing and marketing margins are affected by variability and explaining the sources of sales variability can be important in explaining such things as pricing practices, adoption of packaging, handling, transportation, and product innovations, and changes in the food distribution structure.

Individual food store sales may respond to many short-run factors including nearness to payday, amount and mode of advertising, advertised specials, product quality, and product availability. Competitor's actions are also important but may be difficult to anticipate, measure and evaluate. Important longer-run determinants of sales include store location and image factors such as general level of prices, service, cleanliness, product selection, and reputation for fresh meat and produce.

The original objective of this research was to measure the impact of various short-run advertising and promotional programs on individual food store sales to guide management in design of merchandising programs. As the study progressed it became obvious that there were very important consumer purchasing patterns associated with consumer liquidity and changing effective demand which contributed to sales

variability. The analysis was extended to examine these sales patterns Specifically, the objectives of this paper are to estimate weekly sales forecasting equations for 10 individual supermarkets operated by one chain and located in a single Northern California SMSA and to develop quantitative estimates of the separate effects of selected controllable and uncontrollable factors on weekly sales by department (groceries, meat and produce) for individual supermarkets.

Previous Work

Published studies of weekly retail food store sales tend to focus on sales of individual items or product lines. There have been in-store pricing experiments (see a summary in Doyle and Gidengil); studies to measure the effects of promotional progams on individual items (Hoofnagle; Curhan 1974); price elasticity of demand studies (Funk, Meilke and Huff; Marion and Walker); space allocation and display studies (Cox; Curhan, 1973; Chevalier); and, studies of interactions between short-run strategy variables such as advertising, space allocation and pricing (Curhan, 1974; Wilkinson, Mason and Paksoy). These studies have found that individual items often demonstrate rather dramatic short-run sales responses to changes in price, advertising, space allocation or display but they have not examined the impacts on departmental sales or total store sales. This lack of published research on aggregate food store sales is not surprising, however, since results tend to be firm specific and firms regard data and results as proprietary information.

Analytical Model

Supermarket management focuses on projected weekly sales, gross margins by department, inventory levels and labor requirements in its short-run decision making. Decisions concerning prices, labor scheduling, orders, inventory levels, advertising (mode, level and copy), and promotional specials must be made on a weekly basis. Because of lead times, most decisions must be made two or more weeks in advance without knowledge of competitors' actions. Quantitative estimates of the impact of factors affecting weekly store sales can be an important input to management decision making in this environment.

Total weekly sales were specified as the dependent variable with factors associated with sales variability specified as predetermined variables. The general analytical model is:

$$TS_{ij} = f(P_{ij}, ADV, PRO, PAY, SEA, HOL, T)$$

where: TS_{ij} is total weekly sales in department j (meat, produce, grocery) for store i; P_{ij} is a measure of prices in department j for store i; ADV is advertising; PRO is promotional activity; PAY is the nearness to payday; SEA is a bi-monthly shift variable to measure seasonality of sales; HOL is a shift variable for holidays; and T is a trend variable to measure uniform changes in sales over time.

The model is demand oriented but with important differences from a quantity dependent demand model. The relationship between prices and total dollar sales, for example, may be positive or negative depending on the price elasticity of demand. Also, because of the predictive orientation of the study, competing store variables such as pricing and

advertising were not included. We expect total weekly sales to be a positive function of advertising and promotional activities and to decrease as the time since payday increases.

Data

Data for the analysis covers the 105 week period beginning July 1978 and ending July 1980. The sales and advertising weeks, which were matched, covered the days Wednesday through Tuesday. Advertised specials were effective for one week beginning with the large newspaper food section advertisements each Wednesday morning or for three days beginning with a small newspaper advertisement on Sunday morning. Weekly sales for the 10 supermarkets studied ranged from slightly less than $50,000 to over $200,000 during the study period. Average total sales for the 10 stores during the study period ranged from $57,000 to $151,000 per week.

Results

Parameters for the model of weekly store sales were estimated using ordinary least squares methods. Separate equations were estimated for grocery sales, meat sales, produce sales and total store sales for each of the 10 supermarkets. All variables were entered as natural numbers and all equations are linear. The same set of independent variables was utilized in each of the estimated equations. This yields the result that the estimated coefficients for departmental sales sum to the estimated coefficient for total store sales for each variable for each store. Thus, one can determine the relative contribution of a given

variable's coefficient for a department to the variable's coefficient for total store sales. Note also that the specified variables were included in all equations even though some coefficients were statistically insignificant and a few had signs counter to a priori expections.

The independent variables included in each equation were: week of the month (WK2, WK3, WK4, WK5), holidays (HOL), season (S2, S3, S4, S5, S6), television advertising (TV), newspaper advertising (NEWS), number of store coupons (COU), number of grocery specials (GSP), number of meat specials (MS), average gross margin for meat (GMM), average gross margin for produce (GMP), and trend (T).

The estimated equations for total store sales are shown by store in Table 1. Space restrictions preclude presentation of the separate results to grocery, produce and meat sales. We will, however, briefly discuss these results where appropriate. A brief description of the variables utilized will be presented with the discussion of the estimated coefficients.

Week: Changing effective demand related to nearness to payday is a well-known phenomenon in food retailing but research on its impact is limited. Marion and Walker, in their study of weekly retail meat sales, found that sales tended to decrease as time since the last payday increased. Possible differences in the impact of changing consumer liquidity on sales of meat, produce, and groceries, can have important economic implications.

Dummy variables were used to measure the impact of nearness to payday. The first week of the month was defined as the base week.

Zero-one variables were then specified for weeks two, three, four and five. Note that week five, which occurred in only a few months, can include up to three days from the beginning of the following month.

Each of the estimated coefficients on the week variables had the hypothesized negative sign, the magnitude of the coefficients increased from WK2 to WK4 as hypothesized and 36 of the 40 coefficients were statistically significant at the 95% level using a one-tailed test. Thus, we conclude that nearness to payday does have an important impact on total store sales and that the magnitude of the impact varies by store. Examination of the estimated coefficients by Department revealed similar results except for produce where only 26 of the 40 coefficients were statistically significant and four were positive (but not significant) for WK2. In general, the share of the variation by Department was in line with the percentage of total store sales accounted for by the Department. Most of the estimated coefficients for WK3 and WK4 were negative and statistically significant for produce (16 of 20), meat (20 of 20), and groceries (19 of 20).

Holidays: A zero-one variable was specified for seven holiday weeks which are associated with increased sales. Included were New Years, Easter, Memorial Day, July Fourth, Labor Day, Thanksgiving and Christmas. These holidays had a statistically significant positive impact on total weekly store sales for each of the stores (Table 1). The impact varied from an average of $4,428 per holiday week in store G to $13,807 per holiday week in store F. Overall, the increase in total store sales averaged 8.6% for the holidays considered. Each of the estimated coefficients on the holiday variable was positive for each

department (grocery, meat and produce) in each store but three of the coefficients for meat sales were not significant.

Season and Trend: There may be uniform changes in sales related to seasonality or sales trends in individual stores. Variables for both season and trend were specified. The bi-monthly shift variable has a base period of January-February. Zero-one variables were specified for S2 (March-April), S3 (May-June), S4 (July-August), S5 (September-October), and S6 (November-December). The trend variable, specified as the chronological number of each week (1-105), measures sales growth or decline occurring through time which is not seasonal.

There is little evidence of seasonal changes in total store sales. Only two stores, C and G, have significant coefficients on the shift variables and there is not a consistent pattern of shifts (Table 1). Results are similar for grocery and meat sales. There is definite evidence of seasonality in produce sales, as one might expect, with approximately half of the estimated coefficients being statistically significant. In general, produce sales increase from the January-February base in periods S2, S3 and S4, then they appear to be similar to the base in period S5 and decrease in period S6.

Individual stores had both positive and negative weekly sales trends during the period of analysis. The competitive structure in individual store market areas and the effectiveness of individual store management are believed to be important factors in these measured trends.

Table 1. Estimated Weekly Total Store Sales Equations for 10 Northern California Supermarkets, July 1978-July 1980.

STORES	A	B	C	D	E	F	G	H	I	J
VARIABLES	Estimated Coefficients									
CONSTANT	31,302	87,178	117,372	119,206	81,622	124,438	53,505	70,106	57,534	85,449
	(2.30)*	(8.17)	(9.91)	(9.06)	(9.22)	(4.78)	(8.45)	(8.59)	(5.33)	(4.71)
WK2	-7,053	-2,631	-4,826	-3,556	-4,471	-5,054	-4,581	-2,817	-6,606	-2,833
	(-3.67)	(-1.23)	(-2.13)	(-1.75)	(-2.84)	(-1.74)	(-3.29)	(-1.78)	(-3.49)	(-1.38)
WK3	-8,298	-4,771	-5,994	-4,752	-4,546	-8,627	-4,388	-2,646	-9,604	-4,457
	(-4.24)	(-2.19)	(-2.61)	(-2.30)	(-2.85)	(-2.94)	(-3.11)	(-1.69)	(-4.99)	(-2.14)
WK4	-14,905	-10,402	-10,510	-10,115	-8,528	-15,706	-8,998	-7,395	-16,749	-9,549
	(-7.28)	(-4.57)	(-4.37)	(-4.69)	(-5.09)	(-5.12)	(-6.09)	(-4.47)	(-8.31)	(-4.38)
WK5	-8,895	-5,479	-4,949	-6,068	-5,934	-9,922	-5,193	-4,571	-10,928	-6,355
	(-2.89)	(-1.58)	(-1.35)	(-1.87)	(-2.36)	(-2.15)	(-2.35)	(-1.85)	(-3.58)	(-1.90)
HOL	4,870	8,787	11,996	8,356	6,942	13,807	4,428	7,213	4,477	8,858
	(2.00)	(3.19)	(4.13)	(3.23)	(3.48)	(3.80)	(2.54)	(3.67)	(1.87)	(3.37)
S2	-1,942	-5,484	-7,033	-2,795	-2,064	-3,742	547	-1,923	-999	-3,299
	(-.64)	(-1.52)	(-2.03)	(-.88)	(-.83)	(-.81)	(.25)	(-.80)	(-.34)	(-.99)
S3	-218	-3,954	-6,407	-2,083	-1,836	-401	4,847	1,292	-1,183	-1,176
	(-.07)	(-1.09)	(-1.66)	(-.60)	(-.67)	(-.08)	(2.07)	(.48)	(-.37)	(-.34)
S4	-1,870	-2,653	-9,354	-4,960	-2,554	2,309	3,861	632	-3,674	84
	(-.58)	(-.74)	(-2.45)	(-1.43)	(-.98)	(.48)	(1.64)	(.24)	(-1.17)	(.02)
S5	-2,111	-2,773	-8,132	-1,422	2,064	5,255	1,842	1,385	-1,712	1,445
	(-.62)	(-.74)	(-2.07)	(-.40)	(.72)	(1.04)	(.74)	(.51)	(-.52)	(.40)
S6	-4,172	-5,847	-13,898	252	-2,548	-4,012	-1,178	-1,877	-2,967	-573
	(-1.18)	(-1.53)	(-3.35)	(.07)	(-.84)	(-.77)	(-.46)	(.67)	(-.87)	(-.16)
TV	3,829	1,440	1,629	-646	511	3,109	4,252	113	221	1,754
	(1.69)	(.54)	(.59)	(-.26)	(.28)	(.90)	(2.56)	(.06)	(.10)	(.72)
NEWS	1,666	3,476	2,615	1,506	1,933	2,133	2,878	2,149	986	3,932
	(.94)	(1.76)	(1.26)	(.81)	(1.33)	(.80)	(2.21)	(1.51)	(.56)	(2.09)
COU	815	763	327	1,123	404	129	1,219	90	1,013	1,147
	(1.02)	(.85)	(.34)	(1.30)	(.61)	(.10)	(2.02)	(.14)	(1.28)	(1.35)
GSP	596	742	835	570	460	1,041	286	447	398	616
	(2.13)	(2.39)	(2.49)	(1.91)	(2.02)	(2.50)	(1.43)	(1.94)	(1.43)	(2.07)
MS	347	33	-617	-731	-221	-1,275	153	-225	-2	-173
	(.64)	(.55)	(-.97)	(-1.30)	(-.50)	(-1.65)	(.41)	(-.54)	(-.00)	(-.31)
GMP	66,284	-41,244	-90,990	-26,700	-3,725	-63,798	15,531	16,325	-18,105	-8,410
	(2.22)	(-1.22)	(-3.26)	(-.82)	(-.18)	(-1.45)	(1.09)	(.79)	(-.80)	(-.29)
GMM	77,363	68,614	32,070	10,860	-4,858	147,222	37,720	22,815	33,172	40,704
	(1.30)	(1.49)	(.69)	(.32)	(-.18)	(2.06)	(2.51)	(.85)	(1.11)	(.71)
T	-35	-22	-126	-69	74	200	-63	50	23	358
	(-.91)	(-.50)	(-2.69)	(-1.60)	(2.00)	(3.48)	(-2.24)	(1.62)	(.64)	(8.46)
R^2	.526	.386	.545	.443	.456	.510	.579	.418	.525	.709
F	5.30	3.01	5.72	3.81	4.01	4.97	6.58	3.43	5.27	11.64
DW	2.66	2.34	2.03	2.74	2.62	2.32	2.38	2.24	2.47	2.71
Average Sales	66,077	90,734	87,785	108,780	83,893	150,961	66,455	85,259	56,786	115,959

*T-Statistic in Parenthesis

Advertising: Both newspaper and television advertising were utilized by the chain. The impact of the standard two-page advertisement run each Wednesday in the food section of the two daily newspapers was not included in the analysis since it did not vary. A zero-one variable was used to measure the impact of special newspaper advertisements used at other times of the week or more than two pages in the Wednesday newspaper. Television advertising was utilized 20 weeks during the study period. A zero-one variable was used to measure the impact of television advertising on sales during the weeks it was utilized. No attempt was made to measure carryover or threshold effects.

All but one of the estimated advertising coefficients have the expected positive sign in the total sales equations but only five (two for TV and three for NEWS) were statistically signficiant at the 95% level. The departmental response to advertising varied. Only one of the 20 estimated coefficients for the advertising variables was significant in the grocery sales equations. Four of the 20 coefficients were significant in the meat sales equations while eight of 20 were significant in the produce sales equations. Note that six out of 10 coefficients on the TV variable were significant in the produce sales equations.

Promotional Specials: Three variables were specified as measures of advertised price specials. The first, number of grocery specials, was defined as the number of advertised grocery items which were (1) priced one cent or less over the unit costs of the item, and/or (2) had a combined weekly estimated ad loss of $1,000 or more for all

stores. (Ad loss is defined as the total reduction in the grocery gross margin due to a grocery special.) The second variable, number of meat specials, was defined as the number of meat items featured prominently in the newspaper advertisement and which had a gross margin of less than 15%. A third variable, number of coupons, was defined as the number of items for which store newspaper coupons were available during the week. A lack of variation in the number of produce specials (two were featured each week) precluded its use as a variable.

The number of store coupons was positively related to total weekly sales and total grocery sales in each store but only one of the 20 coefficients was significant. All of the coefficients for coupons were positive in the meat and produce sales equations, with four of 10 significantly greater than zero for meat and seven of 10 significantly greater than zero for produce. Thus, store coupons, which were usually redeemable for grocery items, did not affect grocery sales but did tend to increase meat and produce sales.

The coefficients for the number of grocery specials were positively related to total store sales in each of the 10 stores and eight of the coefficients were significant. Note that most coupon items qualified as a grocery special so that these two variables should be considered together. There was a similar positive relationship between the number of grocery specials and grocery sales with nine of the 10 coefficients significantly greater than zero. The relationship between the number of grocery specials and both meat and produce sales was positive in all stores but only four of the produce coefficients and three of the meat coefficients were significant.

None of the coefficients on the variable for the number of meat specials was significantly related to total store sales. Results were similar for grocery sales with only one of the 10 estimated coefficients for meat specials being significant. Surprisingly, none of the coefficients for number of meat specials was significant in the meat sales equations. We know that sales of special meat items increase but this indicates the specials replace other meat expenditures rather than adding to total meat sales. All of the meat special coefficients have a negative sign in the produce sales equations and four of 10 are significant. This indicates that meat specials tend to have a negative impact on produce sales in the study stores.

Prices: Average percentage gross margin (the difference between selling price and cost expressed as a percent of selling price) was used as a proxy variable for average produce and meat prices. Use of this proxy was based on the expectation that smaller gross margins were associated with lower prices while larger gross margins would indicate higher prices. A possible problem with this variable is that changes in the mix of sales can result in a change in gross margin even though prices are constant. Since accurate gross margin estimates require a physical inventory, gross margins were only measured every four weeks for meat and produce and every 12 weeks for groceries. Even though weekly measurement is preferred for a weekly study, the gross margin data for meat and produce were utilized since they were the best price indicators available. The grocery data were simply too aggregate to reflect weekly changes and were dropped from the analysis.

Only four of the 20 coefficients on the two gross margin variables were significant in the total store sales equations (Table 1). Six of the coefficients for the produce gross margin variable were negative and significant in the produce sales equations indicating that the produce department faces an elastic demand. Eight of the 10 coefficients for the meat gross margin variable were positive in the meat sales equations but only one was significant at the 95% confidence level. Note that positive coefficients are consistent with an inelastic demand relationship.

Concluding Comments

This study indicates that weekly sales forecasting equations can be developed as a guide to management decision-making. Data problems are probably responsible for much of the variability observed in the estimated coefficients. Scanner technology will improve data collection and should yield improved estimates of the impact of both controllable and uncontrollable variables.

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