NORTHEASTERN REGIONAL FRUIT MARKETING PROJECT

Report 1*

Problem:

To investigate the effect on experimental error, of varying the length of observations of apple purchases in stores of a given chain organization.

Source of Data:

Data obtained during the fall of 1950 from a controlled experiment conducted in four supermarkets of the Market Basket Corporation located in the sourthern-tier counties of Western New York. One store was located in each of the cities of Corning, Cortland, Elmira, and Ithaca.[1/]

Findings:

Apple purchases during half-hour, hour, two-hour, and a "day" as observation periods were studied for each of two parts of the week. The first part of the week consisted of the first four days of the week and the second part, Friday and Saturday. The experimental error in purchases for each of the lengths of observation period was expressed on a half-hour basis. Ignoring costs of moving from store to store of a given chain organization it was found to be about equally efficient to take half-hour observations and observations of longer time periods. But when costs of moving between stores is considered, it would be more efficient to take two-hour observations in one store of a given chain than to take four half-hour observations in four different stores. It

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* Biometrics Unit Paper BU - 55M, Cornell Agricultural Experiment Station

1/ Bennett A. Dominick, Jr., "Merchandising McIntosh Apples Under Controlled Conditions - Customer Reaction and Effect on Sales," PH.D thesis, Cornell University, 1952

was also found that greater precision could be obtained by taking observations on week-ends for about half as long a period as during the early parts of the week.

Application:

About the same degree of precision can be obtained by observing either more stores of a given chain organization for shorter time periods or fewer stores for longer time periods. Taking costs of enumeration into account, the data imply that an observation period of at least two hours should be used before considering a larger number of stores, but these results are based upon a very limited situation. The results also pertain to the experimental error in a controlled experiment with a latin square and might not be applicable under other circumstances.

A comparison of the first part of the week with the second indicated that the same precision could be attained by observing stores during the second part of the week for a substantially shorter interval than that necessary for the first part. This tends to support the decision made in 1952-53 and later work that shorter periods of observation be taken on week-ends.

Supporting Data:

During the fall of 1950 a controlled experiment was conducted in four retail stores in the southern-tier counties of Western New York to determine the sales effectiveness of selected merchandising practices applied to McIntosh apples. A latin square design was employed to test the effect of factors such as type of package, size of pricing unit, size of display, location of display and quality on volume of apple sales. 2/ The four stores selected were super markets of the Market Basket Corporation.

2/ For a report on the methodology employed see Methods of Research in Marketing, Paper Number 2, "An Illustration of the Use of the Latin Square in Measuring the Effectiveness of Retail Merchandising Practices," Bennett A. Dominick, Jr., Department of Agricultural Economics, Cornell University Agricultural Experiment Station, New York College of Agriculture, Cornell University, Ithaca, New York, June, 1952

The experiment covered a twelve-week period beginning September 25, 1950, and ending December 16, 1950. This time period was broken down into two-week intervals during which a given set of four merchandising practices or "treatments" were tested. In addition, each week was further subdivided into two parts to permit comparison of the volume of apples sold during the first four days with purchases made during Friday and Saturday. Thus, as indicated in table 1, two 4 x 4 latin squares were set up for each week, each square covering a period of four "days." The first square covered the first four days of the week. For the second square, the nature of the experimental design necessitated that Friday a.m., Friday p.m., Saturday a.m. and Saturday p.m. each be considered as a "day". For each "day" 3/ and store, the sales of apples were

Table 1: Description of Data for Analysis of Effect of Length of Time Period on Experimental Error.1/

Day	Store				Day	Store			
	1	2	3	4		1	2	3	4
Mon.	B	D	C	A	Fri. a.m.	D	A	B	C
Tues.	C	A	B	D	Fri. p.m.	B	C	D	A
Wed.	A	B	D	C	Sat. a.m.	A	B	C	D
Thurs.	D	C	A	B	Sat. p.m.	C	D	A	B

1/ The letters represent merchandising practices

recorded by half-hour periods, except for rest periods. Hence, observation periods of different lengths could be formulated so the effect of length of observation period on experimented error could be estimated.

3/ "Day" as used in this manuscript refers to the time when a particular merchandising practice was on trial in a store. Thus "day" is used to mean a full day with reference to the first part of the week and a half-day with reference to the second part.

From each part of the week, four successive half-hour periods were selected. The sole criteria for choosing which four periods to include was that each of the four stores have observations taken during each of the selected periods and that the periods be successive half-hour periods if possible. Preliminary inspection of the data showed that minor deviations occurred in the times of enumeration in some of the stores. It was found, however, that during the first part of the week, observations were made in each of the four stores each day during the following times: 10:00 a.m. - 10:30 a.m., 10:30 a.m. - 11:00 a.m., 11:30 a.m. - 12:00 p.m. and 12:00 p.m. - 12:30 p.m. Therefore, these four time periods were selected and a latin square analysis was made for each of the four half-hour time periods. The original data for half-hour periods were combined to provide data for one-hour periods: 10:00 a.m. - 11:00 a.m. and 11:30 a.m. - 12:30 p.m. A latin square analysis was made for each of these one-hour periods. Then the original data for the one-hour periods were added together and a similar analysis was made of the combined data. The same general procedure was followed for the second part of the week.

A "day" was also considered as an observation period for comparison with the shorter periods. When interpreting the results for this comparison we need to remember that the half-hour, one-hour, and two-hour periods are morning hours in the first part of the week and hence the volume per hour is lower than for the "day". For the second part of the week the "days" were of approximately the same length and averaged 3.4 hours. The variation in length of "day" was rather large for the first part of the week, particularly as one store was not open on Wednesday afternoon. For this store, on Wednesdays the "day" was only three hours, whereas the average length of day was 6.2 hours. In the original study the plan was to use covariance (the covariate being

number of customers) as a means of adjusting for varying length of "day". The covariate did not help much in reducing the experimental error so the results shown herein are from the usual analysis of variance without a covariance adjustment.

Separate latin square analyses were made for each week in three of the two-week periods out of the twelve in the experiment. To summarize the results, the error sum of squares for the analyses involving half-hour periods, one-hour periods, two-hour periods or a "day" were combined so an average error mean square could be obtained for each length of observation period by first and second parts of weeks. The results are given in Table 2.

Table 2: Experimental Error by Length of Observation Period and Parts of a Week.1/

Length of Observation Period	Mean per period	Standard Error		Coefficient of Variation in per cent
		Actual	On a ½ hour basis	
First part of week				
½ hour	1.7	2.5	2.5	147
1 hour	3.4	3.2	2.3	94
2 hours	6.8	4.4	2.2	65
1 day (6.2 hours)	33.0	11.6	4.6	35
Second part of week				
½ hour	8.0	6.5	6.5	81
1 hour	16.1	10.0	7.1	62
2 hours	32.2	14.4	7.2	45
1 day (3.4 hours)	52.8	16.9	9.2	32

1/ Data are in terms of pounds of apples purchased

There is little if any evidence of a difference in statistical efficiency of the lengths of observation period other than a "day" when the standard errors are expressed on a half hour basis. This means, for example, that if the length of observation period were increased

from one hour to two hours in the same four stores, the effective experimental error would be reduced nearly as much as the reduction would be if 8 stores from the <u>same</u> "population" and one-hour observation periods were used. The second alternative is more expensive in terms of time lost in traveling between stores, cost of travel and making necessary arrangements with the larger number of stores. This implies that observation periods at least two hours long should be used as a means of reducing experimental error before considering a larger number of stores of a particular chain.

For the first part of the week, a comparison of a "day" with shorter observation periods is difficult to interpret. The standard deviation is correlated with the amount sold, and the coefficient of variation for a two-hour period in the afternoon would be expected to be considerably less than 65, the coefficient of variation for a two-hour period in the morning. In other words, if we were comparing a "day" with observation periods in the afternoon, the difference in efficiency would be much less. This problem does not occur to any appreciable extent for the second part of the week.

The existence of correlation between mean and standard deviation is apparent from the fact that the standard errors for a given length of observation period are larger for the second half of the week. However, the variability in purchases, relative to the mean, is substantially less for the second part of the week. For a given time period, the square of the coefficient of variation for the first part of the week to the square of the coefficient of variation for the second part gives a measure of the relative efficiency (table 3). For example, $\frac{147^2}{816^2} = 3.3$, which means that a half-hour period during the second part of the week is 3.3 times more efficient than a half-hour period for the first part.

Table 3: Relative Efficiency of Latin Square of Second Part of Week to the First

Length of Observation Period During Second Part of Week	Relative Efficiency	Length of Observation Period for First Part of Week for Equivalent Precision
½ hour	3.3	1.7 hours
1 hour	2.3	2.3 hours
2 hours	2.0	4.0 hours
1 "day" (3.4 hours)	2.2 1/	1.0 "day" (7.5 hours)

1/ Coefficients of variation were corrected for unequal lengths of "day" before computing relative efficiency so the relative efficiency would be in terms of equal time periods.

That is, a half-hour period during the second part is equivalent in precision to an observation period of $(3.3)(\frac{1}{2}) = 1.7$ hours during the first part of the week. The basic assumption underlying this comparison is that adjacent half-hour periods are independent and that in the case of the half-hour, hour, or two-hour observation period, the observations for the first part of the week would be taken in the morning. If taken in the afternoon during the first part, the difference in efficiency between the two parts of week would be less.

The coefficient of variation for a "day" for the second part of the week was approximately equal to the coefficient of variation for a "day" for the first part. A "day" for the first part of the week was sufficiently longer than a "day" for the second part to offset the higher relative error associated with smaller volume of sales per hour during the first part.

The primary interest in making these comparisons was the determination of the degree of precision obtained by staying in the stores varying lengths of time ignoring possible differences in the population between the two parts of weeks and mornings and afternoons.

The reader is also reminded of the fact that the experiment involved only four stores which were members of the same chain and approximately equal in size. Moreover, the results presented here are in terms of the effect of length of observation period on the error term in a latin square design and hence are not necessarily indicative of what the length of observation period should be for measuring week to week changes in sales.

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Reviewed by Subcommittee

June 7, 1955