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A STUDY OF THE EFFECT OF SHELF SPACE ON SALES OF FRUIT BEVERAGES

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One of the limited resources in a grocery store is shelf space. In allocating shelf space, many food manufacturers and supermarket retailers employ decision rules that assume a positive relationship between the amount of shelf space given to a product and its sales (Food Topics; COSMOS). Retailers generally believe that display-exposure influences product unit sales, so shelf-space allocation is regularly manipulated to increase sales and profits.

Most supermarkets, regardless of product variety, physical size, or clientele served, are devoted to self-service displays, i.e., the customer buys the products without the help of sales personnel. The self-service display areas constitute a purchase setting where the products and brands must stimulate their own demand from the counter, without the direction or encouragement of sales personnel. The result is that if the customer does not see a certain product he can not buy it, and if the customer sees a certain product he may buy it. It has often been stated that the quantity of shelf space allocated to a product influences the perceptibility of that product and hence its sales per unit of shelf space. In this retail context, one of the primary concerns of retail management involves determining the variety of brands to be stocked, and the allocation of scarce display areas among stocked brands to maximize the store's profits. Because the total quantity of available shelf space is limited, the supermarket is confronted with a shelf-space allocation problem.

Past studies pointed out the opportunity that efficient use of shelf space offers to management for improving the profitability of the store (Brown and Tucker; Lee). First, the display of goods on the shelf provides not only an opportunity for a customer to find the goods s/he wants, but also provides a visual display, i.e., a form of advertising, of a specific good or a group of related goods. Generally, the larger the display of a specific good, the more the good is visible to the store's customers, and the more likely the good will be purchased. Usually there is only limited shelf space available in a store and related goods (close substitutes) are displayed side by side on the shelves. For each category of goods, an increase of shelf space allocated to one good can only be accomplished by decreasing the shelf-space allocation of other goods. Prominent display of one good may increase the sales of the good, but may also have a negative impact on the sales of the other goods in the same category. Additionally, different customers may demand different goods, the available of a diverse varieties of goods may attract a larger number of customers and increase sales revenue.

The goods on the shelf may be sold out and become unavailable for customers to purchase. This out-of-stock situation not only deprives the chances for consumers to see and purchase the goods, but also increases the visibility of the goods that are still displayed on the shelf. Therefore, out-of-stock situations would have a negative impact on the sales of out-of-stock goods and, perhaps, a positive impact on the sales of the goods still on the shelf.

In this study, it is assumed that the quantity of self-serviced goods sold (q) is a function of their prices (p), total dollar sales for the category (x), the footage of shelf space allocated (SS), the variety of beverages available (VTY), and the out-of-stock occurrences (OOS). A double-logarithmic functional form was chosen to represent this relationship.[1] More specifically, the demand relationship can be written as

(1) $\log q_i = \alpha_{i0} + \Sigma_j \alpha_{ij} \log p_j + \alpha_{ix} \log x + \Sigma_j \beta_{ij} \log SS_j + \eta_i VTY + \Sigma_j \gamma_{ij} \log OOS_j$;

where α, β, γ, and η are parameters to be estimated and subscript i represents store i.

This study is based on the refrigerated-section-data for a 3,000-supermarket sample around the United States provided by Information Resources, Inc. (IRI). The information of these 3,000 supermarkets was reported as 169 accounts. The account data provided by IRI include out-of-stock in percent of all commodity volume (%ACV), linear footage of shelf space per store, and dollar and volume sales per linear foot for 17 refrigerated juices and drinks. Note that not all 17 juices and drinks were available in all stores; and the 17 refrigerated juices and drinks were grouped into five groups:

1. Orange juice
2. Grapefruit juice
3. Juice drinks: fruit nectar, cranberry cocktail/drink, grapefruit cocktail/drink, and fruit drinks.
4. Other juices: pineapple juice, apple juice, grape juice, blended fruit juices, cider, cranberry juice/juice blend, and other juices.
5. Other beverages: lemon/lime juice, lemonade, vegetable juice/drinks, and tea.

Attention is focused on the shelf space distribution across beverages in measuring beverage variety in a store. Variety could be measured by the number of beverages actually present in the store. However, this approach does not provide any information about the distribution of the shelf space occupied by each individual beverage. For example, in one store orange juice, grapefruit juice, and fruit drinks may occupy 50%, 30%, and 20% of total available shelf space and in another store these three beverages may occupy 70%, 20%, and 10%, respectively. If one uses the number of beverages that were present in the stores, then both stores have three different beverages. However, these three beverages occupied different amounts of shelf space. Therefore, this study uses a measure that accounts for the latter type of distributions in the context of shelf space allocation.

An analytical tool commonly used to study the concentration of an industry is the Herfindahl index (H), which is given by the formula

$$H = \Sigma_i w_i^2,$$

Where, $w_i = SS_i/\Sigma_j SS_j$, is the shelf-space share of the ith beverage. When there is only one beverage present in the store, the index attains its maximum value of 1.0. The value declines with increases in the number of beverages and increases with rising inequality in the shelf-space allocation among any given number of beverages. The range of the Herfindahl index is [1/n, 1],

[1] Different functional forms were tried and the double logarithmic functional form was found to fit the data better than other functional forms.

where n is the number of beverages of interest, i.e., n = 5, with the upper limit being attained when one beverage has all available shelf space, and lower limit when all 5 beverage categories have an equal share of shelf space. A change in shelf space is like a change in competitive position. The Herfindahl index thus measures variety inversely. Alternatively, the Simpson index (S) (Patil and Taillie; Bhargava and Uppuluri; Good) is defined as 1 minus the Herfindahl index, or

$$S = 1 - \Sigma_i w_i.$$

The range of the Simpson index is [0, 1-(1/n)] and measures variety directly.

Another commonly used measure of industrial concentration is the entropy of market shares (Theil; Hart; Hall and Tideman). This measurement is also called Shannon's index (Patil and Taillie) or Gibb's index (Good). The entropy index (E) is defined as

$$E = -\Sigma_i w_i \log(w_i);$$

the entropy or the Shannon index varies from zero (when one beverage has all the shelf space and hence the other 4 beverage categories were not present in the store) to a maximum of log(n) (when all shelf-space shares equal 1/n). In this study, both the Simpson index and entropy index were tried as measures of the variable *VTY*. Based on the resulting R^2, the Simpson index fit better than the entropy index; hence, only the results using the Simpson index are presented.

The dollar and volume sales for the week ending May 6, 2001 were used in this study. Sample statistics for these five categories are presented in Table 1. As shown in Table 1, orange juice had the highest dollar sales among the five beverages studied; the juice drinks category was ranked second, followed by other juices and blends, other beverages, and grapefruit juice ranked at the bottom. Sample averages show that orange juice had 51.9% of the total shelf space but its sales accounted for 74.0% of total dollar sales, and on average, each foot of orange-juice shelf space brought in more than a thousand dollars ($1,039) during the study week. Juice drinks had 25.2% of the shelf space, but its sales accounted for 11.9% of the total dollar sales, and the average revenue per foot of shelf space was $343, about one-third of the average revenue per foot from orange juice sales.

Note that the parameters for price, total dollar sales, and shelf-space variables are demand elasticities in a double-log function. Results shown in Table 2 indicate that all own-price elasticity estimates are negative as expected. These own-price elasticity estimates show that the demand for juice drinks is price elastic and the demands for orange juice, other juices, and other beverages are unitary while the demand for grapefruit juice is inelastic. Cross-price elasticity estimates show that juice drinks are substitutes for orange juice and other beverages are substitutes for grapefruit juice and other juices/blends.

All own-shelf-space demand elasticity estimates are positive and statistically different from zero, an indication that an increase in shelf space would increase sales and vice versa. Of the 20 cross-shelf-space elasticity estimates, nine of them are statistically different from zero. Of these nine non-zero cross-shelf-space elasticity estimates, eight of them are negative and one is positive. Intuitively, one would expect the cross-shelf-space elasticities to be negative, an indication that more shelf space for one beverage or juice would decrease the chances of other beverage/juice being bought by consumers. The one positive cross-shelf-space elasticity estimate shows that an increase in the shelf space allocated to grapefruit juice would increase the sales of orange juice. Perhaps, orange juice and grapefruit juice are usually shelved side by side and the close proximity of the displays of these two closely related juices may explain this positive relationship. This result may also indicate a generic advertising impact.

Most out-of-stock parameter estimates were statistically not different from zero (23 estimates) or did not have the expected negative sign (two estimates); therefore, the out-of-stock variables were deleted in the current analysis.

The coefficients of the Simpson index are positive for orange juice and grapefruit juice, negative for juice drinks, and not different from zero for other juices/blends and other beverages. Note that orange juice had most of the shelf space (i.e., 52% of total shelf-space available for the 17 beverages studied, see Table 1) in the refrigerated beverage category; therefore, a decrease in orange juice shelf space would increase the value of the Simpson index and thus results in a positive impact of orange juice sales. However, a decrease in orange-juice shelf space would also have a direct negative impact on orange-juice sales, the net impact of a reallocation of shelf space involves a direct impact through β_{ij}s and an indirect impact through η_is.

The parameter estimates presented in Table 2 could have been used to find the optimal allocation of shelf space for the beverage/juice category. However, the optimal allocation of shelf space depends on the prices of the beverages sold, the total sales of the refrigerated section, the out-of-stock situations, and the optimal mix of juices/drinks in the section. An optimal shelf-space allocation derived from the sample means of these variables is probably not very useful, because of the differences of stores in size and in the mix of juices/drinks in the refrigerated section. Therefore, the estimates presented in Table 2 were only used to examine the marginal impact of reallocating one foot of shelf space from one category to another on total refrigerated beverage revenue.

Equation (1) and sample means of prices, total dollar sales, and the average shelf space were used to calculate the marginal impact of shelf-space reallocation on total beverage dollar sales. The marginal impact of reallocation one foot of shelf space from product *k* to product *j* can be calculated as

(2) $$v_{ij} = \sum_i \overline{p}_i q_i^{kj} - \sum_i \overline{p}_i q_i ,$$

where

$$q_i = \exp\{\, \alpha_{i0} + \sum_j \alpha_{ij} \log \overline{p} + \alpha_{ix} \log \overline{x} + \sum_j \beta_{ij} \log \overline{SS}_j + \eta_i (1 - \sum_j w_i^2)\,\},\text{ and}$$

$$q_i^{kj} = \exp\{\alpha_{i0} + \sum_j \alpha_{ij} \log \bar{p} + \alpha_{ix} \log \bar{x} + \sum_{l \neq k,j} \beta_{il} \log \overline{SS}_l + \beta_{ik} \log(\overline{SS}_k - 1) + \beta_{ij} \log(\overline{SS}_j + 1)$$
$$+ \eta_i (1 - d(\sum_j w_i^2))\}, \quad i = 1, 2, \ldots, 5;$$

where $(1 - d(\sum_j w_i^2))$ represents the new value of the Simpson index after a reallocation of shelf space. In (2), q_i^{kj} shows the quantity sold of good *i* after one foot of good *k*'s shelf space was reallocated to good *j*. A "bar" on top of the variable represents sample mean. Results are shown in Table 3.

Results in Table 3 show that, in general, retail stores can increase total refrigerated juices/drinks revenue by reallocating juice-drinks and other juices/blends shelf space to orange juice and grapefruit juice. As shown in Table 3, reallocating shelf space from the juice-drinks category to any other juices/beverage categories would increase total beverage dollar sales. On the other hand, reallocating more shelf space from any of the juices/beverage categories to the juice-drinks category would decrease total beverage dollar sales. Results also show that retail stores can increase revenue by reallocating shelf space from any drinks/beverage categories except orange juice to the other beverage category. Note that the sample average of total dollar sales is $58,820, so that the impacts of reallocating of shelf space on total dollar sales are relatively small. For example, the maximum impact of reallocating shelf space was found in the reallocation of one foot of shelf space from orange juice to other juices/blends, a decrease of total beverage dollar sales by $1,113, which represents 1.9 percent of the total beverage revenue.

A common practice in retail stores to analyze the shelf-space reallocation impacts on revenue is to use average revenues. For example, one can use the sample means of revenue per foot of shelf space presented in Table 1 and calculate the changes in average revenue due to a reallocation of one foot of shelf space from category *i* to category *j*. In this case, the revenue change can be calculated as

(3) $$v_{ij}^* = ar_j - ar_i,$$

where ar_i represents the dollar sales per linear foot of shelf space from selling good *i* and v_{ij}^* is the difference between ar_j and ar_i. Results are presented at the bottom part of Table 3. Note that, by the design of (3), the average revenue changes derived from revenue per linear foot of shelf space are symmetrical but have opposite signs, i.e., $v_{ij}^* = -v_{ji}^*$. For example, the revenue difference between orange juice and grapefruit juice is $454 per foot of shelf space. If one subtracts the revenue per foot of orange juice from the revenue per foot of grapefruit juice, the difference is negative; but if one subtracts the revenue per foot of grapefruit juice from the revenue per foot of orange juice, the difference is positive.

If one considers the revenue per linear foot as the impact of shelf-space reallocation on dollar sales, then one finds taking away orange juice or grapefruit juice shelf space and giving it to other juices/drinks would decrease total beverage revenue and reallocating shelf space from other categories to orange juice or grapefruit would increase total beverage revenue. The results obtained from average revenue per linear foot of shelf space are quite different from the marginal impacts of shelf-space reallocation presented at the top of Table 3. For example, based on the average revenue per linear foot of shelf space, the reallocation of one foot of orange juice shelf space to juice drinks would decrease revenue by $578, but the marginal impact presented at the top half indicates the revenue is only decreased by $241, about 60% less. Another example is based on the revenue per linear foot of shelf space, the reallocation of one foot of orange juice shelf space to grapefruit would decrease beverage revenue by $454 but the marginal analysis result indicates that this reallocation actually increase beverage revenue by $238. The use of (3) ignores the influences of shelf-space's advertising effect and the prices of goods. Therefore, the results are not consistent with the marginal effects found in this study.

Table 1 Sample statistics (week ending 05-06-01)

Variable	Mean[a]	Standard Error	Minimum	Maximum
Dollar Sales ($)				
Orange Juice	43,533	25,836	4,292	131,659
Grapefruit Juice	1,634	1,271	97	9,235
Juice Drinks	6,972	4,605	2,210	29,450
Other Juices and Blends	4,874	3,468	403	16,113
Other Beverages	1,807	2,072	90	19,636
Volume (gallons)				
Orange Juice	8,574	4,947	870	24,495
Grapefruit Juice	281	223	18	1,417
Juice Drinks	2,481	2,152	574	13,409
Other Juices and Blends	836	579	84	2,319
Other Beverages	616	811	23	8,114
Shelf Footage (linear ft)				
Orange Juice	41.91	8.06	23.51	69.51
Grapefruit Juice	3.37	1.53	0.60	8.64
Juice Drinks	20.31	8.02	6.26	50.44
Other Juices and Blends	9.20	4.33	1.96	21.21
Other Beverages	5.89	4.11	0.59	32.69
Average Price ($/gallon)				
Orange Juice	$5.14	$1.10	$3.57	$7.88
Grapefruit Juice	$5.89	$1.13	$3.57	$8.54
Juice Drinks	$3.09	$0.66	$1.66	$5.75
Other Juices and Blends	$5.80	$1.22	$3.64	$10.24
Other Beverages	$3.48	$1.67	$1.22	$12.53
Out of Stock (%ACV)				
Orange Juice	0.04	0.37	0.00	4.27
Grapefruit Juice	0.66	3.76	0.00	41.86
Juice Drinks	0.74	3.81	0.00	25.15
Other Juices and Blends	0.93	2.73	0.00	15.29
Other Beverages	1.03	3.29	0.00	25.00
Total Revenue ($)	58,820	31,827	15,347	154,500

[a]The statistics are simple averages and may be different from the weighted total US averages reported by IRI.

Table 2 Elasticity estimates

	Orange Juice	Grapefruit Juice	Juice Drinks	Other Juices & Blends	Other Beverages
Intercept	-4.187*	-6.397*	0.908	-2.121*	-4.556*
	(0.463)	(1.198)	(1.148)	(1.170)	(2.307)
			Average Price ($/pint)		
Orange Juice	-1.087*	-0.322*	-0.108	0.065	-0.801*
	(0.072)	(0.187)	(0.179)	(0.183)	(0.361)
Grapefruit Juice	0.036	-0.712*	-0.340	0.314	0.393
	(0.079)	(0.204)	(0.196)	(0.200)	(0.393)
Juice Drinks	0.235*	-0.281*	-1.554*	-0.015	-0.641*
	(0.055)	(0.141)	(0.135)	(0.138)	(0.272)
Other Juices &	0.094	0.380*	0.006	-1.117*	0.600*
Blends	(0.074)	(0.192)	(0.184)	(0.188)	(0.370)
Other Beverages	-0.046*	0.376*	0.125*	0.297*	-0.896*
	(0.025)	(0.066)	(0.063)	(0.064)	(0.126)
Total Expenditure	1.034*	0.882*	0.862*	0.868*	1.006*
	(0.019)	(0.049)	(0.047)	(0.048)	(0.095)
			Refrigerated Shelf Space (linear feet)		
Orange Juice	0.812*	0.729*	-0.750*	0.000	-0.408
	(0.071)	(0.184)	(0.176)	(0.180)	(0.355)
Grapefruit Juice	-0.060*	0.637*	-0.087	-0.014	-0.033
	(0.024)	(0.061)	(0.058)	(0.060)	(0.117)
Juice Drinks	-0.337*	-0.430*	0.992*	-0.045	-0.047
	(0.030)	(0.078)	(0.074)	(0.076)	(0.150)
Other Juices &	-0.235*	-0.323*	0.002	0.647*	-0.194
Blends	(0.029)	(0.075)	(0.072)	(0.073)	(0.145)
Other Beverages	-0.170*	-0.165*	-0.011	-0.035	0.941*
	(0.021)	(0.055)	(0.053)	(0.054)	(0.106)
The Simpson Index	3.944*	4.593*	-3.402*	0.148	1.253
	(0.414)	(1.072)	(1.027)	(1.047)	(2.063)
R-Sq	0.983	0.933	0.896	0.943	0.855

*Statistically different from zero at $\alpha = 0.5$ level.

Table 3 Estimated revenue change due to a reallocation of one foot of shelf space

From	To				
	Orange Juice	Grapefruit Juice	Juice Drinks	Other Juices & Blends	Other Beverages
			Shelf-Space Marginal Revenue		
Orange Juice		$53	-$356	-$1,113	-$11
Grapefruit Juice	$119		-$172	$5	$152
Juice Drinks	$312	$431		$193	$348
Other Juices & Blends	$127	$231	-$187		$161
Other Beverages	$42	$144	-$269	-$76	
			Revenue Changes Calculated from Average Revenue		
Orange Juice		-$454	-$578	-$471	-$573
Grapefruit Juice	$454		-$125	-$17	-$120
Juice Drinks	$578	$125		$108	$5
Other Juices & Blends	$471	$17	-$108		-$103
Other Beverages	$573	$120	-$5	$103	

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